



# Polymer Assisted Hydraulic Dredging of a Stormwater Pond

## CASE STUDY



### INTRODUCTION

As stormwater ponds introduced in the 1990's continue to age, the number of ponds requiring cleanouts is increasing rapidly. Mechanical dredging of the settled sediment layer is the conventional method of choice; however, there is growing interest in alternative methods that may help reduce cost and overall disturbance of the landscape. Polymer assisted hydraulic dredging is one such method that helps reduce the impact of cleanout operations on the neighbouring community while also providing enhanced protection of the environment.

The use of polymer technology to facilitate water clarification and sediment consolidation during stormwater pond cleanouts is a relatively new approach within the Greater Toronto Area. While cost effectiveness is often a principal concern, other constraints such as space limitations and tight timelines are also key priorities. The current case study describes an application of the polymer anionic polyacrylamide (PAM) to aid in sediment removal from a stormwater management pond in the City of Vaughan, Ontario.

### POND PROFILE

Municipality	City of Vaughan
Cleanout Party	Layfield Canada Ltd.
Drainage Area Land Use	Residential
Pond Age at Time of Cleanout	5 years
Drainage Area (ha)	35.02
Permanent Pool Depth (m)	1.00
Permanent Pool Volume (m <sup>3</sup> /ha)	110
Water Quality and Erosion Control Volume (m <sup>3</sup> /ha)	178
Sediment Removal Method	Hydraulic Dredging
Sediment Handling Method	Landfill Disposal



## PROJECT OBJECTIVES

In Ontario, municipalities typically require landowners to remove sediment accumulated in stormwater management ponds before ownership is transferred to them from the developer. After the pond has been cleaned out, a bathymetric survey of the pond is completed and compared to as-built or original design drawings to confirm that the pond has been restored to its full capacity. The dredging of Pond 4 was undertaken by the Block 11 Landowners Group in 2013 in order to render the pond suitable for assumption by the City of Vaughan.

Based on the completion of a bathymetric survey, it was determined that a total of 1230 m<sup>3</sup> of sediment had accumulated in the pond. Over and above the primary objective of removing this accumulated sediment, the method selected for the dredging of Pond 4 was also required to meet the following secondary objectives.

- Avoid the clearing of vegetation on pond embankments and surrounding areas so as to keep restoration and replanting costs to a minimum;
- Return the pond to its original design capacity for the purpose of assumption by the City of Vaughan;
- Minimize disturbance to local residents and individuals who use the walking trails around the pond;
- Minimize the ecological disturbance of dredging activities to wildlife that inhabit the pond area, particularly waterfowl;
- Prevent the release of sediment to the receiving stream; and
- Complete project on schedule and budget.

## SITE DESCRIPTION

The pond is located on Block 11 in the City of Vaughan, Ontario, near the intersection of Rutherford Road and Bathurst Street (Figure 1). It receives stormwater runoff from 35 hectares of primarily residential land and drains to a tributary of the Upper East Don River. The parkland immediately surrounding the pond is a well vegetated area containing walking trails frequented by local residents. To the south, between the pond and Rutherford Road, is a synagogue and parking lot.

The pond was constructed during the earthworks phase of construction for the residential development in 2006 and functioned as a construction sediment control pond. To date, the pond has never been dredged as it was relatively recently constructed and had not been assumed by the municipality at the time of cleanout.

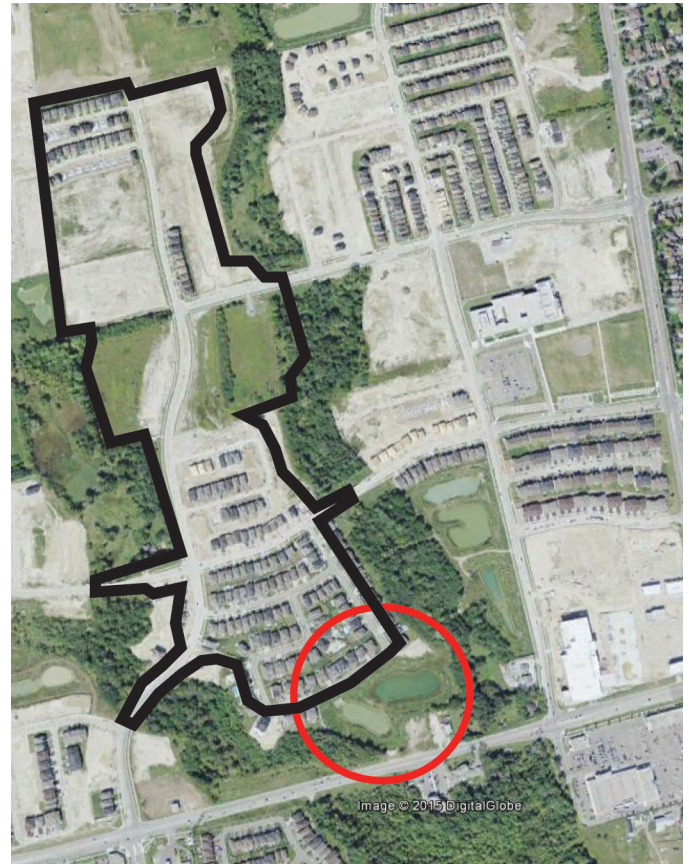


Figure 1. Location and drainage area for Pond 4, Block 11 in Vaughan.

## METHODS

Based on these objectives and the specific constraints and opportunities available at the site, the proponent elected to use a relatively new and unconventional method to clean out Pond 4 – polymer-assisted hydraulic dredging. This method involves the hydraulic dredging of wet sediment, the injection of an anionic polyacrylamide solution into the sediment slurry, and the conveyance of the material to large filter bags for dewatering. The entire cleanout process is detailed in the following subsections.

### Pond Survey

The pre-cleaning bathymetric survey took place in April, 2011. The survey indicated that a total of 1330 m<sup>3</sup> of sediment has accumulated in the pond - 770 m<sup>3</sup> in the sediment forebay and 460 m<sup>3</sup> in the main cell. A GPS total station was used together with a disk and rod to obtain coordinates for the top of the sediment layer. The bathymetry of the pond was compared to the pre-cleaning as-built survey to provide an accurate estimate of accumulated sediment volume.

### Sediment Characterization

The sediment accumulated in the bottom of Pond 4 was sampled in May and April of 2011, and samples were submitted to Maxxam Analytics in Mississauga for laboratory analysis to assess whether the material was suitable for use as fill at a nearby school construction site.

One sample was collected from the forebay and three samples were collected from the main part of the pond (referred to as the wet cell), using an Ekman Dredge Sampler. All samples were analyzed for a series of petroleum hydrocarbons and metals, and concentrations were compared to the Ontario Ministry of Environment's *Soil, Ground Water and Sediment Standards for Use Under Part XV.I of the Environmental Protection Act* (2011). Within the standards, the contaminant thresholds listed under the category for Residential/Parkland use within Table 1, entitled "Full Depth Background Site Condition Standards" was used as the basis for comparison to the contaminant levels in the pond sediment.

A toxicity characteristic leaching procedure (TCLP) was also carried out on the pond sediment samples, in accordance with Ontario Regulation 347/4 which was created under the Environmental Protection Act and addresses the management of waste. TCLP is a method in which landfill-like conditions are applied to a solid waste material in order to yield a leachate – a liquid sample containing dissolved and particulate matter that have drained out of the original material. Schedule 4 lists the maximum acceptable contaminant concentrations for leachates. If contaminant concentrations in the leachate exceed values listed in Schedule 4, the solid material from which the leachate was derived is defined as hazardous waste and must be disposed of accordingly.

### Site Preparation

Based on the dredging method selected, large excavators were not required in the pond and surrounding area. As a result, there was no significant vegetation removal and the need for erosion and sediment control measures was minimal. In order to mitigate the release of sediment from the pond during dredging activities, work was scheduled in the summer during a period over which dry weather was forecasted. Because more than 60% of accumulated sediment was located in the forebay part of the pond, the risk of sediment release to receiving waters was considered to be low. The primary activities associated with preparing the site for dredging were:

- The preparation of a lay down area for the sediment dewatering bags;
- The placement of the hydraulic dredge and steel cable system in the pond; and
- The installation of the pumps, pipes and hoses conveying material between the dredge, polymer supply trailer, and sediment dewatering bags.

The area designated for the placement of the Geotubes® (measuring 45 by 100 feet) was a vacant gravel parking lot immediately south of the pond (Figure 3). The first step in preparing the area was leveling the ground with a backhoe and creating earthen berms around the perimeter. These measures ensured that the Geotubes® would not shift or roll once they were filled. Following this grading, the area was covered with a plastic liner, plastic netting for drainage, and a nonwoven geotextile fabric (Figure 2).



Figure 2. Preparation of laydown area for sediment dewatering Geotubes® (left). The same area with the Geotubes® in place and filtering water (right).





Figure 3. Schematic aerial view of the Pond 4 site during polymer-assisted hydraulic dredging.



Figure 4. Pit Hog™ dredge operating in Pond 4.

Figure 3 illustrates the overall site set up for the dredging of Pond 4. The remote controlled, floating, auger-type dredge used – a Pit Hog™ – was lifted into the pond and removed at the conclusion of dredging with the use of a crane (Figure 4). A diesel generator

was put in place to provide power to the dredge. Hoses from the dredge were connected to a trailer housing the prepared polymer solution in large drums, as well as the metering and dosing equipment. Hoses also connected the trailer to the Geotubes® to which the polymer dosed material was conveyed to allow for settling and filtration.

### Dewatering and Dredging

As depicted in Figure 3, the sediment slurry was suctioned by the dredge, pumped to the trailer for inline polymer injection and mixing, and then pumped to a Geotube® for dewatering (Figure 5). Water drained from the Geotubes® was conveyed back into the forebay part of the pond.

The operation of the dredge (Figure 4) was done by remote control, with the dredge's forward, reverse and lateral movements guided by a steel rail system installed at the ends of the pond. The movement of the dredge was determined based on real time measurement of solids levels in the material being suctioned. The concentration of solids in the slurry being pumped through the dredge was measured by a density meter in the polymer metering and dosing trailer. These real time measurements were observed by an individual in the trailer who remained in constant radio contact with the person remotely operating the dredge. The percent solids level indicated whether or not that part of the pond bottom had been cleared of sediment. When the percent solids decreased at a specific spot, it served as a cue to the operator

that the dredge had sufficiently suctioned the sediment in that area, and should be moved forward to suction the next area.

The role of the polymer used – a solution made from granular anionic PAM and water – is to promote the binding together of the





Figure 5. Sediment dewatering bag laydown area.

suspended sediment particles in the slurry so that they form larger aggregate particles. Once formed, these larger particles are more susceptible to being removed from suspension by gravitational settling or filtration in the Geotube™. In order to ensure the optimal performance of the polymer as a flocculant, the following factors should be considered:

**POLYMER FORMULATION.** Choosing the optimal polymer formulation to use for a given project is based primarily on the sediment characteristics. In preparation for the dredging, bench tests were carried out to determine which polymer formulation would work best with the material. Bench testing reveals not only the extent to which the polymer will cause flocculation, but also the extent to which it will cause a strong floc to form rather than a weak floc that will break apart and be susceptible to re-suspension. For this project, 80 separate 250 mL samples were collected from Pond 4 in

order to accurately characterize the material to be treated, and select the best polymer formulation. The product selected, Solve 109AQ supplied by WaterSolve LLC, is an anionic PAM based powder. It was mixed with water in order to prepare the 0.5% solution used in this project.

**POLYMER DOSING RATE.** Once the polymer formulation is determined, additional bench testing and preliminary onsite testing determines the optimal dose of polymer based on the suspended solids level in the slurry. In this project, establishing the relationship between solids concentration and polymer dose allowed for the development of an algorithm. A computer housed in the trailer (Figure 5) applied the algorithm to provide continuous calculation of the amount of polymer to be injected into the slurry, based on real time measurements of flow rate and solids concentration.

**MIXING TIME.** Once the polymer is injected into the sediment slurry, mixing provides an opportunity for the polymer to react with the suspended sediment particles. Based on bench testing results, the optimal mixing time for the polymer dosed slurry was determined. Within the trailer, the slurry flows through an additional length of pipe and is subjected to turbulence in order to provide the necessary length and quality of mixing.

The final step in the dredging/dewatering process was the pumping of the dosed and mixed slurry into the Geotube™. Here, much of the sediment either settles or is filtered out of suspension (Figure 6). Water draining from the Geotube™ pools slightly in the containment area, where there is some additional sediment settling. The effluent was discharged back into the pond forebay area via two 6" pipes, with a plastic liner installed on the ground at the discharge point to prevent erosion (Figure 6).



Figure 6. Filled sediment dewatering bag (left) and clarity of effluent water after it drains from the sediment dewatering area (right).



The Geotubes™ used to contain the sediment were left to drain for a period of two months. This drying period was longer than what would normally be required, reflecting delays in scheduling of hauling rather than the actual time needed for sediment to be dry enough. Typically, a few weeks of drying time would be sufficient, but this can vary significantly according to the type of material being dewatered and weather conditions. For this project, the solids concentration was 56% at two weeks and roughly 60% at two months post dredging, demonstrating that the additional drying time resulted in a relatively marginal benefit.

### Sediment Hauling and Disposal

At the time of hauling, the Geotubes™ were cut open and the dried sediment (roughly 60% solids) was scooped out with an excavator. Roni Excavating was retained to remove the sediment and transport it to the designated site.

The laboratory analysis of sediment samples revealed that two types of petroleum hydrocarbons exceeded the MOE Table 1 standards. In their analysis of sediment disposal and reuse options, Pinchin Environmental concluded that the sediment could only be reused as fill at a nearby school construction site if contaminant levels in the sediment were similar to, or better than, those at the school site. This option for sediment reuse is part of Ontario Regulation 153/04 (as amended by O.Reg. 511/09), which allows sediment to be reused as fill at a Record of Site Condition (RSC) property, provided that the material does not contain higher contaminant levels than those present at the destination site. An RSC property is a property for which the environmental condition and an RSC has been filed with the Ontario Ministry of Environment's Brownfields Environmental Site Registry.

Based on the petroleum hydrocarbon levels in the pond dredgate, it was determined that the material would not in fact be suitable for reuse at the future school property, and would instead need to be disposed of at a landfill. The sediment – a total volume of 1033 m<sup>3</sup> – was hauled to a municipal landfill at a cost of \$40/tonne for hauling and disposal.

### Site Restoration

A number of dead cattails were removed at the banks of the pond for ease of access. The presence of two access roads eliminated the need to cut down any trees, which ultimately minimized the site restoration activities. Some grading of the access roads was necessary to ensure the optimal function and safety of the pond perimeter and ease of future access.

## RESULTS

The dredging of Pond 4 was carried out successfully and as planned. The following subsections describe and evaluate the success of the project relative to its specific objectives.

### Removal of 1300 m<sup>3</sup> of sediment

Based on a bathymetric survey of the pond completed in 2011, an estimated total of 1230 m<sup>3</sup> of in-situ sediment had accumulated in the pond – 770 m<sup>3</sup> in the forebay and 460 m<sup>3</sup> in the wet cell. The total removed sediment was 800 m<sup>3</sup> from the forebay and 500 m<sup>3</sup> from the permanent pool for a total of 1300 m<sup>3</sup>, which indicates that the method used to estimate the volume of accumulated sediment was relatively accurate. The total volume of sediment-laden pond water removed by the hydraulic dredge was 4,336 m<sup>3</sup>. At a daily average percent solids of 4.9%, the bone-dry equivalent of the



Figure 7. Consistency of Pond 4 sediment at the time of hauling, after two months in the Geotubes™.





Figure 8. The well-established plantings surrounding Pond 4 that remained undisturbed during dredging.

sediment retained in the geotubes amounted to approximately 215 m<sup>3</sup> (Figure 7).

Estimating the total volume of removed sediment during hydraulic dredging is quite different than during mechanical dredging. Since the pumped slurry has a very high water content, very large amount of slurry needs to be pumped in order to obtain a fraction of that volume in the form of workable sediment. The amount of removed sediment is then estimated by applying a solids fraction at the time of removal based on the proportion of solids in the slurry sample. Note that a single sample may misrepresent the solids proportion, as hydraulic dredging removes differing proportions of solids depending on how deep within the sediment depth the pump is submerged. Therefore, a substantial number samples should be acquired to obtain a representative determination of the average sediment contents of the dredged slurry.

### Preserving Vegetation and Site Features

The dredging method used was largely non-invasive, with no excavators requiring access to the pond and only a crane used to lift the dredge into and out of the pond. As such, no significant vegetation removal was necessary to facilitate pond access, and the established vegetation stabilizing pond embankments was also preserved (Figure 8). As a result, the only site restoration activities necessary were the removal of the materials lining the containment area and the re-grading of the parking lot to its original condition. Because there were few construction vehicles required on site, walking trails around the pond area remained accessible to local residents throughout the dredging process.

### Minimizing Ecological Disturbance and Sediment Release to Natural Features

Pond 4 remained functional throughout the dredging process, since the technology used did not require that it be pumped down. The presence of the permanent pool allowed birds and other wildlife to continue to use the pond, while also allowing the pond to continue to function for storm-water management. This was evidenced

during a large 39 mm rainfall event that occurred on June 10, during which the pond continued to provide its stormwater management function. Dredging was continued even while the pond was full because, based on effluent monitoring, the increase in turbidity caused by the operation of the dredge was minimal and did not result in any significant sediment release from the pond.

### Completing the Project on Schedule and Within Budget

The preparation of the laydown area was carried out within three days at the end of May 2013, and dredging was subsequently carried out over the course of ten days, from June 3rd to 13th. The project was carried out as planned and on budget, with no significant delays reported by the project team.

## CHALLENGES AND LESSONS LEARNED

Overall, the project was completed successfully while addressing all objectives. Since hydraulic dredging is still an emerging technology within the environmental consulting industry of pond cleanouts, there were lessons learned that would be beneficial for future implementations.

Discrepancies in volume estimations may occur due to the different type of sediment handling during hydraulic dredging. Because bathymetric surveys are in fact measuring in situ saturated sediment, these total volumes are comprised mostly of water. If a good estimation of the actual solids ratio is unknown, it can be difficult to assess whether the amount of sediment removed is adequate, since the dredgeate has a different solids content than the in situ sediment. This is not a major issue for mechanical dredging, where in-situ sediment estimations are commonly increased by 10-20% to better estimate the expected volume of removed sediment, in its state prior to dewatering.

Uncertainties in estimating sediment volumes made it difficult to determine the number of dewatering bags needed to accommo-

date the dredged sediment. To prepare for a high end of potentially removed sediment volume, technicians allotted more space than was necessary for dewatering. Extra sediment dewatering bags were prepared, but were only opened as required, which helped to reduce costs.

The polymer product used was very effective at dewatering the sediment directed to the sediment dewatering bags. Although it would have only required few weeks to sufficiently dewater, the bags were left on site for two months due to conflicting hauling schedules. In this case, the fact that the sediment was contained in the dewatering bags was highly beneficial, as it was not subject to erosion as it sat over the two month period. The sediment dewatering bags work exceptionally well as sediment containment areas, making the subsequent management of this sediment a smooth operation.

Lastly, there was a minimal amount of land disturbed to facilitate the cleanout, as there was no need to use heavy machinery. Additionally, the adjacent underused parking area served as an ideal sediment management area, further minimizing the need for vegetation clearing and subsequent restoration.



For information on STEP's other stormwater management initiatives, or to access the new guidance on stormwater pond cleanouts, visit us online at [www.sustainabletechnologies.ca](http://www.sustainabletechnologies.ca)

This case study has been prepared by the Toronto and Region Conservation Authority's Sustainable Technologies Evaluation Program. Layfield Canada Ltd. and Bishop Water Technologies carried out the pond clean out project described herein, and as such provided the information and site access required for the development of this document. Funding support for this study was provided by Region of Peel, Region of York, City of Toronto and Government of Canada's Great Lakes Sustainability Fund. The contents of this report do not necessarily represent the policies of the supporting agencies. For more information about this project, please contact [STEP@trca.on.ca](mailto:STEP@trca.on.ca).



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