STATE OF THE LAKE - PORTAGE LAKE-

(Summary of 39 Years of Water Quality Monitors)

Herb Lenon- PhD Fisheries Biologist -

Member Invasive Species Committee of the Portage Lake Watershed Forever and the Onekama Township

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State of the Lake Report Portage Lake 2013

Submitted by Herb Lenon, PhD Fisheries Biologist,

Portage Lake Watershed Forever Invasive Species Committee

INTRODUCTION

During the early months of 2013, Herb Lenon reviewed 39 years of historical water quality data that was available for Portage Lake. Herb is a key member of the Portage Lake Watershed Forever and Onekama Township Invasive Species Committee. Since 2008, he has worked with the committee to provide expanded oversite and definition of the water quality indicators needed to closely monitor Portage lake. . The committee also hired a lake manager to assist in collecting sufficient water quality data to assure that our treatment of the invasive species in and around our lake was not having a negative impact on the lake

The data that was used in this report was obtained from Michigan Department of Natural Resource lake studies in 1974, 1976, 1985, 1999 and 2009. Other data came from the NW Planning and Development Commission Cladophora Algae Shoreline Survey in 1983, repeated by watershed volunteers in 2008, a thorough 12 month study of the lake and tributaries done by the EPA/Snell Environmental Group, Inc. in 1991 a 3 month limnological study done by Great Lakes Water Quality in 2006 and a 6 month limnolgical study was done by the USGS in 2009. Continuing Studies of 4 parameters, spring and fall have been done by the Onekama School students since 1993, and these also have been included in the report.

Yearly extensive studies of invasive species and water quality began in the Fall of 2008 with a plant survey by Professional Lake Management.. The results of this study prompted the Invasive Species Committee of the Watershed to work with Onekama Township to pass a 5 year SAD for the treatment of invasive species in and around Portage Lake. The water quality monitoring was an important part of this program. From 2009 to 2012 the manager from Lakeshore Environmental and the invasive species committee have overseen the treatment and monitoring of the lake. In 2013 Professional Lake Management was contracted to be the lake manager.

Currently 11 water chemistry parameters are monitored twice/year. Phytoplankton and e-coli bacteria are also evaluated. 8 tributary streams and creeks are evaluated with 9 parameters twice/year and 5-7 storm drains are evaluated with 9-11 parameter once/year. Eurasian water milfoil and phragmites have been treated each year since 2009. The phragmites is under control and the eurasian water milfoil remains below the amount that was first treated.

INDEX - PORTAGE LAKE STATE OF THE LAKE 2013

Page 1...........................Dissolved Oxygen (DO

.Water Transparency

Secchi disk (page 1-2)

oligotrophic, mesotrophic, eutrophic

Page 2...........................Turbidity and total idssolved solids

Aquatic macrophyte population

eurasian water milfoil, phragmites

Page 3 ....Native plants

Chlorophyll-a

Total phosphorus (TP)

Parameters for determining eutrophication)([page 3-4)

Page 4..........................Total Kjeldhal nitrogen

pH

alkalinity

conductivity

Page 5..........................tubutaries (page 3-4)

phosphorus levels, lake and streams

Page 6 nitrogen , lake and streams

Cladophora

phytoplankton (page 6-7)

Page 7 .... e.coli page

Storm drains

physical features summary (page 7-8)

Page 8........................Future needs for monitoring

<u>**State of the Lake - Portage Lake – 2013**</u>

Submitted by Herb Lenon, PhD, Fisheries Biologist

Invasive Species Committee of the Portage Lake Watershed Forever

With stratification of the lake in summer, the hypolimnion (lower water below the thermocline) undergoes oxygen reduction due to BOD (biochemical oxygen demand) that results from bacterial decomposition of organic matter on the bottom and from respiration of fishes and other organisms there. **The dissolved oxygen (D.O.) in the two deep basins consistently goes to very low levels, very near zero**. This has been evident from the earliest historical data (1974) to the present. **It continues to be a major concern for the lake**, for if it does go to zero, phosphorus that is bound up in the substrate is changed in form and becomes soluble and released into the water column which increases the fertility of the lake. This would lead to greater "weed" production in the lake. Low oxygen levels (below 5 mg/L) in the hypolimnion are also a concern for the health of warm-water fishes. It is therefore important to continually monitor this D.O. level since it comes very close to 0 mg/L most years and we should do all that we can to prevent that. This concern is also evaluated by what we call the **redox potential** and tends to support what we see with D.O. measurements.

One of the greatest changes that has occurred in Portage Lake over the years has been in the increased transparency of the water. One way that this is measured is with a black and white disk which is lowered down into the water and the depth at which it just disappears from sight is recorded**. Secchi disk transparency has gone from 8-10 feet in earlier years to 20-27 feet more recently.** This corresponds with the appearance of **zebra mussels and then quagga mussels which efficiently filter the water leading to much clearer water** (increased transparency). Zebra mussels first appeared from Europe in Lake St. Clair in 1988. It was probably the late 1900's or early 2000's when they had spread through the state and first appeared in Portage Lake. **The major impact of the increased transparency has been an expanded littoral zone - the shallower area of the lake that supports aquatic plant growth**. In earlier years plants would grow out to about 12-15 feet of water. Now we **have plants growing out to 20-25 feet** due to greater light penetration with increased transparency of the water. This means a significantly greater area of the lake sustains plant production today and thus, there is less plant-free area of the lake.

Secchi disk transparency is one of three parameters (measurable factors) used to determine the degree of eutrophication of the lake. Eutrophication refers to the amount of enrichment or productivity of the lake and is often thought of as the "age" of the lake (a type of lake classification). All lakes age over time as they become more and more enriched. They start out very clear, low fertility and low productive lakes called **oligotrophic lakes (young lakes)**. As they become more enriched, fertile, productive, and less clear they become what we call **mesotrophic lakes (middle age).** Eventually they become quite turbid, very fertile and very productive, choked with "weeds" called **eutrophic lakes (old age**). According to our current Secchi disk transparency values, they would suggest an **oligotrophic classification (young age),** but this is just one of three parameters. The other two parameters used for this determination will be discussed later.

Turbidty and total dissolved solids are two other parameters we measure but there is no historical data for these, so no trends can be seen. Although they are measuring the inverse of transparency (lack of transparency) they tend to support the Secchi disk transparency measurements.

Another significant change that has occurred in Portage Lake is with the aquatic macrophyte (rooted plants, "weed") population. The exotic invasive **Eurasian water milfoil** was already present and abundant in 1991 (Snell Environmental Group). At the same time **exotic curly leaf pondweed** was also present but at a much lower abundance. By our first survey in **2008 Eurasian water milfoil had become a dominant plant species in the lake** and we recognized the need to control it. It can quickly take-over and become a monoculture species severely reducing the diversity of the ecosystem, as well as becoming a major problem for fishermen and boaters, and impacting the local economy. In 2008 another exotic species was identified**: Phragmites (giant common reed**) found around the shoreline, also becoming a monoculture in the shoreline and adjacent wetlands. Hence, the lake was undergoing considerable change in ecology with resultant changes in the lake ecosystem. We have been controlling the exotic invasive species now for four years. The phragmites population has been significantly reduced around the lake which has helped to protect the diversity of the shoreline marsh area. The Eurasian water milfoil population was initially greatly reduced and then rebounded due to miscalculations of the population and consequently, incomplete treatment, but now should come under better control. To complicate this, it has **hybridized with the native northern water milfoil and become more resistant to herbicide as a result of hybrid vigor. Curly leaf pondweed** tends to be more cyclic, coming and going from time to time. **Purple loosestrife** is another invasive exotic plant of the wetlands that can quickly become a monoculture, eliminating all diversity of the wetlands. We have been treating it along with the phragmites and will now begin some biological control of it with beetles which looks promising and more economical and will reduce the herbicide application. Continual treatment will be required to keep the invasive exotic plants under control, mostly by spot treatments where found, since these plants will not be eradicated. **Control of these species is especially important to protect the diversity of the aquatic ecosystem and maintain a high quality lake environment, healthy fish populations, and to stimulate the local economy**.

In the extensive study of 1991 by the Snell Environmental Group only 10 native aquatic plant species were identified and only two were abundant (chara and large leaf pondweed), and one (wild celery) was moderately abundant. During our four year study and treatment, 18-24 native species were identified along with the three exotic species. So **it appears that plant diversity has increased and changed somewhat in composition** from earlier years, and even more so with treatment of the invasive species, the desired result.

Chlorophyll-a is a measure of the amount of green plant pigment in the water, and is perhaps the most important parameter measured since it is an index of the primary production of the lake - the base of the food chain for all organisms. **Chlorophyll-a is a second parameter used to determine the eutrophic state (enrichment or age) of the lake. Our values for the deep basins (open waters) fall mostly in the range for a mesotrophic lake** (mid-range of enrichment - 2-6 ug/L). Only on a few occasions does it move up into the eutrophic (enriched or aged) state (>6 ug/L). Hence, Portage Lake has been fairly consistent over the years but needs to be continually monitored to prevent premature aging (enrichment). Higher rates of productivity in the form of high chlorophyll-a concentrations are found in the shallow east end of the lake and can be indicative of higher nutrient loading from riparian areas and/or the result of wave action stirring up the shallow bottom, bringing up nutrients.

Total phosphorus (TP) is also a very important parameter with phosphorus being the limiting factor for all plant growth in Portage Lake (as with most Michigan Lakes). It is also the **third parameter used to classify (age) lakes**. There appears to be a slight increasing trend in TP from 1974 to the present, but **there is considerable variation over the years and seasonally**. **Portage Lake has become more border-line eutrophic (enriched/aged with >20 ug/L) in this** variable, especially in late summer measurements with average values ranging mostly between 21-30 ug/L. TP tends to be higher in the shallow east end due to wave action and boat motors stirring up the fine sediment from the bottom bringing phosphorus up into the water column. This may imply that the shallow east basin, is in part supplying the open water areas with phosphorus. Phosphorus loading in Portage Lake comes possibly from both the lake and from the watershed - **internal and external factors**, respectively. Internal loading is due to wave and boat churning of sediments, especially in the east end and by anaerobic (lack of oxygen) release of phosphorus from sediment in the deep basins. External loading from the watershed is by tributary inflows and runoff from the land (e.g., fertilizers) along with inadequate septic systems. More will be said about phosphorus loading with discussions of stream studies.

With the three major parameters discussed - Secchi disk transparency, chlorophyll-a, and total phosphorus – we can evaluate the eutrophic (age) state of the lake. This is often computed to give what we call the **Carlson's Trophic State Index (TSI).** To summarize each of the three parameters we have the following**: Transparency** has increased and gone from eutrophic values in historical data prior to early 1990's to mostly oligotrophic values presently. **Chlorophyll-a** values have averaged mesotrophic in the past but were border-line eutrophic in the early 1900's. Since 2009 there have been eutrophic-to-border-line mesotrophic values. **Total phosphorus** values have averaged mesotrophic but with some definite trend toward the eutrophic state in the late summer of the last few years (since 2009). In conclusion then, **Portage Lake is primarily mesotrophic but bordering on becoming eutrophic as seen mostly in total phosphorus content.**

Another potentially important parameter that we look at is the **total Kjeldhal nitrogen (TKN) which is the sum total of all four forms of nitrogen in the water.** A nitrogen-to-phosphorus (N:P) ratio of >10:1 usually implies that the lake is phosphorus limited and not nitrogen limited**. Portage Lake has a N:P ratio of about 22:1 and is thus, strongly phosphorus limited.** So nitrogen is not as important in terms of productivity of the lake. The values for TKN mostly fall into the oligotrophic range (<0.66 mg/L) and thus, do not generally pose a problem. The main concern, however, is with a possible low TKN and a high TP which would tend to develop blue-green algae since they are able to fix nitrogen gas from the atmosphere, and this would be very undesirable due to the appearance of an algal scum and to a serious toxicity problem. This has not occurred yet in Portage Lake, although a small production of blue-green algae does occur during the summer.

pH is the measure of acidity or basicity with a pH of 7.0 being neutral, lower being acidic and higher being basic (alkaline). Historically, Portage Lake has been primarily consistent in the range of 7.7 - 8.9. In our studies from **2009 – 2012 the pH has ranged from 8.0 – 8.5. thus, Portage Lake is somewhat basic and classified as a hard water lake with a moderate calcium carbonate content.** The presence of numerous flowing artesian wells around the lake indicates that carbonates are entering the lake dissolved from underlying limestone bedrock.

Closely related to pH are measurements of alkalinity which evaluate the buffering capacity (less change in pH) of the lake. The higher the alkalinity the greater the buffering capacity and, hence, the greater ability to accept acid inputs from acid rain or runoff without significant impact. Based on alkalinity, as with pH, **Portage Lake is considered a moderately hard water lake and moderately well-buffered with only minor variations occurring from time to time.**

Conductivity of the water is a measure of the amount of minerals present, especially those of salts and other dissolved inorganic substances. It is thus, related to the fertility of the water and serves as a quick check of changes in total water quality and an important measure of possible influences of land use activities such as pollution and road salts. There are no historical conductivity values for Portage Lake and only our values for 2009-2012, so we cannot see any trends. **The values we have for those four years are low and do not indicate any particular problem at this time.**

There are **21-22 permanent tributaries to Portage Lake**, mostly small streams or creeks of which at least 15 are relatively high quality and with steady base flows. Most of them have forested watersheds and sandy soils with rapid drainage which reduces erosion and surface runoff. **We have been studying eight streams for the past four years (2009-2012). The only other stream data is from the Snell Environmental Group in 1991 which was very extensive and important for us,** comparatively. It included 12 months of data for four streams and three months of data (May, August, and December) for 11 other streams. This study was geared primarily to estimating annual phosphorus loading to Portage Lake from the streams. After a full year of sampling and analyses, the **total annual loading of phosphorus to Portage Lake was estimated to be 1,723 lbs/yr. At the same time the outlet to Lake Michigan from Portage Lake was sampled and analyzed and it was calculated to lose phosphorus at 1,720 lbs/yr. Hence, the Portage Lake system appeared to be at nearly equilibrium (input equal to output).**

In general the phosphorus levels of the streams today are similar to or slightly higher than those of the lake, and similar to those of 1991. Thus, the current phosphorus loading to Portage Lake from upland areas of the watershed via tributaries does not appear to be above a level which the lake can assimilate at the existing trophic (enriched) state. However, we must realize that some proportion of the **phosphorus loading is cumulative and wherever it can be controlled it must be done to avoid the potential for future water quality problems**. This is even more important if the watershed continues to be developed. The cumulative effect of phosphorus is a result of phosphorus input by stream, runoff, or inadequate septic systems leaching into ground water and then the lake increasing aquatic plant and algae production This then becomes organic matter deposited in the bottom of the lake as the plants die, taking up oxygen from the water as the organic matter decomposes. **Water quality problems occur then when the oxygen becomes depleted at the sediment-water interface**, especially in the deeper portions of the lake, which results in phosphorus released back into the water column and available for increased algae and plant production. This is what we called internal loading and is the result of cumulative phosphorus interacting with anoxic (zero oxygen) water. **Once this internal loading of phosphorus has begun it sets up a cycle which is self-perpetuating with plant and algae production, plant die-off, decomposition, oxygen reduction, and release of phosphorus to start over again – all in addition to new external phosphorus loading and production**. This process then continues until enough lake phosphorus is flushed out of the system to break the cycle and/or when external sources are reduced. This process is not occurring presently, but there is potential in the future and needs to be carefully monitored along with any reduction in phosphorus input (external loading) that can be accomplished.

Nitrogen input appears to be relatively low in the streams and not of significance. Likewise, all other stream parameters measured over the past four years are in normal ranges, and similar to the lake values.

Another parameter and a **good indicator of phosphorus input into the lake** that we look at from time to time is the occurrence and abundance of **Cladophora algae.** This is a macroscopic, filamentous green algae that is readily seen attached to solid objects (rocks, wood, dock posts, etc.), particularly around the shoreline. A 1983 shoreline survey around the lake revealed **24 sites** where present. The 1991 study by the Snell Environmental Group included a **Cladophora survey and found 47 sites. Of these, 22 sites were attributed to other than natural causes,** most likely as follows: 7 due to septic leakage or in combination with lawn fertilization runoff, 12 other sites due to fertilization alone, and 3 due to lakeshore dumping. Twenty-five sites were considered natural causes which included artesian flows, streams, and wetland inputs. In 2008, we conducted a total lakeshore Cladophora survey on July 21-31 with volunteers. **Forty-six sites** were identified as follows: 12 sites had abundant growths, 13 had moderate growths, and 20 had only scarce growth. It appears that there has been a general reduction is some areas, such as the Portage Pt. area, but there was an increase in other areas, such as along North Point. With warmer waters in 2012, there seemed to be a general increase in Cladophora around the shoreline that year.

Phytoplankton, the microscopic algae in the water column, is an important component of any lake ecosystem, for it is the major base of most food chains in the lake. There are many different species possible and there are good ones and some bad ones. In lake studies, phytoplankton is usually only identified to genera because species identification is difficult, expensive and unnecessary in most cases. We typically refer to 4-5 major groups (Phyla) of algae that make up the phytoplankton population. The green algae generally dominate along with diatoms and these two groups are beneficial and most important in the food chains. **Diatoms in particular are indicators of good water quality. Two other groups that contribute some to the phytoplankton population are the Dinoflagellates (red-brown algae) and the Chrysophhytes (yellow- or brown-green algae). The blue-green algae are undesirable,** capable of forming unsightly algal scums on the surface and producing microtoxins that can cause neurologic or hepatic (liver) dysfunction in animals or humans if ingested in large quantities. They tend to appear more in late summer. It is important to have a good diversity of the desirable species for a healthy well-balanced ecosystem. Comparing the results of the 1991 studies by the Snell Environmental Group with the last four years of our studies, the green algae have increased in diversity, and the blue-green algae have decreased. During the last four years (2009-2012), the diatom population has shown steady increase in abundance, and the green algae has shown an increase until 2012 when it decreased some. There have been up to 21 genera of green algae, typically about 9 genera of diatoms and 2-4 genera of blue-green algae. So there is a good, healthy diversity of phytoplankton algae. **The high ratio of green algae and diatoms to blue-green algae is indicative of clean waters that support a rich, diverse fishery. Nutrient levels in the lake are still low enough to prevent excessive blue-green algae blooms (scum).**

Samples for E. coli bacteria analysis have been taken at various times and at different locations around the lake. In the 1991 study, the only site in the lake of concern was off Eagle Point in May with an E-coli count of 200/100 ml (<130/100 ml is considered non-harmful). In August of 1991, 15 streams were sampled and three had elevated counts: Creek #8, Schimke Creek and Creek #5 with counts of 1210, 560, and 360 per 100 ml, respectively. In 2008, we took samples three times around the lake at eight sites during July and August. **The only site with an elevated count was at the outlet of Schimke Creek with counts of 171 and 205 per 100 ml. in late July and late August, respectively**. Over the past four years (2009-2012) a limited number of E. coli samples have been taken at various sites around the lake and all have been low or below detection levels.

In the past three years (2010-2012) there have been some attempts to **sample storm drains and to analyze for a number of parameters, including several heavy metals, volatile organic compounds, chlorides, and our usual water quality parameters**. In general, this effort has not been adequate for good evaluation due to the fact that it did not occur at times of runoff or there was too limited data. The only indication so far is that there does not appear to be a significant nutrient source from the drains for the lake. None of the heavy metals were detectible except for one very low mercury value, and no volatile organic compounds were detected. Hopefully we will be obtaining better samples in the near future.

We must recognize that Portage Lake has **several physical factors in its favor and only a few of detriment:** 1.) It has a **relatively small watershed relative to the surface area of the lake** which is mostly forested, and thus, has less run-off and lower lake productivity. 2) The soils of the watershed are **mostly well-drained sand or sandy loam** so that, in general, surface runoff is minimized by the permeability of the soils. 3.) It has **a moderately good mean depth** (average = 19 ft.) which implies a lower fertility. 4.) It has a **relatively short water residence time** of 3.5 years due to the outlet to Lake Michigan which results in a greater flushing of the lake and an exchange of water with Lake Michigan to moderate the levels of nutrients and, thus, reduce productivity. 5.) The **maximum effective length and length orientation** of the lake relative to the prevailing wind has both benefit and adverse results. The strong west and east winds and wave action cause a greater movement (exchange) of water in and out of the lake through the outlet. At the same time, the heavy wave action at times causes more mixing of the nutrients into the water from the shallow bottom in the east end of the lake and increases productivity of the lake. 6.) The **relatively large littoral zone** (shallow area out to the edge of plant growth), approximately 55% of the lake surface, would imply a greater area of plant productivity but due to the sandy, wave-swept bottom of much of the littoral zone this limits plant invasion of the shallowest part of the shelf and decreases the total production somewhat.7.) The **relatively low ratio of hypolimnion-to-epilimnion** (lower water-to upper water areas) tends toward greater productivity, especially of phytoplankton, but also aquatic macrophytes (plants). 8**.) Groundwater is an important resource** for Portage Lake and for the streams, and may be more significant to water quality of Portage Lake than runoff, due mainly to the short length and low flows of the tributaries which are primarily ground water inputs.

Continual lake assessment is necessary to maintain a healthy aquatic ecosystem, to detect changes and avoid harmful influences of man. Such an ecosystem implies a variety of environmental habitats available for a diverse group of inhabitants – all part of the complex food web. **A diverse aquatic ecosystem** possesses a greater number of functions and contributes to both the intrinsic and socio-economic values of the lake. A healthy lake will have a greater biodiversity of aquatic invertebrates, aquatic macrophytes (plants), phytoplankton (microscopic algae), fishes and beneficial benthic (bottom) microbial communities. Although Portage Lake contains a healthy biodiversity of plants, fish, and other organisms, it does have a moderately high general productivity and nutrient level, and with continual inputs of nutrients. Thus, the system must be monitored continually to avoid impending problems in the future. **With the outlet to Lake Michigan and its exchange of water and nutrients Portage Lake has a lot going for it.**