Date: November 23, 2018
To: Debbie Moore & Brian Smith
From: Harry Gibbons
Subject: Prioritizing of Potential Management Activities for Lake Beneficial Use Sustainability

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For many years LLCC has proactively managed their lakes, Limerick and Leprechaun, to maintain and enhance their beneficial uses for members and ecological and water quality conditions within the lakes and downstream. This is reflected by LLCC's on-going management of rooted aquatic plants, sediment removal, and water quality monitoring and awareness. Given the lakes are reservoirs and hence do not have the resiliency of natural lakes (due to relatively large watershed influence and shallow morphology of the lakes), there is significant retention of sediment and nutrients within the lake. The capture of sediment and nutrients decreases the water column depth and volume and increases the sediment depth. The net impact is an increase in plant and algae production and restriction in fish migration and boat access, as well as, deterioration in lake water quality. Hence, the question: What should LLCC be planning for future management actions to sustain the relative good lake water quality, balanced aquatic ecosystem and direct beneficial uses of the lakes?

One external factor that is degrading the lakes' overall quality is excess sediment and nutrient loading from the watershed. What can be done to counter this on-going stress? Specifically there are three areas of potential concern that will need to be addressed to achieve the goal of sustainable lakes enjoyment. These are the continued excess loading of sediment and nutrients from Cranberry Creek, the continued and past loading of sediment and nutrients to Lake Leprechaun, and the sediment deposition resulting is increased plant and algal production within the bird sanctuary. The alternatives to be considered for lake sustainability are:

- Controlling sediment and nutrient inflow from Cranberry Creek
  - Alternatives include:
    - Extensive watershed management,
    - Dredging ever 2 to 5 years,
    - Interception of sediment and potential nutrients via a sedimentation pond targeting Cranberry Creek high flow events.
- Sediment removal from portions of Lake Leprechaun
  - Alternatives include:
    - Hydraulic dredging,
    - Lake draw-down for mechanical sediment removal.
- Bird Sanctuary sediment removal and/or nutrient inactivation
  - Alternatives include:
    - Hydraulic dredging without nutrient inactivation,
    - Hydraulic dredging followed by nutrient inactivation,
    - Nutrient inactivation,
    - Rotovation followed by nutrient inactivation,
    - Harvesting, followed by hydraulic dredging and nutrient inactivation.



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The above activities are not intended to replace the current aquatic plant management and water quality monitoring efforts, but they would have an added benefit to these efforts.

The following is a brief outline of discussion points to be considered by LLCC for future management actions to sustain the lakes ecosystem and recreational uses.

## Cranberry Creek Sediment and Nutrient Loading Control

Observations of the sediment inflow and deposition into Lake Limerick since the recent dredging have indicated that sediment loading from the Cranberry Creek is continuing at a high rate and that with the sediment loading there is a biological response within the lake that also indicates that nutrients are also entering the lake resulting in excessive plant and algal production. As presented above there are three basic management alternatives to consider.

The first alternative is extensive watershed management via watershed BMPs (Best Management Practices). Unfortunately, LLCC has limited control or access to upstream watershed areas so this would take extensive and long-term negotiations with outside land owners. Additionally, to effectively prevent the continued watershed loading of sediments and nutrients would be extremely expensive and have only limited potential for realistic control. Therefore, this option is not viable.

The second alternative is dredging every 2 to 5 years depending upon watershed land-use practices that may continue to increase and therefore increase the loading rate and hence the frequency of required dredging to maintain fish passage and lake use within the Cranberry Creek Bay area. The resulting cost of dredging depending upon frequency of dredging events (every 2 to 10 years) could range from $300,000 to $1,800,000. Plus, due to the nutrient inflow from the Creek, a phosphorus inactivation treatment would be required after each dredging; that could cost $25,000 to $50,000 per treatment in order to reduce the filamentous algal growth that is becoming a problem relative to water quality and recreation.

The third alternative is the interception of sediment and potentially nutrients via a sedimentation pond just upstream of the culvert before Cranberry Creek entering Lake Limerick. This pond would only treat high flow events to avoid any adverse impact on stream aquatic life and low flow fish passage. The pond would be located on LLCC land and potentially be a two cell pond that would trap sediment and some associated nutrients. Both sediment and nutrient retention would be enhanced if an alum injection would also be applied to the high flow volumes. This would effectively remove both sediment and phosphorus by increasing the settling rate and chemically capturing the phosphorus increasing sediment removal from 30 to 50% to 75 to 90% and nutrient removal from 30 to 40% to 80 to 95% removal. Capital cost of this alternative would be $150,000 to $350,000 with an annual O & M cost of $8,000 to $20,000, plus an additional $50,000 every 5 to 10 years for sediment removal.

## Sediment Removal from Portions of Lake Leprechaun

The NE portion of Lake Leprechaun has captured a significant amount of sediment from the upstream inflow and construction activities over the years. This has resulted in a significant decrease in lake water depth and volume. The result is an adverse impact on water quality within the lake and



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downstream in Limerick. The sediment has also allowed for the increase in rooted aquatic plant coverage and density as well as reduction in recreational opportunities. As presented above, there are two basic management alternatives to consider.

The first alternative is hydraulic dredging of 2.5 to 4 acres of the NE portion of Lake Leprechaun. Although this is an efficient approach for sediment removal, there are a couple of unknowns that would require some more intensive investigation. The foremost is to what depth should sediment be removed to passively impact the lake and not to damage the lake "seal" that maintains the lake water volume and prevents water loss to the shallow groundwater. Given the lake is part of a stream-wetland system; this could be an important risk to successful dredging. The other consideration is the cost of dredging and sediment disposal. This could range from $300,000 to $700,000.

The second alternative is first to draw the lake down to expose shallow sediments and then remove these sediments via surface mechanical machinery. The removed sediment would not contain the percent of water that would be generated by hydraulic dredging, hence reducing the dredged sediment handling and disposal costs. This removed sediment could then be stored on LLCC land and used for landscaping and other soil matrix needs. In addition, the depth of the sediment removed could be controlled on site by direct visual observation to ensure that a "clay or glacial till" seal is not disturbed. This direct observation of sediment removal would also allow in the field location of sediment removal to increase effectiveness and help with sediment stability post dredging and lake refilling. The relative cost of this alternative is $150,000 to $300,000.

## Bird Sanctuary Sediment Removal and/or Nutrient Inactivation

Lake Limerick's Bird Sanctuary Bay ecological condition reflects the flooding of pre-existing wetlands when the Limerick reservoir was created and the on-going drainage it receives from an upstream wetland system and residential development surrounding the bay. Hence, it is shallow with relatively nutrient rich sediments. Over the last several decades sediment depth has increased both due to sediment input from its drainage area, as well as, organic material build up from rooted emergent and submersed plants. In recent years, this sediment deposition has increased due to increased production of both rooted plants and filamentous algae that is taking advantage of the available nutrients released from the sediment. The sediment internal loading of nutrients is the result of external loading from its immediate drainage area and the decomposition of organic plant matter. Hence, the this portion of the lake is eutrophic (high productive and nutrient rich) and more reflective of a wetland than open water and littoral lake environment. To maintain its historic recreation access and diverse aquatic habitat, steps are needed to reduce sediment build-up and aquatic production. As presented above, there are five basic management alternatives to consider.

The first management alternative is hydraulic dredging of some of the sediments without nutrient inactivation. It has been shown that hydraulic dredging of this type of sediment especially taking into account the bay's on-going external nutrient loading, may only have limited benefit and will have to be repeated fairly often. Also, for the first two to three years after each dredging, re-establishing nutrient balance might result in algal blooms. From both a life-cycle cost and benefit basis, this alternative is not viable relative to short or long-term management goals for the bay and the lake.



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The second management alternative is hydraulic dredging followed by nutrient inactivation. Specifically, this nutrient inactivation would be phosphorus inactivation to limit the availability of phosphorus to enable algal bloom formation. It would also result in increased water clarity; that in itself is a good water quality characteristic, but this may also encourage rooted plant establishment, resulting in increased sedimentation and boat movement interference. Hence, this alternative has some positive aspects relative to the first alternative, but it too may not be cost effective in the long-term.

The third management alternative is nutrient inactivation (again, specifically phosphorus inactivation). Although this alternative would be effective in increasing water clarity and reducing algal blooms if this treatment was conducted annually, it would not truly address the continued loss of water depth due to sedimentation. So, while this alternative would effectively reduce algal and nutrient export to the main lake, it would not address the loss of boating access within the bay over time.

The fourth management alternative is rotovation of the sediments followed by nutrient inactivation (again, specifically phosphorus inactivation). Rotovation is basically rotovating of the sediments like rototilling soil. The problem here is that it would allow both nutrients and sediment migration into the main lake at a greater rate than currently occurring, even with phosphorus inactivation treatments.

The forth management alternative is includes selective plant harvesting or employment of bottom barriers to limit rooted plant coverage, followed by periodic channel maintenance hydraulic dredging to allow boat movement in and out of the bay and a maintenance periodic phosphorus inactivation treatment. This approach would allow for a long-time enhancement of beneficial uses and aquatic, as well as, wetland habitat uses. Hence, this combination of activities would preserve bird and aquatic plant habitat while maintaining local recreational boat passage. It would also slow the nutrient enrichment of the main lake. The cost of this management alternative would be $20,000 to $40,000 every 4 to 8 years.

## Recommendations for Consideration and Priorities

From a long-term sustainable and cost effective benefit perspective the following are recommended for future consideration in order of environmental considerations, user benefit, and implementation; also, accounting for the risk of not proceeding these management activities.

1. The interception of sediment and nutrients via a sedimentation pond(s) just upstream of the culvert before Cranberry Creek entering Lake Limerick. This pond would only treat high flow events to avoid any adverse impact on stream aquatic life and low flow fish passage. The pond(s) would be located on LLCC land and potentially be a two cell pond or two ponds that would trap sediment and some associated nutrients. Both sediment and nutrient retention would be enhanced if an alum injection would also be applied to the high flow volumes. This would effectively remove both sediment and phosphorus by increasing the settling rate and chemically capturing the phosphorus increasing sediment removal from 30 to 50% to 75 to 90% and nutrient removal from 30 to 40% to 80 to 95% removal. Capital cost of this alternative would



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be $150,000 to $350,000 with an annual O & M cost of $8,000 to $20,000 plus an additional $50,000 every 5 to 10 years for sediment removal.

2. The water draw-down of Lake Leprechaun to expose shallow sediments and then remove these sediments via surface mechanical machinery. This removed sediment could be stored on LLCC land and used for landscaping and other soil matrix future needs. In addition, the depth of the sediment removed could be controlled on site by direct visual observation to ensure that a "clay or glacial till" seal is not disturbed. This direct observation of sediment removal would also allow in the field location of sediment removal to increase effectiveness and help with sediment stability post dredging and lake refilling. The relative cost of this alternative is $150,000 to $300,000.
3. Potential management of the bird sanctuary would include selective plant harvesting and/or employment of bottom barriers to limit rooted plant coverage; this would be followed by periodic channel maintenance via hydraulic dredging to allow boat movement in and out of the bay; and a maintenance periodic phosphorus inactivation treatment would be applied to reduce overall bay production and to prevent algal blooms. The cost of this management alternative would be $20,000 to $40,000 every 4 to 8 years.



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