Lake/Dam Committee Motions to the Board, 2April2022

The Lake/Dam Committee meeting minutes for April 2, 2022 have been delayed and will be provided at a later date. To support near term requirements, the Motions to Board from the LDC meeting are being provided for Board Approval. Both motions were unanimously passed by the Committee members in attendance.

Motion 1: Request Board approval of the Park Survey that will be issued to all community members to obtain feedback to guide improvements to LLCC Park amenities. Included are two attachments.

Attachment 1: The Survey
Attachment 2: Justification and Decision Outline

Motion 2: Request Board approval of the recommended weed treatments and locations for Lake Limerick and Lake Leprechaun described in the Draft report from Lake Advocates titled "Technical Status and Monitoring Results memorandum for Lake Limerick 2021", dated February 2022. The areas proposed for weed treatment are identified on pages 16 and 17 of the Draft report; copy attached.

Parks Survey – LLCC

DRAFTED 4/2/2022

Introduction:

This is a formal Lake Limerick HOA Parks Survey. Your answers will be used to inform planning, upgrades, and maintenance of the Lake Limerick parks.

This survey will take about 8 minutes to complete, and it has 3 sections:

1) Park Operations
2) Park Usage and Features
3) Final Comments and Input

To continue and take the survey, please confirm you are a community member by entering either your address or your Division and Lot number. This helps us monitor that the replies we get are from our actual HOA members.

Division number [drop down]

Lot [enter]

Address: [short answer field]

Section 1 Park Operations

How satisfied with the maintenance and cleanliness of the parks?

[***Likert scale**: satisfied, neutral, unsatisfied, no comment]*

[comment box]

How satisfied are you with the accessibility and parking areas of the parks? [scale]

[***Likert scale**: satisfied, neutral, unsatisfied, no comment]*

[comment box]

How satisfied are you with the bathroom facilities [scale]

[***Likert scale**: satisfied, neutral, unsatisfied, no comment]*

[comment box]

How satisfied are you with the hours of operation?

[***Likert scale****: satisfied, neutral, unsatisfied, no comment]*

[comment box]

When it comes to basic operations of parks, is there anything else you'd like us to know?

[comment box]

Section 2: Park Usage and Features

Presently LLCC has seven (7) parks.

Please indicate the parks you frequent the most (check all that apply):

- Anglia Park
- Banbury Park
- Log Toy Park
- Way to Tipperary Park
- Park at the Inn
- Lake Leprechaun Park
- Old Lyme Park

What is it about these locations that keeps you coming back?

[comment box]

What features about LLCC parks do you most value? Please indicate your top 4 features.

[limit four check boxes]

- Swimming & beaches
- Boating access
- Fishing
- Play structures & toys for children
- Nature, wildlife, and wooded areas
- Trails
- Basketball
- Tennis and pickleball
- Fencing or contained spaces
- Paved areas for biking, skating, etc.

- Covered picnic or seating areas
- Other:

When it comes to common areas and parks, what do you wish LLCC had more of? Please indicate your top 4 features.

[limit four check boxes]

- Swimming & beaches
- Boating access
- Fishing
- Play structures & toys for children
- Nature, wildlife, and wooded areas
- Trails
- Basketball
- Tennis and pickleball
- Fencing or contained spaces
- Paved areas for biking, skating, etc.
- Covered picnic or seating areas
- Other:

Section 3: Final Comments

Do you have any concerns about the parks in Lake Limerick community?

[comment box]

Do you have any other requests or recommendations about the parks in Lake Limerick community?

[comment box]

Is there anything else about the parks in the Lake Limerick community that you'd like to share with the committee or Board?

[comment box]

CLOSING message after submission:

Thank you for helping us have great community parks. We appreciate your time and input. If you have questions, please email

This survey was designed by the **Lake-Dam Committee**. See the calendar at LakeLimerick.com to join one of our meetings or learn more about the committee's work.

Statement to the Board: Parks Survey
Lake-Dam Committee

Survey Justification and Decision Outline

Lake Limerick Country Club (LLCC) is fortunate to have seven individual parks for the use and enjoyment of its members. LLCC places importance on maintaining the overall cleanliness, quality and utility of our parks in much the same way we manage all community amenities.

The committee knows it's important that members have an opportunity to provide input on current status of our parks as well as what additional functionality they would like to see added to them.

Purpose:

The parks survey has been prepared by the Lake-Dam Committee as a means of soliciting member inputs on the parks: including status, functionality, and hopes.

Duration:

As drafted, the survey will take about 5-8 minutes to complete and has been collaboratively designed by committee members.

Distribution:

If accepted by the Board, the Lake Dam committee requests this survey to be distributed as a Survey Monkey survey (link for an e-survey). Lake Dam Committee members are willing to create the survey in Survey Monkey with permission or oversight by the office, if required. We do not intend to make additional work for office staff and thus are prepared to fully launch this survey if the board approves the committee to do so. We will utilize the office's account for Survey Monkey.

Guidance from the Committee:

To guard against "question fatigue" we populated the questions with intention and specificity to our needs. As drafted, the survey will take about 5-8 minutes to complete, depending on depth of responses.

This survey will only be useful if members take the time to complete it. Surveys that run longer than what we have proposed are usually not completed by survey takers. We respectfully caution against adding questions or text. We hope that if additional questions for the survey arise, or if the board sees an unmet need, that perhaps a separate survey be created.

How the survey will be used:

Survey responses are data. They will be used to guide future Lake-Dam recommendations to the Board regarding upgrades, expansions, and/or park maintenance. Full and complete data will be made available directly to the board (if requested) and the survey data will live in the LLCC's survey monkey account. The full survey data will also be shared with the Lake Dam Committee members to inform committee priorities.

Summary of our Parks:

Five of these parks are on Lake Limerick and include; 1) Anglia Park 2) Banbury Park, 3) Log Toy Park. 4) Way to Tipperary Park and 5) Park at the Inn. These five parks offer a number of amenities to LLCC members including swimming, fishing, boat launches, picnic areas, children's play areas, a sports court and places to just sit and relax with your friends. We also have a park on Lake Leprechaun and Old Lyme Park in Division 4 which provide similar amenities for adjacent members.

Technical Status and Monitoring Results Memorandum
For
Lake Limerick 2021

FEBRUARY 2022

PREPARED FOR:

Lake Committee

Lake Limerick Country Club

PREPARED BY:

LAKE ADVOCATES

Scientifically Based Lake Restoration, Management & Protection

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Acknowledgements

Thank you to all the Lake Limerick and Leprechaun volunteers who care about the health of their lakes and want to preserve their ecological and recreational uses. Special thanks to Debbie Moore, Tim Reber, Kelly Evans, Brian Smith, Dave Kohler, Roger Milliman, and Larry Duvall for their assistance with this project. Also, LLCC staff continued to provide project assistance, delivering quality service, and working within stringent deadlines outlined in the environmental permit.

1.0 INTRODUCTION

The continued goals for aquatic plant and water quality management in Lakes Limerick and Leprechaun during 2017 through 2021 were to preserve the ecological balance and to maintain good water quality within both lakes, while also improving conditions for recreational and aesthetic beneficial uses. In addition, post-dredging project monitoring of the benthic macroinvertebrate community in Cranberry Cove was completed through 2021 to identify changes in community structure and function post- 2016 dredging.

Aquatic plants are a critical component of lake ecosystems. Submerged aquatic vegetation provides physical habitat for fish and other aquatic life, and influences lake chemistry. As aquatic plants grow, they take up nutrients (such as nitrogen and phosphorus) from lake sediments and from the water column and photosynthesize, producing organic carbon and oxygen. These processes can mitigate the deleterious impacts of high nutrient concentrations (e.g. the occurrence of toxic algae blooms) by lowering overall water column nutrient concentrations. Aquatic plants also benefit fish populations by providing both physical habitat structure for different age classes of fish, but also, for the invertebrates (aquatic insects) that fish feed upon. However, if runoff and/or inflows consistently contribute nutrients to littoral areas, concentrations of nutrients can become elevated, stimulating excessive growth of both aquatic plants and algae. In addition, introduction of non-native invasive plants can accelerate over fertilization of the lake with direct and indirect negative impacts to the aquatic ecosystem. This impedes recreational and aesthetic beneficial uses and impairs aquatic habitat. Comprehensive lake management and monitoring is necessary in order to maintain a balanced aquatic ecosystem.

Based on the information provided by annual plant surveys, proactive lake management practices have been implemented at this site since 2005 and have had good success relative to attaining lake management goals and overall ecological stability of the lakes. Aquatic plant communities in both lakes were previously dominated by Brazilian elodea (*Egeria densa*), but with repeated limited four-year cycles of herbicide treatments, native species such as the pondweed *Potamogeton amplifolius* have reestablished and become dominant. Following the 2014 surveys and treatments, it was recommended that the Lake Limerick Country Club (LLCC) dredge a portion of Lake Leprechaun and a portion of Lake Limerick in order to increase fish access to Cranberry Creek and King Creek while also allowing boating access. In addition, the sediment removal project removed nutrients and reduced aquatic plant densities within these specific target areas.

In-lake treatment of non-native and excessively dense aquatic plant growth was targeted for 2018 and 2019 as identified by the 2017 survey (Figure 2.2-1 and Figure 2.2-2). However, other monitoring requirements outlined in the Environmental Permit issued by Mason County for the Lake Limerick dredging project were completed. Benthic macroinvertebrates were collected in October 2017, September 2019 and October 2021 in order to monitor progress of potential effects of shifting sediment in the dredged area. This material was expected to be shifted from shallow areas during the high flow input in each of the coves and directed to deeper areas away from the shoreline.

A major component of 2016 lake management efforts were dredging of King's Cove and Cranberry Cove in Lake Limerick. Fine sediments had accumulated in both regions, limiting fish habitat and impeding recreational use of these areas. As a result, benthic macroinvertebrate community characterization was completed before dredging, one-year following the project, two years following that collection and another collection completed five years after dredging in 2016. Results of the post-dredging monitoring results are discussed in this report.

2.0 LAKE LIMERICK

2.1 DREDGING

During summer 2016, two shallow coves in Lake Limerick – King's Cove and Cranberry Cove– were dredged to remove sediment that had accumulated on the lake bottom. Over time, the accumulation of fines (silts and decomposed organic material) at the mouths of the creeks that drain into these coves had covered up potential habitable substrate for aquatic life. In addition, the sediment had filled in the lake bottom, reducing the overall depth of water in these coves by 1 to 5 feet– limiting the ability of boats to access these coves and shrinking the area in which it was possible to swim. The primary objectives of the dredging operation were to: a) improve in-lake fisheries habitat and fish access to streams, and b) provide better access to the coves for recreation. Specific goals were to: a) remove a total of 5,000 cubic yards of soft sediment from Kings Cove and Cranberry Cove, b) expose hard sediment to improve habitable areas for benthic communities and fish spawning, and c) improve the thalweg gradient in both coves, allowing remaining soft sediments to be moved during future high flow events and preventing the coves from being clogged for an extended time. Additional photos detailing dredging operations can be found in the 2019 Report (see Section 7.0, Lake Advocates 2019).

On September 11th, 2015, Tetra Tech staff mapped the bathymetry of Lake Limerick using a Lowrance HDS-7 fish-finder/chartplotter with StructureScan HD sonar imaging system and an LSS-2 HD Transom Transducer. This survey confirmed that the northwest corner, by the outlet of Cranberry Creek, was very shallow, as was the small extension of the lake along the north shore (King Cove). In 2016, both the dredging contractor (Marine Industrial Construction) and Tetra Tech independently conducted additional, higher resolution bathymetric surveys of Cranberry Cove and King's Cove before and after dredging. The pre-dredge surveys were used to plan dredging activities and to establish dredging transects and document volume and area of sediment removal.

The dredging was conducted using a barge-mounted hydraulic MudCat® dredge. The MudCat® loosened fine sediments with a cutter head and then suctioned the loose material into a pump intake, effectively removing the material from the lake bottom while also limiting turbidity impacts (MIC 2016). Dredging began at the upstream end of each job site boundary and proceeded downstream. Turbidity impacts were further limited by the installation of a turbidity curtain along the boundary of the dredging area. The pump intake on the MudCat® connected to a floating pipeline, which transported the dredged material to the de-watering site at Log Toy Park. As the dredge material arrived at the de-watering site, a flocculent was injected in order to accelerate the de-watering process (MIC 2016). The flocculent used for the Lake Limerick project was Aquamark®, a readily biodegradable organic polymer. After the flocculent was injected, the dredge material was pumped into geosynthetic de-watering bags. When it was initially collected, the dredge material was approximately 80% water and 20% sediment (MIC 2016). The de-watering bags allowed water to seep from the dredge materials over a period of days so that the sediment gradually dried out and became compressed. After passing through a ground filter cloth and silt fences

positioned to block direct re-entry of water into the lake, the clean water runoff from the geo-bags seeped into the ground (MIC 2016). Once the de-watering process was complete (after 2-3 days), the de-watering bags were split open to reveal the compacted de-watered material (composed primarily of silt), which was loaded into trucks and transported to a gravel mine for use as fill. The de-watered sediment was significantly lighter and more compact than the original wet material.
When the dredging was conducted, the MudCat® cut a channel in the sediment, removing the accumulated material. As the dredging occurred, some additional material sloughed from the banks of the newly cut channel and was suctioned up, adding to the total volume of material being dredged. As the material was removed from the newly cut channel, it exposed hard sediments, improving benthic habitat. Water quality monitoring during dredging ensured that containment structures were functioning properly. Turbidity monitoring during dredging indicated that the design of the dredging equipment and set-up successfully minimized turbidity impacts. Turbidity was monitored during dredging operations above dredging in the tributary, below the dredge (roughly 150 feet and inside the turbidity curtain) for an early warning site, and 300 feet downstream of the work site (outside of the turbidity curtain) (MIC 2016). Turbidity remained low throughout the project and no exceedances occurred (MIC 2016).

Detailed topographic/bathymetric transect profiles were completed within one week upon completion of dredging in each of the coves. In King's cove, the dredging improved the gradient of the thalweg, increasing the water depth by 2 to 2.5 feet along most of the thalweg. Dredging increased the depth of the water throughout the northeastern portion of the cove, especially near the mouth of the inlet.

The gradient of the thalweg was also improved in Cranberry Cove. Water depth increased by approximately 2 feet along the length of the thalweg (Figure 7-16). In addition, dredging increased the depth of the water throughout the center of the cove, in particular near the Cranberry Creek inlet (Figure 6-17). The post-dredging substrate in this cove was composed of moderate-to-large round cobbles (MIC 2016).

The volume of sediment removed was estimated both during and after dredging, using multiple techniques. While dredging was actively underway, the depth and lateral progress of the dredge were monitored *in-situ* using GPS data and logs of cutter head depth and were used to estimate removal volumes. On shore, the rate at which sediment was pumped into the de-watering bags was recorded, as was the volume of compacted sediment removed from the de-watering bags. Finally, the original and post-dredging bathymetries were compared in order to estimate the quantity of sediment removed by dredging. *In-situ* estimates of dredging in King's Cove totaled 2,650 cubic yards of material, and *in-situ* estimates for Cranberry totaled 3,764 cubic yards of material (MIC 2016). The total *in-situ* estimate was 6,454 cubic yards of material (MIC 2016). The on shore volumetric estimate of dredge material was reached using pumping logs and totaled 6,600 cubic yards of material (MIC 2016). Volumetric totals were also computed by comparing pre- and post- dredging maps of lake-bottom bathymetry. By this method the total dredging volumes were estimated to be 2,899 cubic yards for King's Cove and 3,291 cubic yards for Cranberry Cove (MIC 2016). The overall total computed using bathymetric data and accounting for sloughing was 6,809 cubic yards of dredged material (MIC 2016). Once de-watering was complete, the volume of compacted dredged sediment was estimated to be approximately 1,000 cubic yards, indicating that the de-watering system achieved a compaction ratio of 6:1 (original volume: compacted volume), reducing the volume of the dredged material by approximately 85% (MIC 2016). The 1,000 cubic yards of compacted material was trucked off site to a gravel quarry to be used as fill (MIC 2016).

Overall, the dredging operations in King's Cove and Cranberry Creek successfully met the goals of the project. Over 6,000 cubic yards of material was removed from the two coves. The fishery habitat was increased in both coves, as dredging exposed substrate that is better for spawning and improved access to inflow streams for winter steelhead, coho, and resident cutthroat. The substrate is still more habitable for benthic macroinvertebrates, which helps restore the natural ecological function of benthic communities. Recreational opportunities in both coves have also been improved, as the increased water depth provided better access for boats, makes swimming more enjoyable, affords a better fishing environment, and is aesthetically pleasing. However, the on-going input of sediment and nutrients, especial from Cranberry Creek, has resulted in a filamentous algae and aquatic rooted plant growth that has reduced some of the immediate benefits of the dredging project.

The pre-dredging benthic macroinvertebrate samples were collected from three locations in Cranberry Cove (August 29, 2016). Three replicate benthic samples were collected from each location using a petite ponar dredge; one location nearest the mouth of Cranberry Creek, a second site located further into the deeper part of Cranberry Cove, and a third site near the deepest part of the cove. Benthic sampling results reflect pre-dredging conditions along the original thalweg from the creek mouth to the lake. Results from pre-dredging samples were compared against samples collected during year 1 (2017), year 3 (2019), and year 5 (2021) following completion of dredging. This report compared pre-dredging samples to those benthic macroinvertebrate samples collected one-year following the dredging project.

Pre-Dredging Benthic Macroinvertebrate Samples

Density of benthic macroinvertebrate taxa at each of the locations was relatively similar among sites (Table 6-1). Three benthic taxa were dominant at each sampling location; the isopod *Caecidotia*, Oligochaeta (aquatic earthworms), and chironomid larvae (Table 6-2; midges). Taxa from these groups of benthic macroinvertebrates are tolerant of environmental conditions present in lake (lentic) environments like high oxygen demand in organically-enriched sediments (results in low dissolved oxygen), warm water temperature, and a large organic food base (unconsolidated sediment and abundant algae and plant material). Also, indicators for these types of conditions in the lake are the caddisflies (Trichoptera) collected in all three of the samples. *Agraylea* sp. and *Oxyethira* sp. inhabit lakes throughout North America (Wiggins 1977) and were found in low density from Cranberry Cove samples. These taxa inhabit areas with aquatic plants and feed on filamentous algae by piercing and then emptying the contents. The fingernail clams (Sphaeriidae) were collected in all but one replicate sample from Cranberry Cove. This mollusk group is known to inhabit lakes throughout North America and is tolerant of a variety of lake water quality and habitat conditions that more sensitive taxa find stressful (Pennak 1978).

Post-Dredging Benthic Macroinvertebrate Samples

Benthic samples were collected from three locations the year following dredging in Cranberry Cove (October 7, 2017), two years following the initial post-dredging sample collection (September 28, 2019) and the final post-dredging sample collection five-years later (October 8, 2021). Three replicate benthic samples were collected from each location using a petite ponar dredge; one location nearest the mouth of Cranberry Creek, a second site located further into the deeper part of Cranberry Cove, and a third site near the deepest part of the cove. Benthic sampling results reflect pre-dredging conditions along the original thalweg from the creek mouth to the lake. Results from pre-dredging samples are being compared with the post-dredging activity during years 1, 3, and 5 following completion of dredging. Year 1 comparisons are based on results from 2017 sampling in Cranberry Cove and reported in Table 6-3 (general taxonomic groups) and Table 6-4 (Chironomidae taxa). Post-dredging (year 3) 2019 sample collection from Cranberry Cove is reported in Table 6-5 (general taxonomic groups) and in Table 6-6 (Chironomidae taxa). Final benthic sampling was conducted in Cranberry Cove during the end of the index sampling period year 5 (2021).

Dominant taxa from the 2017 samples collected at locations in Cranberry Creek included the same as those from 2016 (e.g., *Caecidotia* and Oligochaeta) with Sphaeriidae (pea clams) and *Hyallela* sp. (sideswimmers) appearing as co-dominant. The pea clams require hard-bottomed surface to colonize and survive. The sideswimmers typically reside in open water and in locations where vertical habitat, like macrophytes, are established. The year following the dredging project has resulted in exposure of existing habitat and is one of the goals for improving ecosystem function for the benefit of fish use; including natural production of fish food and improvement of habitat for rearing, and spawning.

Benthic samples were collected again in 2019 (Year 3) following completion of dredging. Location for replicate samples remained the same as those collected before dredging in 2016 and immediately following dredging in 2017. Three replicate samples were collected in each of three locations in Cranberry Cove. Benthic community development continued to change from the previous sample collection in 2017 (Year 1). The upper site in Cranberry Cove had much lower aquatic invertebrate densities when compared with previous years. The lower site in Cranberry Cove had thicker, low-growing aquatic macrophytes that hosted a variety of Chironomidae taxa and aquatic worms. This was the primary substrate used by these large groups of aquatic invertebrates. In contrast, the upper site in Cranberry Cove had noticeably more gravel-sized substrate than in previous years with embedded sticks and twigs that serve as substrate for algae and aquatic invertebrates. The number of caddisfly taxa increased from 2017, but resembled the densities and varieties found at all sites from pre-dredging sampling. Portions of the aquatic invertebrate community returned to pre-dredging conditions based on individual taxa and densities. The pea clams were present in almost all replicate samples from the lower- to the upper Cranberry Cove locations indicating availability of hard-bottomed substrates; including those where the low-growing aquatic macrophytes were dominant in the lower collection site.

Benthic samples were collected again in 2021 (Year 5) following completion of dredging. Location for replicate samples remained the same as those collected before dredging in 2016 and immediately following dredging in 2017 and again three years following dredging in 2019. Three replicate samples were collected in each of three locations in Cranberry Cove. Benthic community development continued to change from the previous sample collection in 2019 (Year 3). Total number of taxa continued to decline at the Cranberry Cove locations with losses in the Chironomidae taxa and increases in specialized taxa from the Order Trichoptera (caddisflies). Aquatic plant management herbicide treatment in the lake resulted in little to no plants growing during benthic macroinvertebrate collection. This meant that taxa appearing for the first time at Cranberry Cove sites were taking advantage of a different food base and habitat conditions.

2.2 LEPRECHAUN AND LIMERICK AQUATIC PLANT SURVEY RESULTS

The results of the June 16, 2017 and conformation aquatic plant survey in September 28, 2017 for Lakes Leprechaun and Limerick are present below in Figures 2.2-1 and 2.2-2, respectfully. Also, shown on these figures are the 2018 proposed treatment area. In the December 2018 update report proposed future treatment areas for 2019 (Figure 2.2-3 and Figure 2.2-4) was presented. Included in this report are the aquatic plant survey maps from 2020 and 2021, including the treatment areas.

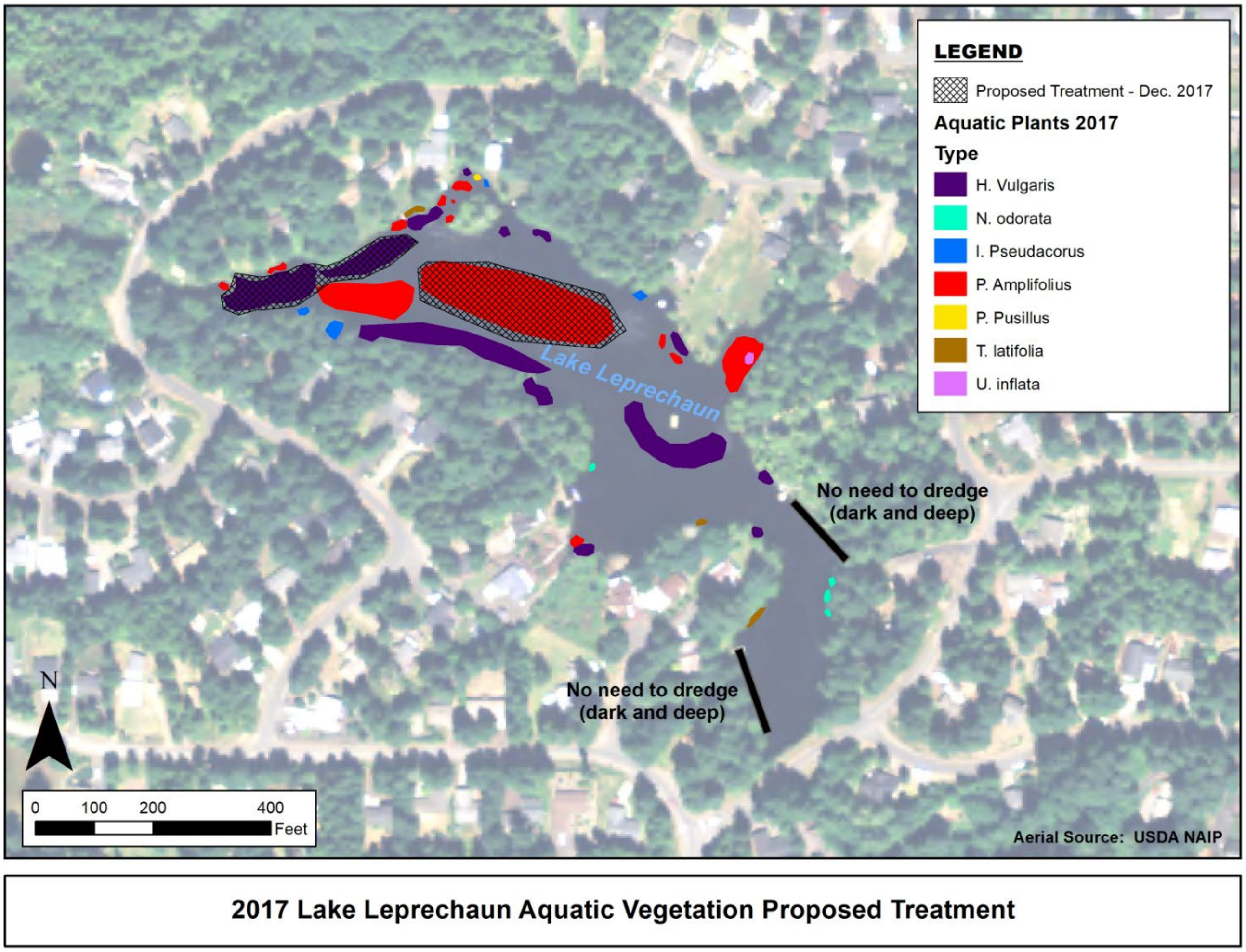

Figure 2.2-1. Aquatic plant 2017 map for Lake Leprechaun showing treatment areas for 2018.

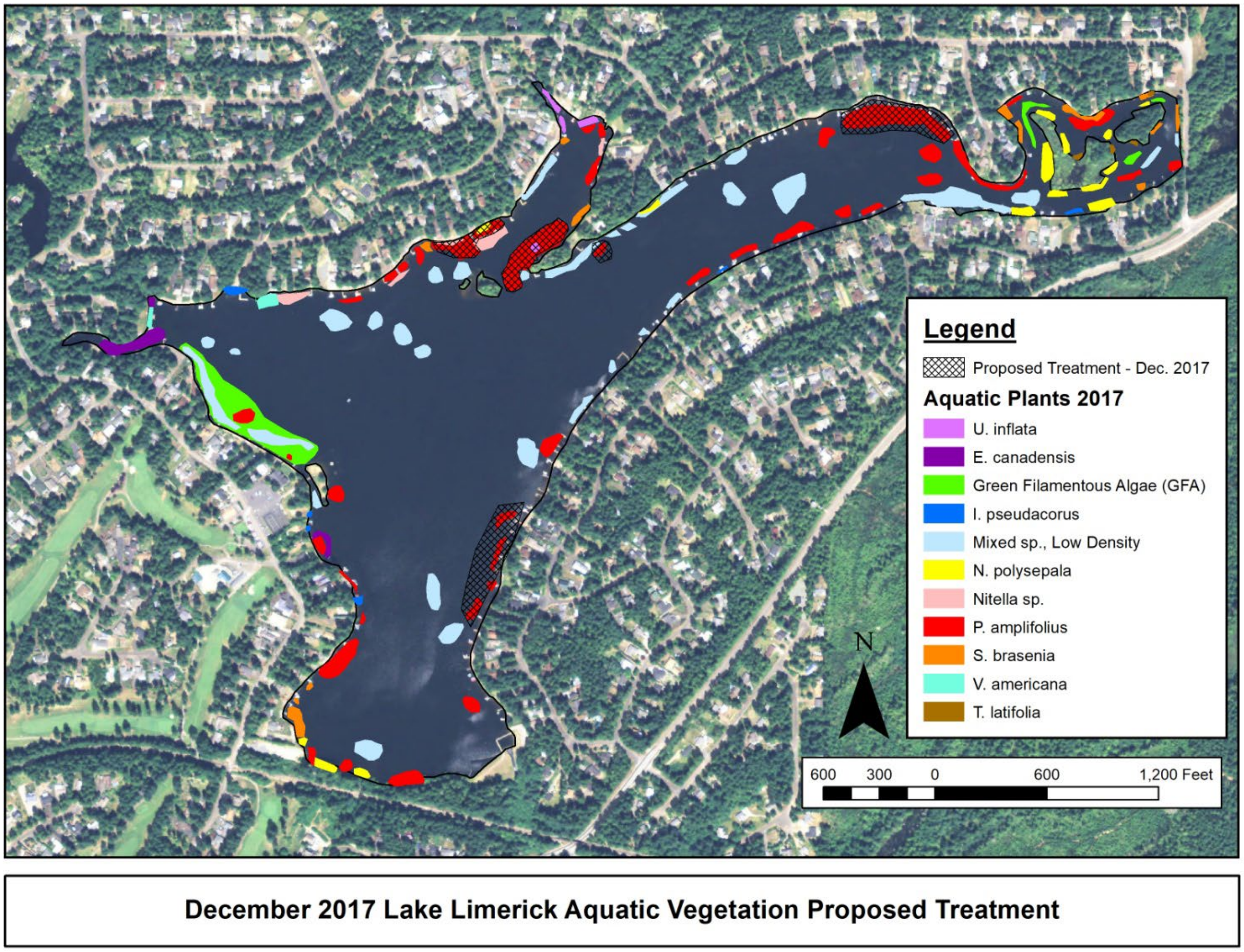

Figure 2.2-2. Aquatic plant 2017 map for Lake Limerick showing treatment areas for 2018.

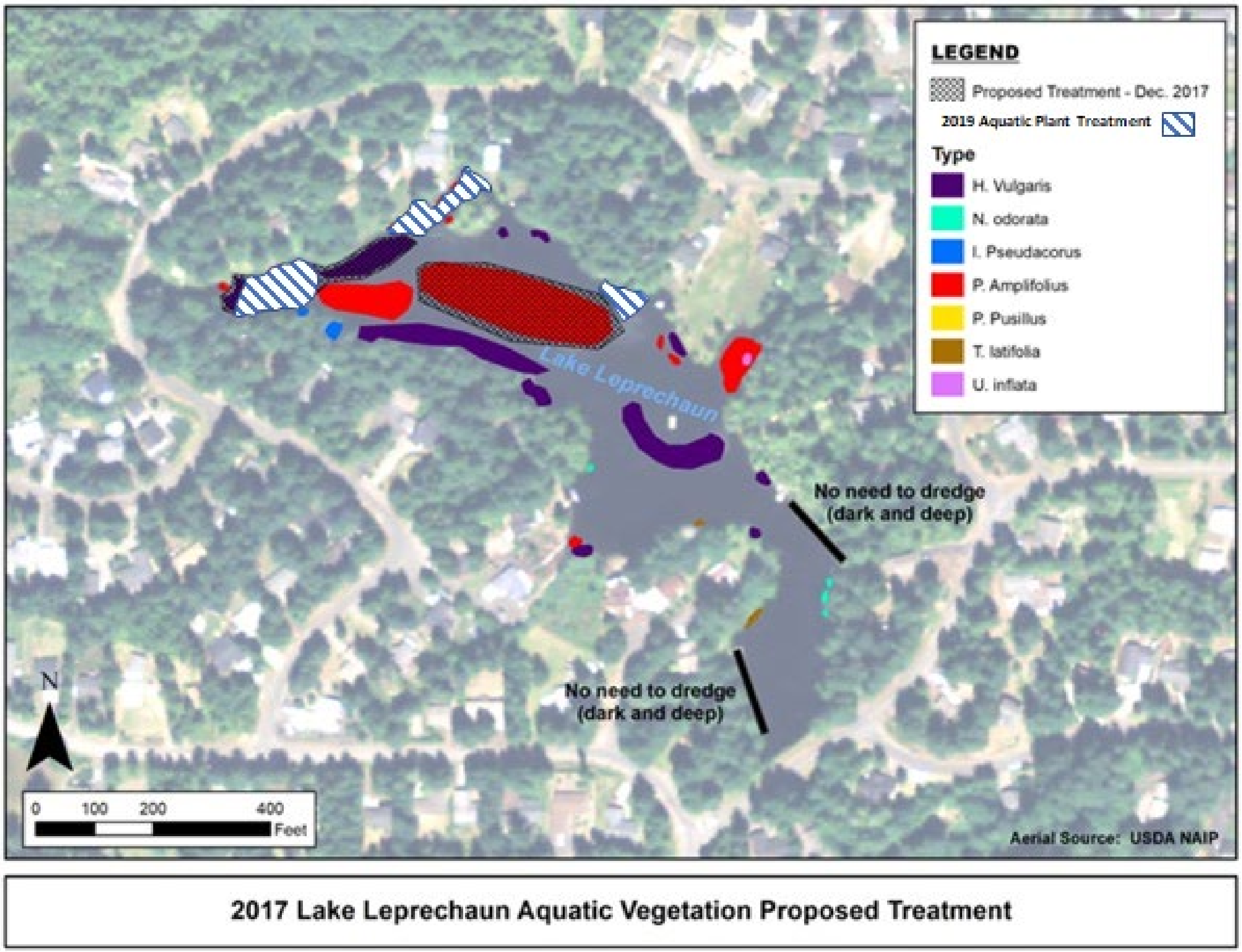

Figure 2.2-3. Aquatic plant 2017 map for Lake Leprechaun showing treatment areas for 2019.

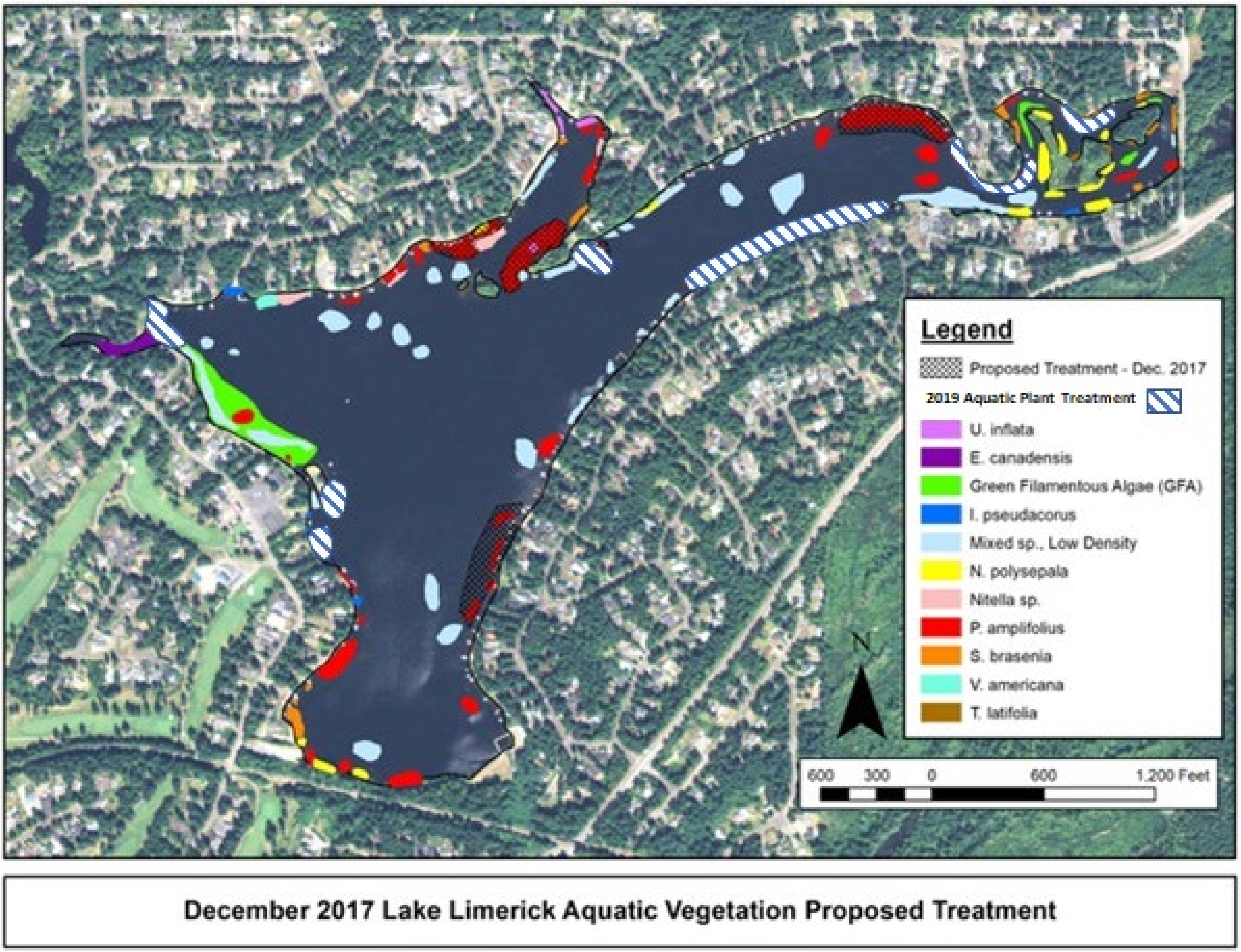

Figure 2.2-4 Aquatic plant 2017 map for Lake Limerick showing treatment areas for 2019.

Recent aquatic plant surveys were completed on June 26, 2020 and October 2, 2020 on Lake Limerick and on Lake Leprechaun(Figure 2.2-5 and 2.2-6, respectively). Invasive aquatic plants were identified two times during the year, at the beginning of the growing season and before senescence began. Treatment areas are identified in Figure 2.2-3 and Figure 2.2-4 including suggested treatment strategies identified for each of the areas where invasive plant patches were identified.

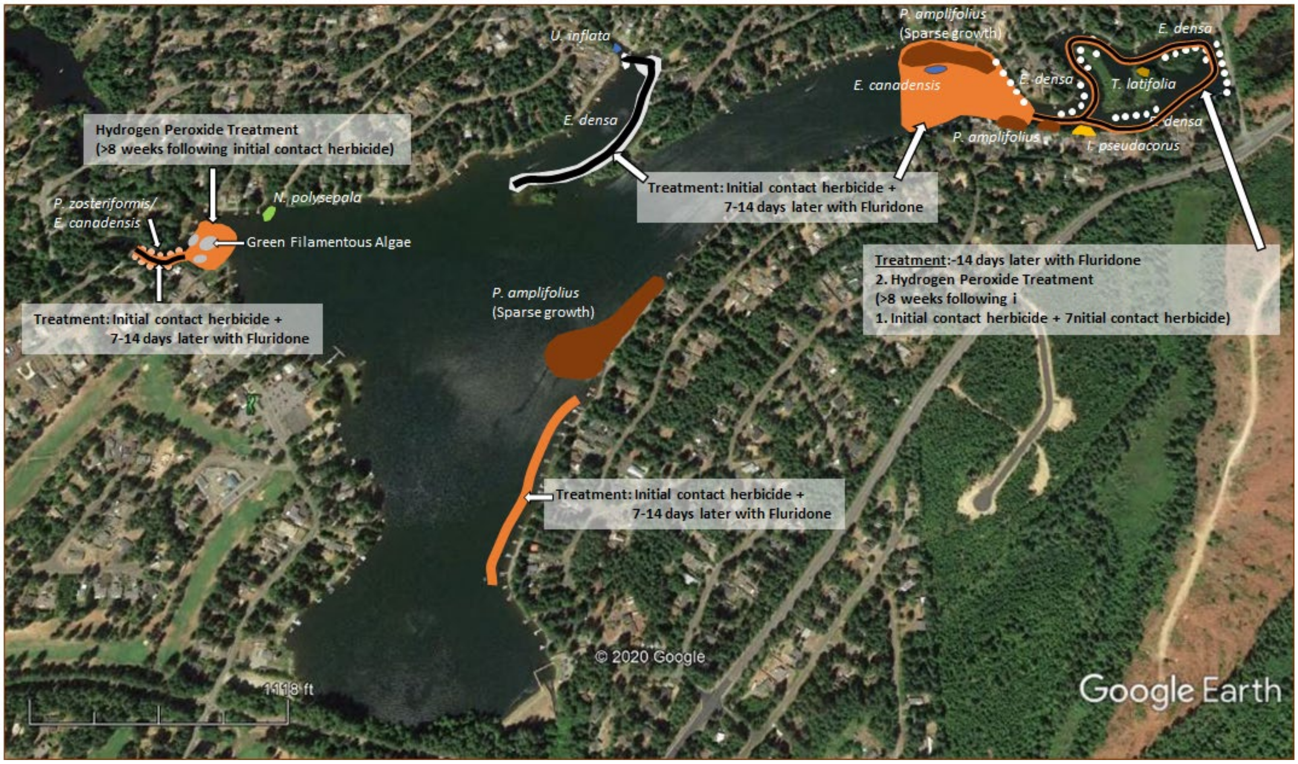

Figure 2.2-5. Invasive aquatic plants identified from surveys on June 26, 2020 and October 2, 2020 in Lake Limerick, including suggested treatment strategies.

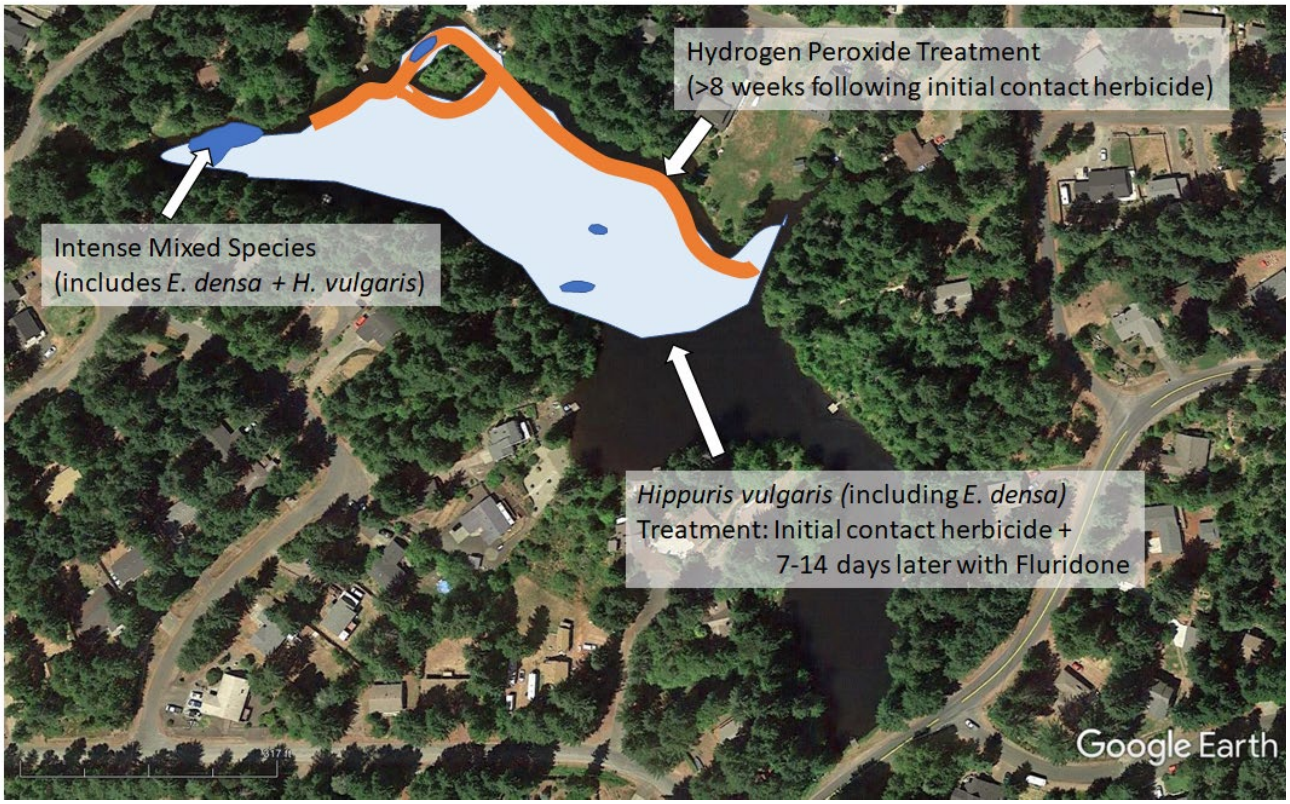

Figure 2.2- 6. Invasive aquatic plants identified from surveys on June 26, 2020 and October 2, 2020 in Lake Leprechaun, including suggested treatment strategies.

Recent aquatic plant surveys were completed on June 4, 2021 and October 8, 2021 on Lake Limerick and on Lake Leprechaun (Figure 2.2-7 and 2.2-8, respectively). Invasive aquatic plants were identified two times during the year, at the beginning of the growing season and before senescence began. The non-native invasive *Egeria densa* is still present throughout the lake but dramatically less dense than historical levels and now is at depth from 8 to 20 feet, except in the northeast littoral area including the Bird Sanctuary. Treatment areas are identified in Figure 2.2-7 and Figure 2.2-8 including suggested treatment strategies identified for each of the areas where invasive plant patches were identified.

Treatment with Diquat® (a contact herbicide) will be followed in same area by Sonar One® (a fluridone pellet systemic herbicide) within 10 days of the initial treatment. Another treatment that will be applied in spring and late July is PAK 27 algaecide (sodium carbonate peroxyhydrate; hydrogen peroxide) represented by the goldenrod swath in Figure 2.2-7 and Figure 2.2-8.

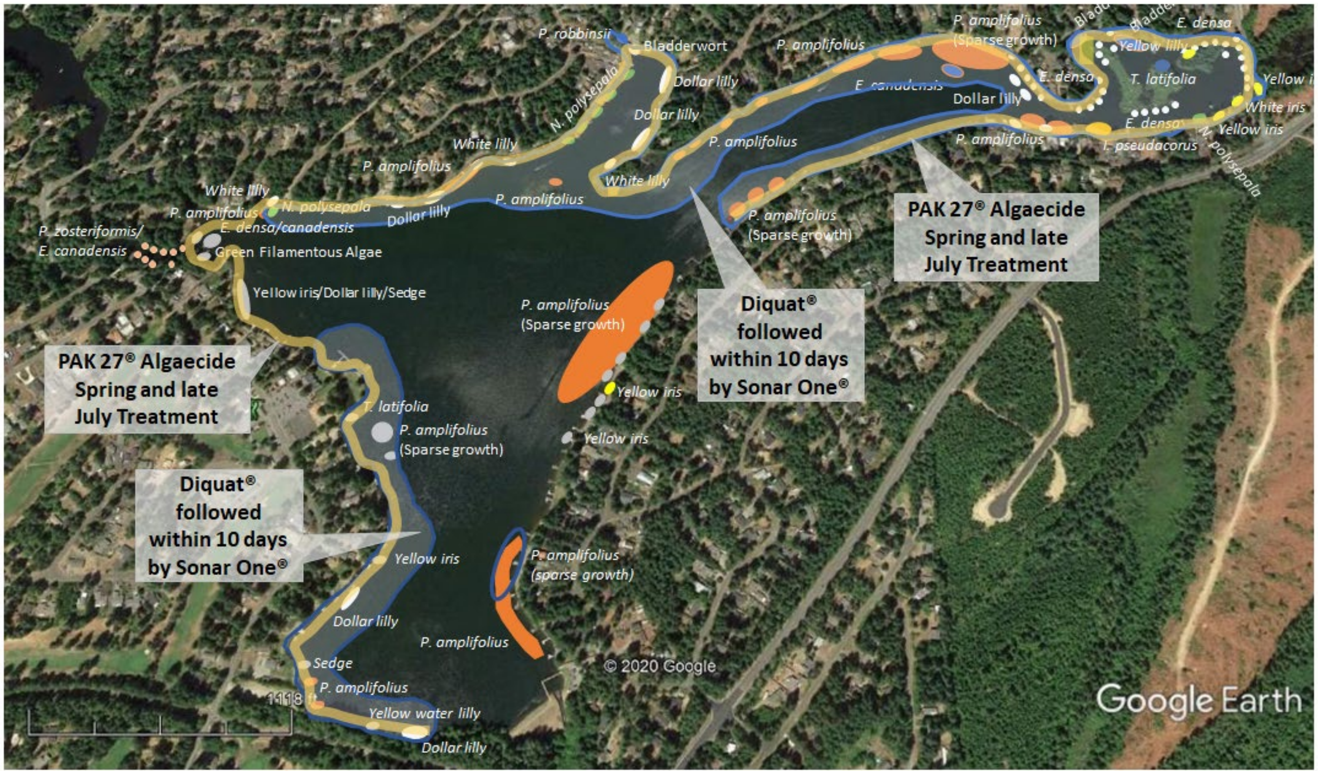

Figure 2.2- 7. Invasive aquatic plants identified from surveys on June 4, 2021 and October 8, 2021 in Lake Limerick, including suggested treatment strategies.

Most notable from the fall plant survey is that *Egeria densa* has been greatly reduced in coverage and density and is now only randomly observed in the south end of Lake Leprechaun.

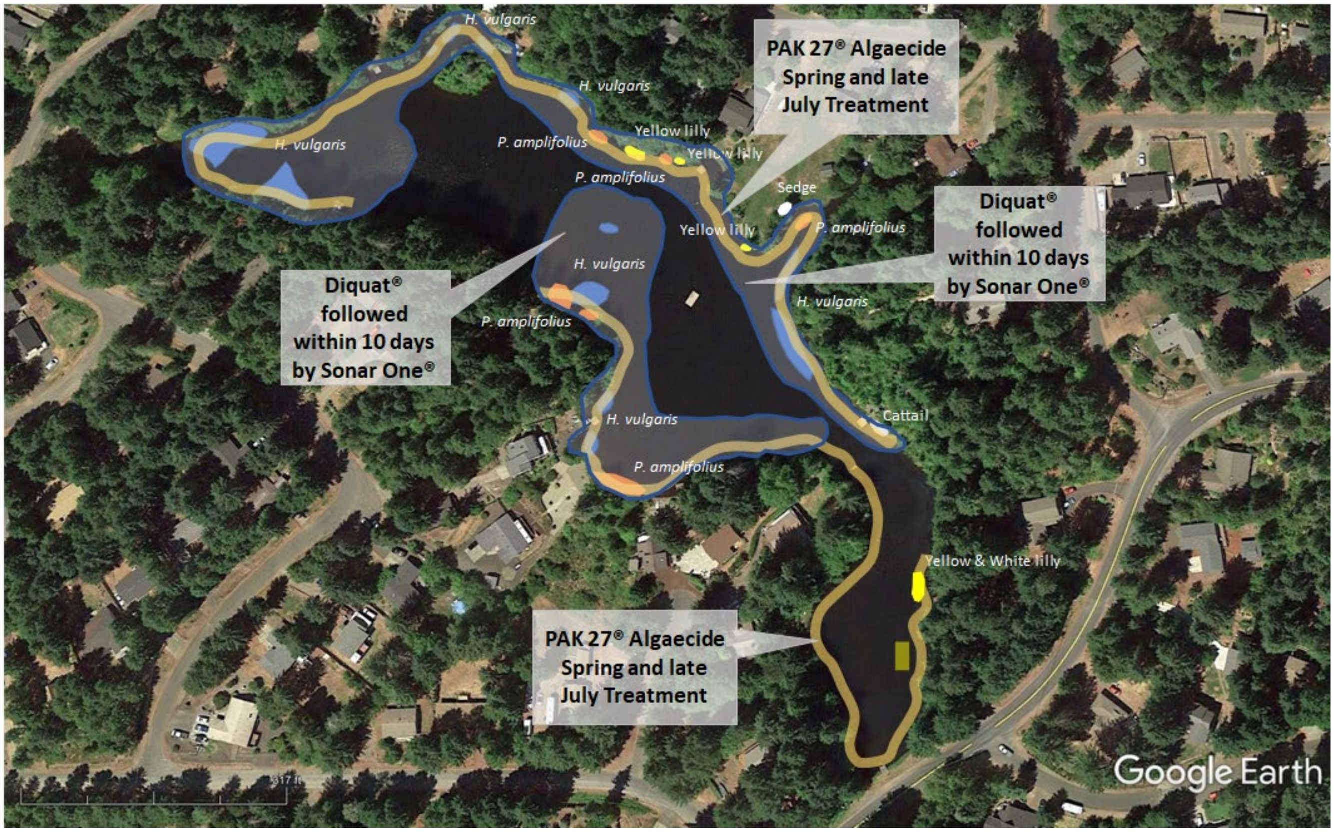

Figure 2.2- 8. Invasive aquatic plants identified from surveys on June 8, 2021 and October 15, 2021 in Lake Leprechaun, including suggested treatment strategies.

2.3 WATER QUALITY MONITORING RESULTS

Lake water quality samples were taken on September 28, 2017. The general results indicated that the lake remains in a mesotrophic state at that time, meaning the lake is moderately productive but not overly enriched with nutrients. The target range to phosphorus for Lake Limerick is less than 25 µg/L. The indicator threshold for eutrophic over productive lake is 25 µg P/L to 35 µg P/L. At that range the lake will start to show cyanobacteria dominance of the phytoplankton with chlorophyll *a* (photosynthetic pigment) at 7.5 µg/L or greater concentration. At that density there is a possibility for a potential HAB event (harmful algal bloom) that can also potentially produce toxins. Currently, the lake's phytoplankton is dominated by diatoms and green algae that are not blooms nor do they produce algal toxins. However, we have observed, over the last two decades, a significant increase in occurrence and density of green filamentous algae that originates on the sediment surface and within the macrophytes littoral plants (rooted shallow water plants). This is a direct result of increasing nutrient availability. The combination of this increasing production will also trend over time to potential HABs. Hence, now is the time to engage with direct and indirect steps to limit both phosphorus and nitrogen within the lake by controlling nutrient loading. General recommendations for this are presented in the recommendation Section 4. See Table 2.3-1 below for detailed results.

Table 2.3-1. Water quality results from September 2017 sampling.

Location	Total-Phosphorus, µg/L	Soluble Reactive-Phosphorus, µg/L	Chlorophyll a, µg/L	Relative rating H-high, M-moderate, L-low
Dam S1	21	1	5.3	M-H, L, M-H
Dam S2	22	1		M-H, L
Banbury	20	1	2.7	M-H, L, L-M
Tipperary	19	1	2.9	M-H, L, L-M

2.4 BENTHIC MACROINVERTEBRATES: COMPARISON OF RESULTS

Comparison of the taxa (species) list between 2016 and 2017 benthic macroinvertebrate monitoring samples documented taxa loss and taxa gain (Table 6-8). These Tables report presence and absence of species at each of the monitoring locations in Cranberry Creek (upper, middle, and lower) and report species presence during the 2016 and 2017 sampling events. An example shows that the snail, *Physa* sp., was absent during the 2016 sampling event at upper- and middle locations but appeared at the lower sampling location during both years.

Table 6-7 (general taxa) and Table 6-10 (Chironomidae) highlight with shaded cells change in the species list at each of the sampling locations in Cranberry Creek. These cells were further examined to determine if a species loss or gain occurred between the 2016 and 2017 sampling events. These changes in taxa composition were tallied and reported in Table 6-8 (general taxa) and Table 6-11 (Chironomidae). This information identifies when species richness increases and those responsible for the increase. An increase in species richness reflects improvement in substrate conditions by establishment of post-dredging habitat complexity and in the chemical environment (e.g., dissolved oxygen concentrations). A similar comparison of taxa change for each sampling location in Cranberry Cove was made between pre-dredging (2016) and year 3 (2019). Changes in general aquatic invertebrate taxa among the years 2016, 2017, 2019 and 2021 are reported in Table 6-9. Changes in the Chironomidae taxa between the years 2016, 2017, 2019 and 2021are reported in Table 6-12.

In all sampling locations, species richness increased from the 2016 event to the 2017 event for both general taxa (Table 6-8) and the Chironomidae (Table 6-11). The overall number of general taxa increased at the upper location by one and increased by four taxa at the lower sampling location (Table 6-8). The lower sampling location had greater depth of soft-, organic dredge material than did the upper site. Snails (*Physa* sp.) and caddisflies (*Triaenodes* sp.) appeared at sampled locations with hard-bottomed substrates. These taxa appeared at the upper and middle sites following dredging indicating presence of hard-bottom substrate that remained free of overlying organic deposits in contrast to pre-dredge conditions (Table 6-5). Crayfish (Mystacidae) were captured at all sites during post-dredge sampling. Crayfish consume detritus (dead plant and animal material) from the bottom of lakes and streams preferring the larger particle sized organic material (CPOM: coarse particulate organic matter). The pre-dredge organic matter was much finer and represented a poor food-base for crayfish, as well, smothered hard-bottomed sediments for other taxa that eventually appeared following dredging and opportunity for benthic macroinvertebrate colonization.

Taxa that appeared in 2019 that were not collected in previous years were: Ephydridae (shore flies), *Hemerodromia* (dance flies), and *Polycentropus* (a caddisfly species that was not collected either before or following dredging). Shore flies and dance flies are members of a large, and diverse group of aquatic invertebrates known as Diptera (black flies, mosquitoes and midges). These aquatic invertebrates inhabit wetlands and other still water environments including shallow lake habitat. Both groups are fairly tolerant to stressful environmental conditions in the lake environment but are more sensitive species than most others in the Order Diptera. The other aquatic invertebrate not previously collected in 2016 or 2017 was *Polycentropus* (a lake-dwelling caddisfly). Appearance of this aquatic invertebrate species in 2019 collections indicates a maturing benthic community that is beginning to diversify in successive years and contains taxa sensitive to stressful environmental conditions. *Ferrissia* (a freshwater limpet) has been collected during all four sampling events (pre- and post-dredging). This limpet species inhabits northern lakes that have cool, well-oxygenated water and is an indicator of good water quality conditions.

Common taxa that appeared in 2021 at all sampling locations in Cranberry Cover were: Amphipoda, *Caecidotea* sp., Sphaeriidae, Oligochaeta, and *Bezzia* sp. (a biting midge that inhabits lake environments). Highest densities of individual taxa were Sphaeriidae (also known as pea clams or fingernail clams) and Oligochaeta at all benthic sampling locations. Notable taxa collected from Cranberry Cove were *Sialis* sp. (also known as alderflies) and collected from the upper- and middle locations while the caddisflies Hydroptilidae and *Oxyethira* sp. were collected from the lower location. The remaining caddisfly Leptoceridae was found in low abundance at each of the three locations in Cranberry Cove (Table 6-7). This species preys on freshwater sponges found in lakes and on snails (Morse and Lenat 2005). Highest non-midge density of benthic macroinvertebrates was collected from the middle Cranberry Cove sampling location (Table 6-7).

Unique taxa appearing in 2021 (five years following dredging) were Hydroptilidae (purse-case caddisflies) and *Sialis* sp. (alderflies). The hydroptilid caddisflies are piercers and feed on either algal cells or on fluid of prey (micro- benthic macroinvertebrates) (Pritchard and Leischner 1973). Their presence indicates development of the biological community to include higher trophic levels than from previous years following dredging. *Sialis* sp. is a top predator that has a long-lived life cycle (two-years) in the aquatic environment. Among preferred benthic prey preferred by *Sialis* sp. are the Chironomidae and Oligochaeta. Both taxonomic groups represent the largest number of benthic macroinvertebrates collected in both the upper- and middle-sampling locations of Cranberry Cove. The benthic macroinvertebrate community is becoming more complex by increasing in number of species and in representation of trophic (feeding) groups. Fully functioning freshwater benthic communities include representative taxa from all trophic levels like primary consumers (plant and algae food base), detritivores (consume dead plants and animals), and predators (consume live benthic invertebrates).

Changes in the lake bottom occur in Cranberry Cove as sediment source of delivery continues from Cranberry Creek. Moving forward, periodic bathymetric surveys starting in 2022 should be conducted to evaluate the effect of sediment translocation on the transect gradients established prior to and following dredging. Channel shape in Cranberry Cove should be mapped over time leading to recommendation of potential long-term maintenance needs. It is expected that deeper portions of the thalweg transect in both coves will become slightly shallower due to sediment transport from the upstream shallow areas.

Future benthic macroinvertebrate monitoring should occur every five-years following the 2021 monitoring event. This frequency for benthic monitoring will benefit consideration of future dredging needs. Coordination of the benthic macroinvertebrate surveys with the bathymetric surveys is recommended beginning 2026.

3.0 PERMIT STATUS

AquaTechnex is the administrator for the herbicide permit and that permit is valid through 2022. For economic and liability efficiency Lake Advocates recommends that AquaTechnex should continue to be the permit holder and administrator for the coming permit cycle (historically every 5 years).

4.0 CURRENT AND ON-GOING RECOMMENDATIONS

Recommendations:

- Staff from LLCC, representative of the Dam Committee, and Lake Advocates staff meetings will continue each spring to coordinate lake level monitoring and sampling efforts for the following season. Water quality sampling continues to occur twice a year, late spring and late summer, to help provide the long-term data base for future reference.

- Aquatic plant mapping will continue annually at both Lake Limerick and Lake Leprechaun in May to June and in late August to September to establish treatment zones, assess effectiveness of past treatment efforts and develop management plans for both lakes on a sustainable adaptive basis.
  - Given that aquatic macrophytes have been managed in the past in both lakes, management efforts in moving forward focus on continued general aquatic plant management with a focus on non-native invasive species as well as native excessive density plant beds. This also included very specific areas where treatment is needed in order to maintain and enhance aquatic habitat and recreational activities while tracking and exploring filamentous green algae reduction through nutrient limitation and other means (e.g., the bird sanctuary).

  - Management efforts are continuing to strive to establish and support balanced native macrophyte communities, so that invasive species are kept out of the lakes. To date, management activities have succeeded in this capacity (e.g., *Egeria densa*) has not been a dominant plant in the lakes in recent years, but it is still resident and will return in the absence of basic control efforts and will expand its coverage and density). Another invasive non-native plant that has recently expanded its coverage is *Nuphar odorata* (fragrant waterlily also known as white, blue or pink waterlily) should be annually assessed as to how aggressive control should be planned.

  - It is important, however, to avoid over-controlling the growth of aquatic macrophytes, because filamentous green algae are more likely to emerge as dominant species and will result in increased nutrient recycling and reduction in aquatic and fisheries habitat as well as recreation. This could lead to increasing cyanobacteria presence, which would contribute to overall water quality decline and potentially result in HABs. Hence, a rotating control program that targets 15 to 30% of the lakes area each year will continue as in the past two decades.

- To this end, next year's plant management program (2022) will include the following:

  - Exploration of management alternatives for the bird sanctuary, given observed dense growth of aquatic plants and filamentous algae in this area. This includes macrophyte control and filamentous green-algae control with hydrogen peroxide. Future efforts may also include nutrient inactivation (small alum treatment) to limit algal growth by reducing sediment phosphorus recycling. In addition, a future small-scale dredging action will be needed to remove nutrient enriched shallow sediments.

  - Assessment of carry-over growth of yellow iris, and continued treatment of the invasive species in shoreline areas, to curtail its growth. The timing of the iris treatment and the chemicals used for treatment will be reviewed and will depend on the assessment of carryover in the spring survey, the permit requirements for potential herbicides, and the fishery window for the permit.

  - Targeted control of non-native species, if any, will be identified by spring and fall surveys.

  - Treatment of specific patches of native species that are excessively impeding recreational activities and adversely impacting aquatic habitat and water quality due to excess density.

Plant mapping will continue to be conducted in both lakes during September in order to assess the effectiveness of the summer control activities and in order to plan for the efforts that will be needed in coming years.

During 2019, water quality monitoring was conducted only in May-June and August-September. Water quality monitoring will continue to be more limited in scope in the ensuing years than in 2013-2015 because the lakes are in relatively good shape. Water quality data from late spring and late fall will be sufficient to monitor general water quality in both lakes for signs of change. In addition, based on the cost of the analysis and the limited information that it provides as a result of the good water quality conditions, low nutrient levels, and historical lack of cyanobacteria within both lakes, phytoplankton samples were collected in 2019 in the absence of surface algal scum (possible presence of blue-green algae). To help track phytoplankton densities, chlorophyll *a* was sampled along with phosphorus samples.

The final dredging permit required benthic macroinvertebrate monitoring collection through 2021 (July 1 through October 15) (Ecology 2014). A comparison of succeeding samples from Cranberry Cove was completed with the pre-/post-dredging results in this report. Data analysis focuses on indicator aquatic invertebrate taxa that identified stressors from physical habitat or water quality degradation. Biometrics normally used for analysis of biological condition were not used because a Benthic Index of Biotic Integrity did not exist for lake and reservoirs in the Puget Lowland Ecoregion (the region both lakes are located). Instead, simple expressions like number of species, function of notable species, and changes in the benthic community identified by appearance and disappearance of species are the primary indicators for interpreting results. The focus for analysis identified benthic macroinvertebrate response to removal of fine sediments from hard sediments, recolonization of hard sediments, and availability of food base following dredging. The benthic macroinvertebrate community following dredging was examined for suitability as food for resident fish in Lake Limerick. Benthic macroinvertebrate sampling should be conducted every five-years following the 2021 sampling event. This information is useful for detecting change based on sediment deposition and movement in the coves.

LLCC will explore future dredging projects in Lake Limerick and Lake Leprechaun and evaluate long-term maintenance needs associated with the completed dredging projects in Lake Limerick.

- More information on sediment in Lake Leprechaun is necessary to effectively explore dredging portions of that lake.

Long-term Dredging Strategy

- Dredging portions of Lake Leprechaun is needed due to sedimentation, *i.e.*, the inlet bay.
- Approximately one quarter of lake Leprechaun shoreline area will be dredged along with aquatic plants in those areas
- Develop a strategy for lowering lake level prior to dredging
- Location of the existing valve at spillway (need to determine distance below the surface)
- Pumping water below level of the valve

Bird Sanctuary sediment removal and/or nutrient inactivation in Lake Limerick

- Alternatives include and will be evaluated against goals:
  - Hydraulic dredging without nutrient inactivation,
  - Hydraulic dredging followed by nutrient inactivation,
  - Nutrient inactivation,
  - Rotovation followed by nutrient inactivation,
  - Harvesting, followed by mechanical dredging and nutrient inactivation.

Short-term Aquatic Plant Management Strategy

- Goal is to stress plants earlier in the season with a contact herbicide, either Diquat or Endothall and follow with hydrogen peroxide. The second application occurs 14 days following contact application and use a systemic herbicide (Fluridone: soluble form early

or quick release pellet in the late spring or early summer followed by a pellet form, time-release later in the summer.)
    - Application permits are already in place for 2022 aquatic plant treatment
    - Aquatechnex is the applicator holding the current permit; April/May 2022 timeline for application

- LLCC will actively promote septic tank management and education to reduce nutrient loading to the lakes as well as landscaping education to enhance shoreline protection (including waterfowl management) and nutrient buffering.

- Control sediment and nutrient inflow from Cranberry Creek
    - Alternatives include:
        - Extensive watershed management,
        - Dredging every 2 to 5 years,
        - Interception of sediment and potential nutrients via a sedimentation pond targeting Cranberry Creek high flow events.

Additional detail for sediment control and dredging recommendations are reported in the Technical Memorandum (November 23, 2018) from Lake Advocates. The focus of technical discussion in this Memorandum was prioritization of potential management activities for sustaining beneficial uses in the lake.

5.0 REFERENCES

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6.0 BENTHIC DATA TABLES

Table 6-1. Benthic sampling results from three locations in Cranberry Cove before dredging (08/29/2016).

	Cranberry Creek (Upper Location)			Cranberry Creek (Middle Location)			Cranberry Creek (Lower Location)		
Latitude	47° 17' 12" N			47° 17' 00" N			47° 17' 12" N		
Longitude	123° 03' 18" W			123° 03' 15" W			123° 03' 13" W		
Sample Replicate	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Acari		1					1		
Amphipoda			33	1	4	2	1	7	3
Hyalella	1	4					1		
Caecidotia	49	77	19	8	104	56	89	37	16
Cladocera		1	1				1		
Copepoda		2	4	1	4		1		
Hirudinea		1		1	1			1	
Hydra			1						
Ferrissia		5	1	7	2	1		1	1
Gyraulus		10	3	1	1	1	2		
Physa								2	
Sphaeriidae	1	3		48	9	18	4	16	4
Pisidium							2		
Nematoda	1	2	10	3	6	6	3	15	11
Oligochaeta	14	81	49	9	32	10	111	59	25
Ostracoda		2	1		1	1	17	6	2
Turbellaria		3		3	4			1	
Coenagrion					1				
Agraylea larva		6	2	3	1		5	9	
Agraylea pupa							4	5	
Oxyethira larva							1	1	
Oxyethira pupa				1					
Leptoceridae Pupa					1				
Neotopsyche			2		1				
Sialis sp.			1		6		1	1	
Ceratopogoninae		2	3		5		5	3	5
Chironomidae larva	8	89	161	65	87	15	128	46	32
Chironomidae pupa		2			1		1		
Total Density	**74**	**291**	**291**	**151**	**271**	**110**	**378**	**210**	**99**

Additional Notes: Mollusc shell had decalicified, Amphipod genus possibly *Hyallela* sp., Oligochaeta bodies damaged. Whole samples sorted.

Table 6-2. Chironomidae identified from pre-dredging replicate samples from Cranberry Cove (08/29/2016).

	Cranberry Creek (Upper Location)			Cranberry Creek (Middle Location)			Cranberry Creek (Lower Location)		
Latitude	47° 17' 12" N			47° 17' 00" N			47° 17' 12" N		
Longitude	123° 03' 18" W			123° 03' 15" W			123° 03' 13" W		
Sample Replicate	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Chironomus			6	2			48	21	19
Cladopelma		1	6	1	3		4	1	
Clinotanypus				1	10	3	2	1	1
Cricotopus			7		8			1	
Dicrotendipes		53	46	3	9	1	7	4	2
Microtendipes pedellus grp.		1	1			1	2	1	
Nanocladius			2		4				
Pagastiella							1		
Parachironomus		1	1		2				
Paratanytarsus		3	4		1				
Phaenopsectra					1		1		
Polypedilum	4	16	47	5	12	2	8	4	1
Procladius	5	6	29		32	5	39	7	3
Psectrocladius			3						
Pseudochironomus		1							
Tanytarsus		1							1
Thienemannimyia complex			1	1				2	
Total Density	**9**	**83**	**153**	**13**	**82**	**12**	**112**	**42**	**27**

Table 6-3. Benthic sampling results from three locations in Cranberry Cove after dredging (10/07/2017).

	Cranberry Creek (Upper Location)			Cranberry Creek (Middle Location)			Cranberry Creek (Lower Location)		
Latitude	**47º17'12" N**			**47º17'00" N**			**47º17'12" N**		
Longitude	**123º03'18" W**			**123º03'15" W**			**123º03'13" W**		
Sample Replicate	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Acari	2	1	5	1	2	3			
Crangonyx					2				
Hyalella	9	14	16	9	3	15	26	35	58
Caecidotea	15	17	24	42	28	4	46	111	109
Cladocera		1		1	1		5	17	15
Cladocera				1			1		
Copepoda	2	8	9	1			7	6	1
Hirudinea		1	1	1		1			1
Hydra	10	6	4	36	6	85	3		
Ferrissia					1	16	2	3	2
Gyraulus	1			8	1	9	9	15	4
Menetus			2				1	3	
Physa	3			1		1		1	
Sphaeriidae	9	9	19	26	13	5	10	81	76
Nematoda								1	
Oligochaeta	337	203	144	170	39	140	295	162	121
Ostracoda		2	4	1					
Turbellaria	14	21	92	8		5	31	19	20
Coenagrionidae	1								
Coenagrion/Enallagma								1	
Agraylea Larva	26	15	34	9	1	5			
Oxyethira larva	14	90	133	2			1	3	
Oxyethira pupa	17	110	45						
Mystacidea	2	1		3	2	3	22	41	41
Triaenodes			4	1					
Ceratopogoninae	5	7	2	4	3	4	21	10	3
Empididae									1
Chironomidae larva	50	31	27	200	34	237	85	96	81
Chironomidae pupa	1				1				
Total Density	**515**	**537**	**565**	**525**	**137**	**533**	**565**	**605**	**533**

Table 6-4. Chironomidae identified from post-dredging replicate samples from Cranberry Cove (10/07/2017).

	Cranberry Creek (Upper Location)			Cranberry Creek (Middle Location)			Cranberry Creek (Lower Location)		
Latitude	47º17'12" N			47º17'00" N			47º17'12" N		
Longitude	123º03'18" W			123º03'15" W			123º03'13" W		
Sample Replicate	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Chironomus				2	1		1	2	1
Cladopelma	5			6	2		3	2	
Cladotanytarsus	1						1		
Clinotanypus			1						
Cricotopus		1							
Cricotopusbicinctus grp		1	1						
Cryptochironomus			1		1				
Dicrotendipes	70	86	66	172	21	217	41	21	12
Guttipelopia									2
Labrundinia						1			
Microtendipespedellus grp.						1	2	1	2
Nanocladius				1					
Pagastiella		2							
Parachironomus									
Paratanytarsus		1		2		1			
Phaenopsectra									
Polypedilum	1	1		1	1	4		2	
Procladius	3	2	11	3	10	3	4	3	9
Psectrocladius				1					
Pseudochironomus									
Tanytarsus	1	1		2		3		1	
Thienemannimyia complex						1			
Total Density	**81**	**95**	**80**	**190**	**36**	**231**	**52**	**32**	**26**

Table 6-5. Benthic sampling results from three locations in Cranberry Cove after dredging (09/28/2019).

	Cranberry Creek (Upper Location)			Cranberry Creek (Middle Location)			Cranberry Creek (Lower Location)		
Latitude	47°17'12" N			47°17'00" N			47°17'12" N		
Longitude	123°03'18" W			123°03'15" W			123°03'13" W		
Sample Replicate	1	2	3	1	2	3	1	2	3
Acari		4	1			2	1	1	
Amphipoda	2	7	1	5	25	9	23	40	14
Caecidotea	4	8	11	4	9	17	5	1	3
Hirudinea		1				4	1		1
Hydra		1	1	1		1	8	15	18
Ferrissia				3	2	7			
Gyraulus					1	1	17	4	5
Physa						1	1	2	4
Sphaeriidae			1	4	6	2	8	11	2
Nematoda	2	2	8	1		1	1		
Oligochaeta	2	10		1	4	38	40	43	116
Ostracoda	1	5		3	6	8	7	28	1
Turbellaria		3			2		5	6	10
Coenagrionidae						1			
Sialis			4						
Agraylea Larva	2	1	9		3	14		7	6
Orthotrichia		6	3			4	5	1	
Oxyethira larva		1					2		
Oxyethira pupa			1		1	1			1
Oecetis									1
Triaenodes							3	5	2
Polycentropus					1	1			1
Ceratopogoninae		1			2	2	2	2	1
Chironomidae larva	24	80	62	13	88	398	208	335	362
Chironomidae pupa		2	2		1	3	2	4	1
Hemerodromia								9	
Ephydridae pupa					1				
Total Density	**35**	**132**	**104**	**35**	**151**	**515**	**339**	**505**	**549**

Table 6-6. Chironomidae identified from post-dredging replicate samples from Cranberry Cove (09/28/2019).

	Cranberry Creek (Upper Location)			Cranberry Creek (Middle Location)			Cranberry Creek (Lower Location)		
Latitude	47º17'12" N			47º17'00" N			47º17'12" N		
Longitude	123º03'18" W			123º03'15" W			123º03'13" W		
Sample Replicate	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Ablabesmyia							1	5	4
Chironomus	3		1	2	1	10	6	1	4
Cladopelma	2	1	4	1	2	3			
Cladotanytarsus									
Clinotanypus			2		1				
Corynoneura		7	2				1		
Cricotopus									
Cricotopusbicinctus grp									
Cryptochironomus									
Dicrotendipes	3	36	38	3	50	288	112	291	263
Guttipelopia									
Labrundinia	6		1	1				1	
Microtendipes pedellus grp.					4	11	28		10
Nanocladius		1	1		1	3	1	4	
Nilotanypus					8				
Pagastiella									
Parachironomus									
Paratanytarsus		8	5		2	2			2
Phaenopsectra									3
Polypedilum	2	9	1	2	3		6		
Procladius	5	8	3	4	5	6	9	2	8
Psectrocladius					1		2	6	2
Pseudochironomus									
Tanytarsus	2	1				5	19	11	31
Thienemanniella					1	1		1	
Thienemannimyia complex						15	2	2	
Total Density	**23**	**71**	**58**	**13**	**79**	**344**	**187**	**319**	**327**

Table 6-7. Benthic sampling results from three locations in Cranberry Cove after dredging (10/08/2021).

	Cranberry Creek (Upper Location)			Cranberry Creek (Middle Location)			Cranberry Creek (Lower Location)		
Latitude	47°17'12" N			47°17'00" N			47°17'12" N		
Longitude	123°03'18" W			123°03'15" W			123°03'13" W		
Sample Replicate	1	2	3	1	2	3	1	2	3
Acari			1		1	1		5	4
*Amphipoda**	5	3	7	8	15	11	6	25	20
Caecidotea	24	19	20	28	78	12	7	32	17
Hirudinea							1		1
Ferrissia		1			1				
Gyraulus				1					
Menetus		3		1	1				
Planorbiidae						1			
Physella		2							
Sphaeriidae	66	61	33	57	54	35	22	70	30
Nematoda		1							
Oligochaeta	56	49	54	281	223	125	20	71	5
Ostracoda					6	1	2	14	13
Turbellaria		1			1				1
Epitheca				1					
Sialis		2				1			
Hydroptilidae								3	1
Oxyethira larva							2		
Oxyethira pupa								2	1
Leptoceridae	1				1		1		1
Bezzia	4	7	4	2	11	1	3	4	3
Chironomidae pupa								1	
Total Density	**151**	**149**	**119**	**379**	**392**	**188**	**64**	**227**	**97**

*Possibly *Crangonyx sp.*

Table 6-8. Chironomidae identified from post-dredging replicate samples from Cranberry Cove (10/08/2021).

	Cranberry Creek (Upper Location)			Cranberry Creek (Middle Location)			Cranberry Creek (Lower Location)		
Latitude	47º17'12" N			47º17'00" N			47º17'12" N		
Longitude	123º03'18" W			123º03'15" W			123º03'13" W		
Sample Replicate	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Chironomus				5	7	11	4	20	15
Cladopelma	136	131	142	138	87	79	3	42	26
Cladotanytarus	1		1		2				
Clinotanypus	1							1	
Corynoneura		1							
Crytochironomus	1					1			1
Dicrotendipes	7	32	6		10	2	10	15	3
Labrundinia							1	10	3
Microtendipes pedellus grp.							1		
Polypedilum	3	1	5	15	9	4		12	21
Procladius	21	17	17	34	36	9	12	74	150
Psectrocladius		1		1					
Tanytarsus	4	7	3	6	4	1	1	8	6
Thienemannimyia complex		1							
Total Density	**174**	**191**	**174**	**199**	**155**	**107**	**32**	**182**	**225**

Table 6-9. Benthic taxa comparison between 2016, 2017, 2019 and 2021 sampling results.

Taxon	Collection Year											
	2016	2017	2019	2021	2016	2017	2019	2021	2016	2017	2019	2021
	Cranberry Cr (Upper)				Cranberry Cr (Middle)				Cranberry Cr (Lower)			
Acari	X	X	X	X	X	X	X	X	X		X	X
Amphipoda			X	X			X	X			X	X
Crangonyx				X		X		X				X
Hyalella	X	X				X			X	X		
Caecidotea	X	X	X	X	X	X	X	X	X	X	X	X
Cladocera	X	X			X	X			X	X		
Copepoda	X	X			X	X			X	X		
Hirudinea	X	X	X		X	X	X		X	X	X	X
Hydra	X	X	X			X	X			X	X	
Ferrissia	X			X	X	X	X	X	X	X		
Gyraulus	X	X			X	X	X	X	X	X	X	
Menetus		X		X				X	X	X		
Physa		X				X	X		X	X	X	
Physella				X								
Planorbidae								X				
Sphaeriidae	X	X	X	X	X	X	X	X	X	X	X	X
Nematoda	X		X	X	X		X		X	X	X	
Oligochaeta	X	X	X	X	X	X	X	X	X	X	X	X
Ostracoda	X	X	X		X	X	X	X	X		X	X
Turbellaria	X	X	X	X	X	X	X	X	X	X	X	X
Epitheca								X				
Sialis				X				X				
Coenagrionidae		X					X					
Coenagrion/Enallagma					X					X		
Agraylea Larva	X	X	X		X	X	X		X		X	
Oxyethira larva		X	X			X			X	X	X	X
Oxyethira pupa		X	X		X		X				X	X
Hydroptilidae												X

Taxon	Collection Year											
	2016	2017	2019	2021	2016	2017	2019	2021	2016	2017	2019	2021
	Cranberry Cr (Upper)				Cranberry Cr (Middle)				Cranberry Cr (Lower)			
Polycentropus							X				X	
Leptoceridae				X				X				X
Mystacidae		X				X				X		
Triaenodes		X				X					X	
Ceratopogoninae	X	X	X		X	X	X		X	X	X	
Empididae										X		
Hemerodromia											X	
Bezzia												
Ephydridae pupa				X			X	X				X
Chironomidae larva	X	X	X	X	X	X	X	X	X	X	X	X
Chironomidae pupa	X	X	X		X		X				X	X

Table 6-10. Relative change in number of taxa from Cranberry Creek sample locations (2016/2017).

Direction of Change	Collection Year		
	2016 → 2017	2016 → 2017	2016 → 2017
	Cranberry Cr (Upper)	Cranberry Cr (Middle)	Cranberry Cr (Lower)
Increasing # of Taxa	+3	+6	+5
Decreasing # of Taxa	-2	-3	-1
Net Taxa Gain	+1	+3	+4

Table 6-11. Relative change in number of taxa from Cranberry Creek sample locations (2016/2019).

Direction of Change	Collection Year		
	2016 → 2019	2016 → 2019	2016 → 2019
	Cranberry Cr (Upper)	Cranberry Cr (Middle)	Cranberry Cr (Lower)
Increasing # of Taxa	+1	+5	+3
Decreasing # of Taxa	-5	-3	-5
Net Taxa Gain	-4	+2	-2

Table 6-12. Relative change in number of taxa from Cranberry Creek sample locations (2016/2021).

Direction of Change	Collection Year		
	2016 → 2021	2016 → 2021	2016 → 2021
	Cranberry Cr (Upper)	Cranberry Cr (Middle)	Cranberry Cr (Lower)
Increasing # of Taxa	+7	+7	+6
Decreasing # of Taxa	-10	-9	-9
Net Taxa Gain	-3	-2	-3

Table 6-13. Comparison of Chironomidae taxa in Cranberry Creek between 2016, 2017, 2019 and 2021 sampling results.

Taxon	Collection Year											
	2016	2017	2019	2021	2016	2017	2019	2021	2016	2017	2019	2021
	Cranberry Cr (Upper)				Cranberry Cr (Middle)				Cranberry Cr (Lower)			
Ablabesmyia											X	
Chironomus	X		X		X	X	X	X	X	X	X	X
Cladopelma	X	X	X	X	X	X	X	X	X	X		X
Cladotanytarsus		X		X				X		X		
Clinotanypus		X	X	X	X		X		X			X
Corynoneura			X	X							X	
Cricotopus	X	X			X				X			
Cricotopusbicinctus grp		X										
Cryptochironomus		X		X		X		X				X
Dicrotendipes	X	X	X	X	X	X	X	X	X	X	X	X
Guttipelopia			X				X			X		
Labrundinia			X			X	X				X	X
Microtendipes pedellus grp.	X				X	X	X		X	X	X	X
Nanocladius	X		X		X	X	X				X	
Pagastiella		X							X			
Parachironomus	X				X							
Paratanytarsus	X	X	X		X	X	X				X	
Phaenopsectra					X				X		X	
Polypedilum	X	X	X	X	X	X	X	X	X	X	X	X
Procladius	X	X	X	X	X	X	X	X	X	X	X	X
Psectrocladius	X			X		X	X	X			X	
Pseudochironomus	X											
Tanytarsus	X	X	X	X		X	X	X	X	X	X	X
Thienemanniella							X				X	
Thienemannimyia complex	X			X	X	X	X		X		X	

Table 6-14. Relative change in number of Chironomidae taxa from Cranberry Creek sample locations (2016/2017).

Direction of Change	Collection Year		
	2016 → 2017	2016 → 2017	2016 → 2017
	Cranberry Cr (Upper)	Cranberry Cr (Middle)	Cranberry Cr (Lower)
Increasing # of Taxa	+5	+4	+5
Decreasing # of Taxa	-5	-3	-1
Net Taxa Gain	0	+1	+4

Table 6-15. Relative change in number of Chironomidae taxa from Cranberry Creek sample locations (2016/2019).

Direction of Change	Collection Year		
	2016 → 2019	2016 → 2019	2016 → 2019
	Cranberry Cr (Upper)	Cranberry Cr (Middle)	Cranberry Cr (Lower)
Increasing # of Taxa	+3	+4	+5
Decreasing # of Taxa	-6	-3	-4
Net Taxa Gain	-3	+1	+1

Table 6-16. Relative change in number of Chironomidae taxa from Cranberry Creek sample locations (2016/2021).

Direction of Change	Collection Year		
	2016 → 2021	2016 → 2021	2016 → 2021
	Cranberry Cr (Upper)	Cranberry Cr (Middle)	Cranberry Cr (Lower)
Increasing # of Taxa	+3	+4	+2
Decreasing # of Taxa	-10	-8	-4
Net Taxa Gain	-7	-4	-2