FEASIBILITY ANALYSIS
ARSENIC IMPACTED SEDIMENTS
BRIGGS POND
VILLAGE OF PAW PAW
VAN BUREN COUNTY, MICHIGAN

Prepared for:

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1.0 INTRODUCTION

Phillips Environmental Consulting Services, Inc. has been retained by the Village of Paw Paw to prepare this Feasibility Analysis to evaluate potential treatment and disposal options for sediments planned to be dredged from a sediment trap within Briggs Pond (formerly known as Ismond Pond) located in the Village of Paw Paw. The general area is shown on the attached Site Location Map.

2.0 BACKGROUND

Briggs Pond was created in 1904 when a dam was constructed on the South Branch of the Paw Paw River for a hydroelectric power plant. The dam is located south of, and upstream from, Maple Lake (created and preserved by the Maple Lake Dam located north of the lake) and just downstream of the confluence of the South Branch of the Paw Paw River (sometimes called the West Branch above this point) and the East Branch of the Paw Paw River. Briggs Pond connects to Maple Lake by way of the South Branch of the Paw Paw River, and acts as a natural sedimentation basin.

Sedimentation in Briggs Pond has become so significant that sediment transport is occurring over the dam and into Maple Lake, affecting the aesthetic and recreational value of the lake. A short-term solution has been to dredge the sediments from both Maple Lake and Briggs Pond. The Village of Paw Paw currently holds a permit issued by the Michigan Department of Environmental Quality (MDEQ) by authority of Part 301 (Inland Lakes and Streams) of the Natural Resources and Environmental Protection Act 451, PA 1994, as amended, Joint Permit Number 06-80-0029-P. The permit allows the dredging of 5,000 cubic yards of material to create a sediment trap within Briggs Pond on an annual basis during the months of March and April. The permit expires on July 10, 2011. This Feasibility Analysis assumes that all dredging is conducted in accordance with an MDEQ approved permit, or permit exemption.

Files reviewed from the Village of Paw Paw Department of Public Services indicate that upwards of 1,000,000 cubic yards of sediment require removal from Briggs Pond and Maple Lake in order to restore the historic depth and nature of both water bodies. Dredging is a short-term solution to the problem of sedimentation. Studies indicate that sediments continue to flow in to the area from upstream erosion of the streambed and channel, with contribution from the erosion of farmland and areas under development. Recommendations to address sedimentation within the watershed are described in the <u>Paw Paw River Watershed Management Plan</u> (Southwest Michigan Planning Commission, August 2008).

2.1 Available Sediment Sampling and Analytical Data

An overview of available sampling and analysis of sediment samples collected from Maple Lake and Briggs Pond is described here in order to provide background for treatment and disposal requirements. The analytical data are included as Appendix A, along with maps showing the sediment sample locations where available.

The first available analytical data are from four sediment samples collected from the south basin of Maple Lake on July 12, 1991. The samples were analyzed for eleven metals, volatile organic hydrocarbons (VOCs) and organochlorine pesticides. None of the VOCs or organochlorine pesticides was detected to method detection limits. Metal concentrations were all below the current Statewide Default Background Concentrations (Background), with the exception of arsenic in two of the samples, and barium in one of the samples. Arsenic concentrations ranged from 2.6 mg/kg to 12.1 mg/kg. Barium concentrations ranged between 17.8 mg/kg and 128 mg/kg. At the time the concentrations were all considered to be representative of background.

In June, 1997, four respective sediment samples were each collected from Maple Lake (ML) and Briggs Pond (BP) for analysis by TriMatrix Laboratories, Inc. of eleven metals, VOCs, pesticides, polynuclear aromatic hydrocarbons (PNAs), polychlorinated biphenyl's (PCBs). The data indicate the presence of VOCs, PNAs, pesticides and PCBs in at least one of the sediment samples collected from each water body. VOCs and PNAs appeared most prevalent in Maple Lake sediment samples. A brief review of the data indicate that only one PNA compound in two samples from Maple Lake, as well as lead and arsenic exceed the applicable criteria for designating the material as inert without further testing of leachability; arsenic being the most prevalent concern. Arsenic concentrations ranged from 12 to 30 mg/kg in Maple Lake and between 27 and 58 mg/kg in Briggs Pond. Lead did not exceed current Background concentrations in the samples from Briggs Pond, but ranged between 21 mg/kg and 155 mg/kg in Maple Lake. In July, 1997, it appears that several of the locations were resampled for analysis of VOCs, PNAs, pesticides and PCBs. The results were generally consistent with the previous data, confirming the presence of these compounds at some of the locations.

In March 1998 six sediment samples were collected by Harrington Engineering & Construction from Maple Lake for analysis by EIS Analytical Services, Inc. of the eleven metals by total concentrations in the sediments and concentrations in a leachate created using the Synthetic Precipitation Leaching Procedure (SPLP); a procedure that simulates natural leaching through the soil/sediments by rain water. The locations of the samples are not known, but they appear to have been collected from Maple Lake at locations designated as "A" through "F".

Total concentrations appeared to be within the Background concentrations, with the exception of one sample exhibiting barium and arsenic exceeding Background concentrations, and another with arsenic exceeding Background concentrations. The highest concentration of arsenic detected was 9.48 mg/kg. However, analyses were reported as wet weight instead of dry weight; thus, reporting lower concentrations than required dry weight analysis. SPLP analysis indicated the presence of arsenic exceeding the current Part 115 criterion of 1 ug/L. The highest concentration of arsenic detected in the SPLP leachate was 6.6 ug/L. The US EPA Drinking Water Standard for arsenic is 10 ug/L. It was noted that the detection limit for lead was higher than the criterion for comparison. During this sampling event, six soil samples were collected from around the Village of Paw Paw for analysis of the eleven metals for a site specific evaluation of background metal concentrations in the area.

In July of 2000, thirty-seven (37) sediment samples were collected by Inland Marine Construction, Inc. from the west side of the south basin (“West Basin”) of Maple Lake for analysis by EIS Analytical Services, Inc. of total arsenic (locations ML-1 through ML-36). Concentrations ranged from 1.7 mg/kg to 36 mg/kg, dry weight, with an average concentration of about 12 mg/kg.

In May 2002, twenty-one (21) sediment samples were collected by Inland Marine Construction, Inc. from locations unknown, but appearing to be from the west basin of Maple Lake (locations ML-1 through ML-24), based on notations in the file. Total arsenic concentrations were analyzed by EIS Analytical Services, Inc. and were found to range between <5 mg/kg to 48.2 mg/kg, dry weight. The average concentration was about 24.5 mg/kg. In July 2002, five of the locations with the highest concentrations were resampled. The detected concentrations were generally consistent with the previous data.

In February 2006, representatives of the Village of Paw Paw collected ten (10) sediment samples from Briggs Pond and the associated South Branch of the Paw Paw River for analysis of total arsenic by KAR Laboratories, Inc. of Kalamazoo, Michigan. Total arsenic concentrations ranged between 6 and 94 mg/kg arsenic. Three additional samples were collected from Briggs Pond in October/November 2007 for analysis of total arsenic. The arsenic concentrations ranged between 29 and 60 mg/kg.

In summary, limited analytical data are available regarding the sediment quality in Briggs Pond, with more data available for Maple Lake. While additional testing may be warranted in the future, the available data indicate that arsenic is the constituent of concern, leaching from the sediments at concentrations exceeding its current criterion listed under Part 115. Arsenic concentrations are elevated in both Briggs Pond and Maple Lake, with higher concentrations in Briggs Pond. The higher concentrations in Briggs Pond may reflect the finer sediments present upgradient of the dam.

2.2 Sediment Characterization Requirements

According to rules promulgated under the Solid Waste Management Act, Part 115 of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (Solid Waste Management Act) dredge material may require testing to determine appropriate placement. The paragraphs below briefly outline these testing requirements and a Dredge Testing Flow Chart prepared by the MDEQ is included in Appendix B.

Testing is not required if the dredged material can be buried on the site of generation, not in a wetland or floodplain, and at least four feet above the water table, but may require clean cover and deed restriction.

Testing of the sediments is required if the sediments are planned to be placed off site, in an upland area outside of a Type II landfill, to determine if the material is a solid waste. If the sediments are graded and are more than 95% sand, no additional testing is required. In this event the material is considered inert, not a solid waste, and can be hauled for general reuse. If the sediments are less than 95% sand (more than 5% fines), the sediments require additional testing.

If the sediments exhibit more than 5% fines, a minimum of six discrete samples are required for analysis of a list of twelve (12) metals, PNAs and PCBs. Analysis of concentrations of constituents in a Toxicity Characteristics Leaching Procedure (TCLP) or SPLP leachate generated using the sediments is required for any constituent with a concentration exceeding 20 times Background concentrations for metals or 20 times it's Type B Criterion. The presence of any constituent exceeding the Part 115 "Type B" Criterion in the leachate causes the material to be classified as a solid waste. If these concentrations are not exceeded, the material is classified as inert and does not require special consideration for use.

A notation in the file materials indicates that in or before August 2003 graduation testing was completed on the sediment of Briggs Pond. More than 5% of fines were present, requiring further testing. In May, 2004, AR Blystra Ltd. conducted gradation analysis of four sediment samples collected from sedimentation basins. None of the four samples had more than 0.2% fines, indicating that the sediments in the sedimentation basins are less than 5% fines and do not require any further testing. These notations and testing data are included in Appendix A.

Six sediment samples have been collected from Maple Lake for the required analyses, with the exception that manganese has not been tested for, in 1998 as described above. The SPLP analyses of eleven (11) metals indicated that arsenic exceeded its 1 ug/L concentration necessary to designate the material as inert. Also, the detection limit for lead in the SPLP analysis was too high to allow comparison to its criterion; therefore, lead may also exceed its criterion. Analyses of sediments in Briggs Pond have been limited to the four samples collected in 1997 for analysis of the eleven metals, VOCs, pesticides, PNAs and PCBs, and the thirteen samples collected in 2006 and 2007 for analysis of total arsenic. No leachate analyses are available for sediment samples collected from Briggs Pond.

In summary, the sediments in Briggs Pond and Maple Lake, but maybe not those in the sedimentation basins, require testing to determine if the sediments are classified as a solid waste prior to dredging. Leachate analyses of sediment samples collected from Maple Lake indicate that arsenic concentrations exceed criteria, and the sediments are classified as a solid waste. Although leachate testing has not been conducted on sediment samples from Briggs Pond, based on comparison of the total concentrations and leachate testing conducted on sediment samples from Maple Lake, it is reasonable to expect, for the purposes of this assessment, that arsenic concentrations in the sediments from Briggs Pond would not meet the current criterion for designation of the sediments as inert. Therefore, they also would be considered a solid waste.

2.3 Options for Placement/Disposal of Dredged Sediments

As described above, an option for placement of sediments, according to rules promulgated under the Solid Waste Management Act, is to place them on the site of generation. In this instance, no testing is required, although it may be required to place clean cover over the sediments and a deed restriction on the property, in the form of a Restrictive Covenant, to protect against potential direct contact concerns.

If the sediments are not intended to be deposited on site as described above, testing is required to determine if the material is a solid waste. If the testing shows that the material is inert, it is not a solid waste and does not require special consideration for use. As described above, the sediments in Maple Lake and Briggs Pond appear likely to be a solid waste based on available data, and the current criterion for arsenic (which may be changed to a higher allowable concentration in the future to be consistent with federal standards).

Lastly, materials may be designated as inert by the director of the MDEQ based on a petition made in accordance with a rule of promulgated under the Solid Waste Management Act. In the case of dredged sediments, the petition is likely to be prepared in accordance with Rule 116 of the Act, which provides criteria for designating a material as appropriate for reuse at a specific location. The petition must show that the material does not pose a threat to groundwater or otherwise pose an unacceptable risk. The material does not pose a threat to groundwater if the concentration of each constituent is either: 1.) less than the leachate concentration generated by background soil; or, 2.) less than the method detection limit for the constituent in question: or 3.) less than the concentration that represents an increased cancer risk of 1:1,000,000 if a carcinogen and, if not a carcinogen, less than the concentration that represents the human life cycle safe concentration, less than its secondary maximum contaminant level, if it has one, and less than a concentration that impacts adverse aesthetic characteristics to groundwater. Such a designation may allow for material exceeding direct contact criteria to be placed off site at a specific property with clean cover (to protect against direct contact concerns) and a deed restriction.

If the materials are not designated as inert through any of the options described above, the rules provide little alternative to disposal at an approved licensed facility, such as a licensed Type II landfill. For this Feasibility Analysis, the costs of constructing, permitting, operating and monitoring an approvable licensed facility is considered cost prohibitive and is not discussed further.

3.0 FEASIBILITY ANALYSIS

The alternatives discussed below are options which, individually, or in combination, could result in protection of human health and the environment, comply with applicable or relevant and appropriate requirements, be a permanent solution, and be cost effective.

Phillips Environmental Consulting evaluated potentially applicable options for placement of the dredged sediments that include the following:

- No Action
- Removal of the Briggs Pond Dam, Channelization of Briggs Pond and Bank Stabilization
- Dredging and Placement of Sediments at an Upland Location on an Adjoining Property
- Dredging and Placement of Sediments at an Upland Location not Adjoining the Property with a Restrictive Covenant (sediments exhibiting direct contact concerns only)
- Dredging and Disposal of Sediments at a Type II Landfill
- Dredging and on site (adjoining property) Treatment of Sediments
- Dredging and Off Site Treatment; and
- In Situ Sediment Treatment and Dredging.

In addition, to further assess the feasibility of the last three options that involve sediment treatment, Phillips Environmental Consulting evaluated the following sediment treatment options:

- Solidification/stabilization
- Soil washing/acid extraction
- Soil flushing
- Electrokinetics; and
- Phytoremediation.

Each of these options is briefly described below.

3.1 No Action

Description

With this "no action" option, the sediments would continue to accumulate in Briggs Pond and flow into Maple Lake, making the lake unusable for recreational purposes, especially at the southern basin of Maple Lake where a significant amount of sediments have already accumulated. This option is not deemed acceptable to the Village of Paw Paw, Paw Paw Township or to the residents around Maple Lake.

Advantages

Advantages of this option are that the solution quickly prevents exposure to contaminants as the sediments will remain covered by water or vegetation at the waters edge, no remedial system equipment installation is necessary, there are no disturbances to the property, it is a low energy solution, and there are no direct costs.

Disadvantages

The primary disadvantage is the loss of the pond and areas of Maple Lake to sedimentation. This may result in loss of recreational resources, lowered property values, and might be, at least for a period, aesthetically displeasing.

Cost

There are no costs associated with implementation of this option.

Effectiveness

This alternative does nothing to remove sediments from Briggs Pond, or Maple Lake, and does not address potential long term implications of continued sediment deposition.

Feasibility

This option does not feasibly address the accumulated sediments.

Time

This option requires no time for implementation, but will never meet the objectives of the Village.

3.2 Removal of the Briggs Pond Dam, Rechannelization of Briggs Pond and Bank Stabilization

Description

Removal of the dam, rechannelization of the South Branch of the Paw Paw River, along with bank stabilization and the installation and maintenance of a sedimentation basin has the potential to provide a long-term management strategy to dealing with sedimentation, along with a strategy for addressing existing sedimentation in Briggs Pond. A large amount of the sediments in Briggs Pond, the location with the highest concentrations of total arsenic, might be allowed to be left in place with clean cover and deed restrictions to prevent direct contact exposures in the form of a Restrictive Covenant. Removal of the dam would cause water levels in the area of Briggs Pond to be lowered by 8 to 10 feet, drying up most of the area. The South Branch of the Paw Paw River would be rechannelized to form a river bed and the banks of the river would be stabilized to mitigate and/or prevent sedimentation. Wetland areas and a sediment basin(s) within the South Branch of the Paw Paw River would allow for continued sediment removal prior to discharge to Maple Lake.

Advantages

Advantages of this scenario include its potential for lower long-term costs and it will not involve long term dredging of sediments from the Pond, except those in the sedimentation basin(s). By lowering the elevation of the water, upland areas might be created for placement of dredged sediments on site. This may include the sediments dredged to create the channel, those already accumulated in Maple Lake, and for long-term on site placement of sediments dredged from the sedimentation basin(s). Studies show that after the first few years, sediments in the sedimentation basin become sandier, not requiring special considerations for placement. This alternative effectively addresses the transport and potential direct contact with contaminated sediments; and, once constructed, provides minimal disturbance to the site. It has the potential to provide for long term cost savings in safety and environmental compliance, repair, and maintenance of the dam. It is a low energy approach and may complement more aggressive remedial technologies (if necessary). This option may also be amenable to a long-term plan for added recreational uses of the river and adjoining Maple Lake, such as canoeing, kayaking, and fishing access, and the extension of boardwalks and walkways along the river. Although rechannelization of the river and associated bank stabilization may affect some existing biological systems, the change may create new and worthwhile ecological niches for fisheries and wildlife in the area. The project may become an economic stimulus for recreation and development in the area. A dam removal proposal may be amenable to public funding resources.

Disadvantages

Removal of the dam will require careful planning as it will result in significant changes to the natural environment. Care will be necessary to prevent the proliferation of weed species as a result of the dam removal. Loss of open water currently provided by Briggs Pond may be considered a disadvantage to area residents, and may affect local biological systems. The dam removal may require addressing numerous legal and regulatory issues. Wetland areas may be lost, although some may be established. Short-term impacts of dam removal can increase water turbidity and sediment placement downstream if not carefully managed; however, several studies have shown that the increased sediment load caused by the dam removal is a short term affect. Sediments dredged to form a new channel for the South Branch of the Paw Paw River, and those excess sediments existing in Maple Lake, may need to be disposed of at a Type II Landfill. It might also be necessary to dispose of sediments from Briggs Pond, outside of the newly created channel. If the sediments are placed on site, the sediments will need to be covered with clean soil and a deed restriction in the form of a Restrictive Covenant will be necessary to protect against direct contact exposures. A sedimentation basin will be necessary that has appropriate access; this might require the construction of a road through areas with existing soils unsuitable for construction (removal of muck soils and replacement with stabilized material may be necessary). This alternative relies upon the reduction of sedimentation into the South Branch of the Paw Paw River along all of its upstream reaches to best allow it to be a viable long-term solution.

Cost

The cost for dam removal is likely insignificant to the cost of dredging, sediment disposal (if necessary), rechannelization of the river, stabilization of the banks, and replacement and/or enhancement of access areas to the River. The estimated range of costs for implementing this option is $300,000 to $1,500,000, with the costs largely dependent upon the final design and associated plans for sediment dredging and placement. For example, if most or all of the sediments can remain on site, and sediments from Maple Lake are dredged and placed on the created upland areas on site, the costs will be significantly lower.

Effectiveness

This plan has the ability to be effective, but it will require careful planning and design. The effectiveness of this option will be dependent upon the creation of a sedimentation basin with adequate maintenance to effectively limit the continued deposition of sediments into Maple Lake.

Feasibility

This scenario is feasible but requires adequate planning and public support.

Time

It is expected that this plan will require several years to plan and implement, especially if funding requests are to be made to help fund the project. Implementation of the project itself is likely to require only one to two months, unless the project is purposefully planned to be completed in phases. Thereafter, maintenance of the sedimentation basins will be necessary fairly frequently until a new equilibrium is reached and the sedimentation process stabilized. At that time, if the sediments are being placed on site, the clean cover is placed and vegetated in accordance with the recorded deed restrictions.

3.3 Dredging and Placement of Sediments at an Upland Location on an Adjoining Property

Description

According to rules promulgated under the Solid Waste Management Act, Part 115 of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (Solid Waste Management Act), a dredged material can be placed on the site of generation, not in a wetland or floodplain, and at least four feet above the water table, with clean cover and a Restrictive Covenant. On the site of generation means property that is adjacent and contiguous to the lake or stream where the material is dredged and is under the same ownership. In this event, no testing is necessary.

Advantages

Advantages of this scenario are that this is a low-energy, cost effective approach that minimizes the transport of the sediments and protects against potential direct contact and drinking water concerns. It can complement more aggressive remedial technologies. The areas of sediment placement can be converted to park areas, sledding hills, etc. for public use and benefit. This option might be combined with rechannelization of the river, which will likely create upland areas for the placement of sediments in Maple Lake and future sediments recovered from a sedimentation basin.

Disadvantages

This approach is limited to the availability of upland areas owned by the Village of Paw Paw that are adjacent and contiguous to the areas to be dredged. Those areas only have the potential for placement of only so much material before the slopes become problematic. Purchase of land to accomplish this method of sediment placement may be prohibitively expensive. This option does not involve the destruction of contaminants, just its physical removal to a new location. Lastly, this alternative relies upon the reduction of sedimentation into the South Branch of the Paw Paw River along its upstream reaches to best allow it to be a viable long-term solution.

Cost

The estimated range of costs for dredging and disposal of sediments on an adjoining property is expected to range between $10 and $20 per cubic yard.

Effectiveness

This option adequately allows for the dredging and placement of sediments in manner that results in protection of human health and the environment, complies with applicable or relevant and appropriate requirements, be a permanent solution, and be cost effective.

Feasibility

This option is only feasible if land is available that meets the requirements of being at an upland location adjoining the water body where the sediments are dredged.

Time

This option can be implemented at any time that the appropriate land is available.

3.4 Dredging and Placement of Sediments at an Upland Location not Adjoining the Property with a Restrictive Covenant (sediments exhibiting direct contact concerns only)

Description

This option would involve the preparation of a petition to the director of the MDEQ to designate the sediments to be dredged as inert for use at a specific property in accordance with Rule 116, as described above. The rule requires that the material not exceed current groundwater protection criteria, but would allow the placement of materials exceeding direct contact criteria at a property not contiguous with the river, with clean cover and a restrictive covenant.

Advantages

Upon a rule change that amends the current arsenic drinking water protection criterion referenced in Part 115 of Michigan's Solid Waste Management Act, this option may allow for quick removal of large areas of sediments, especially those in all or portions of Maple Lake. Assuming the availability of suitable land and a source of clean cover soil, this option is a lower cost and lower energy option than disposal of the sediments at a type II landfill. This option offers more flexibility in the location as the Property does not need to be adjoining the area where the sediments are dredged, although the MDEQ prefers that it is located within the same watershed. Upon placement of the sediments and recording of the Restrictive Covenant, the property can be used for recreational purposes, or developed for a use that continues to protect against direct contact hazards in accordance with the restrictions outlined in the Restrictive Covenant.

Disadvantages

The biggest disadvantage to this option is that it excludes sediments exceeding Part 115 drinking water protection criteria, which, based on the present criterion for arsenic, currently excludes almost all of the sediments to be dredged. If the criterion is changed, additional testing is required for further evaluation of the feasibility of this option. A petition is required to be submitted to the MDEQ for approval prior to dredging and transport of the sediments. Other disadvantages to this scenario is that it has high energy costs, involves a significant disruption to site activities, and it does not involve the destruction of contaminant, just its physical removal to a new location, with the potential for direct contact concerns during dredging, transportation, filling and covering of the soils. As with all of these options, this alternative relies upon the reduction of sedimentation into the South Branch of the Paw Paw River along its upstream reaches to best allow it to be a viable long-term solution. Lastly, the property use will always be restricted unless the soil is remediated to below the required cleanup criteria.

Cost

The estimated range of costs for dredging and disposal of sediments on a property owned within the watershed, but not adjoining the river is expected to range between $15 and $25 per cubic yard.

Effectiveness

This option adequately allows for the dredging and placement of sediments in a manner that results in protection of human health and the environment, complies with applicable or relevant and appropriate requirements, is a permanent solution, and is cost effective.

Feasibility

Under the present rules, this is not likely a feasible option as arsenic concentrations in an SPLP leachate exceed its Part 115 drinking water protection criterion of 1 ug/L. However, if the rules change to allow an arsenic criterion consistent with the US EPA Maximum Contaminant Level of 10 ug/L, at least some of the sediments, especially those from Maple Lake, may be amenable to this option. Available SPLP data from sediment samples collected from Maple Lake exceeded the current arsenic criterion, but did not exceed the arsenic US EPA Maximum Contaminant Level of 10 ug/L. The highest detected concentration was 6.6 ug/L. Additional sampling is likely to be required for further evaluation, especially of the sediments in Briggs Pond.

Time

This option can be implemented at any time that the appropriate land is available. Additional time may be necessary to prepare and record the restrictive covenant with MDEQ approval, and place the required soil cover over the sediments.

3.5 Dredging and Disposal of Sediments at a Type II Landfill

Description

Sediments dredged from the Pond, and perhaps Maple Lake in the future, can be transported to a Type II landfill upon approval for disposal. This option may be accompanied by the use of a bag made of a geomembrane (a Geobag® or Geotube®) to dewater the sediments prior to transfer to a landfill, if approved by the MDEQ. The sediments may be placed in a bag at an upland location adjoining the area dredged, the water would drain back to the water way. The sediments would be removed from the bag and transported to a Type II Landfill for disposal.

Advantages

Advantages of this scenario include limited testing requirements and ease of arrangements compared to Option 3.4 above, and other options listed below. This alternative is clearly authorized by the MDEQ, although a special authorization may be required to use the Geobags®. The site of sediment placement will not likely remain a long-term management issue for the Village of Paw Paw, as it will under alternatives requiring a Restrictive Covenant.

Disadvantages

Disadvantages to this scenario is that it has high energy costs, is expensive, involves a significant disruption to site activities, and it does not involve the destruction of most contaminants, just its physical removal to a new location, with the potential for direct contact concerns during dredging, transportation, and disposal. Additional testing may be required by the MDEQ to use the Geobags®. As with all of these options, this alternative relies upon the reduction or elimination of sedimentation into the South Branch of the Paw Paw River along its upstream reaches to best allow it to be a viable long-term solution.

Cost

The estimated range of costs for dredging and disposal of sediments at a Type II landfill is expected to range between $28 and $38 per cubic yard. The cost for two Geobags®, capable of dewatering 5000 cubic yards, is about $20,000. Bench testing can be completed to determine if the sediments can be dewatered enough to affect a cost savings.

Effectiveness

This option adequately allows for the dredging and placement of sediments in a manner that results in protection of human health and the environment, complies with applicable or relevant and appropriate requirements, and is a permanent solution.

Feasibility

This scenario is feasible due to the ease of implementation and approval.

Time

This option can be implemented at any time that approval from the landfill is received. Landfill approval may require an application, the provision of analytical data, and perhaps new testing necessary to adequately characterize the material.

3.6 Dredging and On Site (adjoining property) Treatment of Sediments

Although not clearly spelled out in the Solid Waste Management Act, it appears that a limited amount of sediments exceeding Part 115 Drinking Water Protection Criteria can be placed at an upland location on site (in accordance with Rule 144 of the Act) and treated. Upon achieving reduction in arsenic concentrations to less than the Drinking Water Protection Criteria, the sediments would require clean cover and a Restrictive Covenant would be placed on the property if concentrations of any constituents remain above direct contact criteria. Relocation of the treated sediments would require a petition to the director to designate the material appropriate for general reuse in accord with Rule 115 of the Solid Waste Management Act or for use at a specific property in accord with Rule 116, if direct contact criteria are exceeded (requiring clean cover and a deed restriction).

As described in section 3.3, placement of sediments at an on site location does not require testing and the sediments can stay at that location with clean cover and a Restrictive Covenant, making treatment unnecessary. However, this option helps to address the issue of limited land space. If the sediments are treated and then transported off site, the location may be used for treatment of the next set of dredged materials.

This scenario assumes that arsenic would require treatment to meet Part 115 Drinking Water Protection Criterion for arsenic. Methods that are potentially feasible for treatment of arsenic in sediments are evaluated as a subset of this feasibility analysis in section 3.9 below.

<u>Advantages</u>

This alternative provides for a longer term solution to the placement of sediments in the event that land owned by the Village of Paw Paw contiguous with the area to be dredged is limited and insufficient in size. The only testing required is characterization prior to excavation of the sediments for transport off site for general reuse following treatment, and testing necessary to ensure the appropriate design and operational efficiency of the treatment technology. It may be less expensive than dredging and transport of sediments to a landfill, assuming that the treatment costs are minimal, that treatment is effective, and the availability of the land. Depending on the type and effectiveness of the treatment option chosen, this alternative may allow for the destruction and/or reduction in contaminants, not just transport from one place to another. This alternative has the potential to prepare the sediment for general reuse and has the capacity to reduce long-term hazards.

<u>Disadvantages</u>

Disadvantages of this option are the availability of land owned by the Village of Paw Paw that is contiguous with the areas to be dredged, the unknown effectiveness of the treatment technology, its lack of use within the State of Michigan, and the need for MDEQ approval for relocation of the materials after treatment (if desired). Treatment of arsenic to the current standard may be difficult, if not impossible. Available treatment technologies may not be amenable to site and sediment characteristics. This may be a high energy option as the sediments require treatment and moving both before and after treatment. As with all of these options, this alternative relies upon the reduction of sedimentation into the South Branch of the Paw Paw River along its upstream reaches to best allow it to be a viable long-term solution.

Cost

This option is more expensive than option 3.3, Dredging and Placement of Sediments at an Upland Location on an Adjoining Property, through the addition of treatment costs, testing, MDEQ approval to transport the sediments off site after treatment for general reuse, and the cost of excavation and transport. However, if the land is available and the treatment costs are low, this may be more cost effective than option 3.5, Dredging and Disposal of Sediments at a Type II Landfill. The estimated cost to treat the soil is dependent upon the treatment technology, and those costs are described in section 3.9 below.

Effectiveness

The effectiveness of this alternative is dependent upon the treatment technology employed.

Feasibility

This option is only feasible if land is available that meets the requirements of being at an upland location adjoining the water body where the sediments are dredged and the employed treatment technology is feasible.

Time

The estimated time required to implement this alternative is dependent upon the treatment technology employed, and those timelines are described in section 3.9 below.

3.7 Dredging and Off Site Treatment

Discussions with Mr. Duane Roskosky of the MDEQ Waste and Hazardous Materials Division (WHMD) indicate that this alternative is not readily feasible for sediments that exceed Part 115 Drinking Water Protection Criteria. Any sediment exhibiting concentrations of a constituent exceeding its (Part 115) Drinking Water Protection criterion is considered a solid waste and must be transported to an approved solid waste facility. However, this alternative might be used if sediments only exceed Direct Contact criteria. In this case, the soils might be treated off site for general reuse to allow the Restrictive Covenant to be removed from the deed for the Property at a later date. Alternatively, following treatment, the soil may be designated by the MDEQ as inert, and allowed to be transported off site for general reuse.

Methods that are potential feasible for treatment of arsenic in sediments are evaluated as a subset of this feasibility analysis in section 3.9 below.

Advantages

This alternative provides for a longer term solution to the placement of sediments in the event that a suitable upland area contiguous to the dredging is limited. If allowed by the MDEQ, this alternative may be less expensive than dredging and transport of sediments to a landfill, assuming that the treatment costs are minimal, that treatment is effective, and the availability of the land. This alternative, if effective and allowed, allows for the destruction and/or reduction in contaminants, not just transport from one place to another. This alternative prepares the sediment for general reuse and has the capacity to reduce long-term hazards. The Property is not encumbered by a deed restriction that limits its long-term use.

Disadvantages

The main disadvantage of this option is that under current rules, the MDEQ will not allow transport of sediments impacted above current Part 115 Drinking Water Protection standards to an unlicensed facility. Other disadvantages of this option are the unknown effectiveness of the treatment technology, its lack of use within the State of Michigan, and the need for MDEQ approval for removal of the deed restriction and/or general reuse of the materials after treatment. Treatment of arsenic to the current standard may be difficult, if not impossible. Available treatment technologies may not be amenable to site and sediment characteristics. As with all of these options, this alternative relies upon the reduction of sedimentation into the South Branch of the Paw Paw River along its upstream reaches to best allow it to be a viable long-term solution.

Cost

If allowed, this option is more expensive than option 3.3, Dredging and Placement of Sediments at an Upland Location on an Adjoining Property, through the addition of treatment costs, testing, MDEQ approval to transport the sediments off site after treatment for general reuse, and the cost of excavation and transport. However, if the land is available and the treatment costs are low, this may be more cost effective than option 3.5, Dredging and Disposal of Sediments at a Type II Landfill. The estimated cost to treat the soil is dependent upon the treatment technology, and those costs are described in section 3.9 below.

Effectiveness

The effectiveness of this alternative is dependent upon the treatment technology employed.

Feasibility

Under the present rules, this is not likely a feasible option as arsenic concentrations in an SPLP leachate exceed its Part 115 drinking water protection criterion of 1 ug/L. However, if the rules change to allow an arsenic criterion consistent with the US EPA Maximum Contaminant Level of 10 ug/L, at least some of the sediments, especially those from Maple Lake, may be amenable to this option. Available SPLP data from sediment samples collected from Maple Lake exceeded the current arsenic criterion, but did not exceed the arsenic US EPA Maximum Contaminant Level of 10 ug/L. The highest detected concentration was 6.6 ug/L. Additional sampling is likely to be required for further evaluation, especially of the sediments in Briggs Pond.

Time

The estimated time required to implement this alternative is dependent upon the treatment technology employed, and those timelines are described in section 3.9 below.

3.8 In Situ Sediment Treatment and Dredging

It may be possible to treat sediments in place. Upon achieving reduction in arsenic concentrations to less than the Drinking Water Protection Criteria, the sediments might be moved for general reuse. The movement of the sediments off of the site would require a permit to dredge and might require a petition to the director to designate the material appropriate for general reuse in accord with Rule 115 of the Solid Waste Management Act if the material was considered solid waste. This scenario assumes that arsenic would require treatment to meet Part 115 Drinking Water Protection Criteria. Methods that are potentially feasible for treatment of arsenic in sediments are evaluated as a subset of this feasibility analysis in section 3.9 below.

Advantages

If feasible, this alternative provides for a longer term solution to the placement of sediments. Because the sediments would not be moved prior to treatment, the only testing required is characterization prior to excavation of the sediments for transport off site for general reuse. However, testing will also likely be necessary to ensure the appropriate design and operational efficiency of the treatment technology. It may be less expensive than dredging and transport of sediments to a landfill, assuming that the treatment costs are minimal, that treatment is effective. This alternative, if effective, is a low energy alternative and allows for the destruction and/or reduction in contaminants, not just transport from one place to another. This alternative has the potential to prepare the sediment for general reuse and has the capacity to reduce long-term hazards.

Disadvantages

Disadvantages of this option are the unknown effectiveness of the treatment technology, its lack of use within the State of Michigan, and the need for a permit to dredge the sediments and the potential need for MDEQ approval for general reuse of the materials after treatment. Treatment of arsenic to the current standard may be difficult, if not impossible. Available treatment technologies may not be amenable to site and sediment characteristics. As with all of these options, this alternative relies upon the reduction of sedimentation into the South Branch of the Paw Paw River along its upstream reaches to best allow it to be a viable long-term solution.

Cost

This option is more expensive than option 3.3, Dredging and Placement of Sediments at an Upland Location on an Adjoining Property, through the addition of treatment costs, testing, MDEQ approval to transport the sediments off site after treatment, and the cost of transport of the dredged sediments to an off site location. However, if treatment is effective and costs are low, this may be more cost effective than option 3.5, Dredging and Disposal of Sediments at a Type II Landfill. The estimated cost to treat the soil is dependent upon the treatment technology, and those costs are described in section 3.9 below.

Effectiveness

The effectiveness of this alternative is dependent upon the treatment technology employed.

Feasibility

This option is only feasible if the employed treatment technology is feasible.

Time

The estimated time required to implement this alternative is dependent upon the treatment technology employed, and those timelines are described in section 3.9 below.

3.9 Sediment Treatment Options

Five methods of treating arsenic impacted sediments are generally cited in the literature as potentially feasible technologies. These are as follows:

- Solidification/stabilization
- Soil washing/acid extraction
- Soil flushing
- Electrokinetics; and
- Phytoremediation.

Each of these is briefly described below along with the potential application to the placement alternatives described in sections 3.6, 3.7 and 3.8 above.

3.91 Solidification and Stabilization

Solidification and stabilization (S/S) is a remediation option that reduces the mobility of metal contamination in soil. The process uses binders or reagents like cement, lime, phosphate, sulfur, or fly ash to solidify and immobilize the metal contaminant. According to a US EPA publication, Arsenic Treatment Technologies for Soil, Waste and Water (US EPA, 2002), S/S can likely produce a stabilized product that meets the regulatory threshold of 5 mg/L leachable arsenic as measured by the Toxicity Characteristics Leaching Procedure (TCLP). A test using the SPLP procedure may produce even better results, perhaps meeting the applicable Part 115 criterion of 1 ug/L. Two instances of in situ treatment of soils by injecting solutions have been reported, but no instances of using in situ S/S for sediments, or similar treatments in Michigan have been identified. Generally this treatment is used to render potentially hazardous waste as non-hazardous for disposal at a Type II landfill.

The advantage is that when properly treated the metal, arsenic, is no longer mobile and potentially harmful. The disadvantage is that the arsenic is not generally removed, but rather immobilized. Changes in conditions, such as degradation of the binder or reagent, may cause the arsenic to remobilize, requiring long-term monitoring of conditions. The option requires adequate mixing to distribute the binder or reagent, and fine particles can be problematic as they are difficult to mix.

Treatment costs are reported to range between $60 and $290 per ton. This technology appears cost prohibitive for the purposes of this project, but the technology has the potential to complement other options.

3.92 Soil Washing/Acid Extraction

Soil washing begins with physical separation based on the soil particle size followed by washing with cyclone or gravity separation for further separation. Contaminants generally bind to the smaller particles. Therefore, after separating the smaller particles (clay and silt) from the larger particles (sand and gravel) the larger particles are generally considered clean; reducing the volume of waste. Chemical additives, such as surfactants or acids, can be added to the wash to help remove the contaminant. The resulting wash water and concentrated sludge of smaller particle sized materials require additional treatment and/or proper disposal.

The advantage of this technology is that it can reduce the volume of material requiring treatment, especially when materials are characterized as a hazardous waste. A potential concern is that use of this technology on material that is not classified as hazardous waste poses the potential to create a waste that becomes classified as hazardous; thereby increasing treatment and disposal costs, albeit a reduced volume. This technology is generally limited to soils with a range of particle sizes with the contaminants preferentially adsorbed to the fine particles. In this instance the range of particle sizes is expected to be greater in Maple Lake than Briggs Pond, where a larger percentage of fines are present. If the soil is homogeneous with a high number of fines, there may not be a significant change of the volume of sediments requiring treatment/disposal.

Reports of this technology indicate that costs range between $30 to $400 per ton. This technology also appears cost prohibitive, but the technology may complement other options.

3.93 Soil Flushing

Soil flushing is a remediation technique that uses water or a mixture of water with additives to designed to mobilize and flush the contaminants from the soil. This is an in situ treatment technology where the water mixture would be injected or sprayed in the contaminated area which would dissolve or emulsify the contaminants. The water mixture would then be extracted using downgradient wells or trenches and collected for treatment. The treated groundwater can then be reinjected or otherwise properly discharged. This is a treatment technology generally used at sites with high concentrations of arsenic.

Advantages are that the equipment is relatively easy to construct and operate, and the operation does not require disposal of the sediments. Disadvantages include the potential need for disposal of the process sludge or residual solids from the water treatment system, and the process may cause contaminants to mobilize and spread to uncontaminated areas.

Specific costs data for this technology could not be found in the literature, but it is reasonable to expect that the costs to set up and monitor the system is greater that the costs to excavate the sediments for disposal at a Type II Landfill as described in section 3.5.

3.94 Electrokinetics

Metals in soil have been remediated using electrokinetics; a technique that applies a low intensity electrical current between electrodes (a cathode and an anode) placed in the soil. It is an in situ treatment technology that can also be used with excavated soil. The charged metal species are transported to the electrodes where they are removed and treated above ground. There is limited performance data for this technology, with most of the experience occurring in European nations. This process is mainly applicable to small particle sized, low-permeability soils in groundwater with a low flow rate.

This is another technology with relatively few reports of its use for arsenic treatment, though one study reported the reduction of arsenic concentrations in soil from 250 mg/kg to less than 30 mg/kg. No specific uses of the treatment of impacted sediments were found. The advantage is that it can be completed in place without the need to take the excavated sediments off site for treatment. The soil moisture and soil characteristics at the site might be appropriate, but the flow of surface water may be too fast to allow recovery of the arsenic in the area of the electrodes.

Estimated costs for the in situ treatment of arsenic using this technology range from $50 to $270 per cubic yard of impacted soil. This technology appears cost prohibitive for the purposes of this project.

3.95 Phytoremediation

Phytoremediation is the process by which plants remediate the environment by contaminant removal, degradation, or stabilization. Phytoremediation can be successful in soil, groundwater, and waste and can be accomplished in situ or ex situ depending upon the location of the contamination and the plant chosen for the remediation. There are four main ways in which plants remediate contamination. These are: phytoextraction, phytostabilization, phyto-degradation, and rhizofiltration. Phytoextraction involves the uptake of contaminants in the plant roots and accumulation in the plant shoots and leaves. Phytostabilization involves the production of chemical compounds to immobilize contaminants in the soil. Phytodegradation involves the metabolism of the contaminant by the plant, and rhizofiltration involves degradation of the contaminant that takes place around the root.

Several types of plants have been identified that treat arsenic. These include poplar and cottonwood trees, sunflower, Indian mustard, corn and several types of grasses and ferns.

Advantages of phytoremedation include lower initial setup costs and even lower costs provided the area is suitable for in situ remediation. There are lower operating costs with its low energy requirements due to the majority of the energy coming from the sun, in the form of solar energy. Phytoremedation is an aesthetically pleasing option and therefore public support is generally high.

This technology is generally limited to shallow contamination that can be reached by plant roots and sites with low to medium levels of contamination are best suited. High levels of contaminants may become toxic to the plants. This option is also not a good choice if there is a short time frame due to the generally slow uptake of the contaminants and the shorter growing seasons in Michigan. Although phytoremediation is an aesthetically pleasing option the resulting contaminated plants could be harmful to wildlife and therefore must be monitored. Lastly, plant materials with accumulated contaminant concentrations may need to be harvested and properly disposed.

This treatment technology has the potential to be both feasible and more cost effective than disposal at a Type II landfill, especially if conducted in situ. As described in the options above, while amenable to treatment of soils excavated and placed at an off site upland location, approval from the MDEQ to treat soils exceeding Part 115 Drinking Water Protection criteria off site may not be cost effectively achievable.

3.96 Summary of Treatment Options

Based on this review of the primary options for treatment of arsenic in sediments, the most feasible and cost effective option is phytoremediation. This technology has the potential to be used both in situ and with excavated sediments placed in a shallow layer on the ground surface. Several plants have been identified that have the potential to accumulate arsenic from the sediments that are suitable to Michigan's growing season. The sediments may require amendment with nutrients and fertilizers to enhance and enable sufficient plant growth, similar to general agronomic practices and the resultant plants will likely require disposal at a licensed landfill. Lastly, potential wildlife impacts require consideration.

3.10 Feasibility Analysis Summary

The remediation alternatives were compared using five objectives: (1) cost of the remediation alternative, (2) ability of the treatment to reduce the volume, toxicity and mobility of the contaminant, (3) the effectiveness or ease at which the treatment alternative will obtain an acceptable cleanup criteria, (4) the feasibility or constructability of the remediation alternative given a specific site, and (5) the time associated with construction, remediation, and closure of each treatment alternative.

The following table compares the alternatives based on the five stated objectives. Each alternative was given a ranking of 1 (best for that objective) through 5 (worst). Therefore, the alternative with the lowest total is proposed as the best remedial alternative.

Treatment Methods Ranking System

METHODS(s)	No Action	Removal of Dam and Stream Channelization	Dredging and Placement on Site	Dredging and Placement Off Site	Dredging and Disposal at Type II Landfill	Dredging and On site Treatment	Dredging and Off Site Treatment	In Situ Treatment
Cost	1	2-5	2	3	5	4	5	3
Reduction of Volume, Toxicity and Mobility	5	4	5	5	5	2	2	2
Effectiveness	5	2	2	2	2	2	2	2
Feasibility	5	2	2-5	5	1	5	5	5
Time	5	3	2	3	1	5	5	5
TOTALS	**21**	**14-16**	**13-16**	**18**	**15**	**18**	**19**	**17**

This summary indicates that the driving objectives for selection of an alternative are feasibility and cost. Dredging and disposal at a Type II landfill is indicated to be a preferable option based on its feasibility, despite its cost. Should land adjoining the area to be dredged be readily available, its feasibility ranking is reduced and it becomes the most preferable option. Should the MDEQ Part 115 rules be changed to establish a higher arsenic concentration protective of groundwater, off site placement of the sediments may become feasible, at least for sediments from some locations. Based on its potential to reduce costs in the long-term and reduce the mobility of the sediments, removal of the dam and channelization of the river might be given serious consideration. It especially becomes a preferred option if funding assistance is found to reduce the cost to the Village.

Upon review of these options, potential funding assistance options, availability of land adjoining the river, and perhaps additional testing, a variety of these options may be selected in order to address both short-term and long term considerations.

4.0 REMARKS

The activities and recommendations contained within this report represent the professional opinions of Phillips Environmental Consulting Services, Inc. These opinions are based on information currently available and are developed in accordance with currently accepted environmental consulting practices. Other than this, no warranty is implied or intended.