NOTES referenced in "**Comments on Stantec's Community Studies for Sandy Lake (a Future Serviced Community): Significant omissions & misinterpretation of data related to the water quality of Sandy Lake".** Document of Jul 18, 2025, sent to Honourable Colton LeBlanc, Minister of Growth and Development, Nova Scotia; cc Melissa Eavis, Lead HRM Planner for Sandy Lake SPA; Mayor Andy Filmore, Halifax, N.S.; Clayton Developments, Halifax, Halifax Regional Councillors; John Haseltine, Stantec Consultants Ltd; Environment and Sustainability Standing Committee, HRM; Sandy Lake Conservation Association, Bedford,NS, From: David Patriquin, Prof. of Biology, Dalhousie University (retired)

1. '**Minister Designates New Special Planning Area;** Two Major Studies Complete" NS Gov News Release, Growth and Development, May 16, 2025. https://news.novascotia.ca/en/2025/05/16/minister-designates-new-special-planning-area-two-major-studies-complete. There is a related CBC News Report: "N.S. designates new special planning area near Blue Mountain-Birch Cove Lakes" by Taryn Grant, Haley Ryan, May 16, 2025. https://www.cbc.ca/news/canada/nova-scotia/n-s-designates-new-special-planning-area-near-blue-mountain-birch-cove-lakes-1.7536939

2. **Stantec Consulting Ltd. awarded the contract to conduct the Future Serviced Communities Studies for four Special Planning Areas**

The **RFP** was issued Oct 6, 2022, Closing Date Nov 16, 2022 https://procurement-portal.novascotia.ca/tenders/HRM-22-373 Award Announced Mar 14, 2023.
Completion of Studies was originally targeted for March 2024. Final studies were made public on May 16, 2025.

From Future Service Communities webpage for 2 Jun 2023:
(https://web.archive.org/web/20230602212747/https://www.shapeyourcityhalifax.ca/futureservicecommunitieshttps://www.shapeyourcityhalifax.ca/futureservicecommunities)

The need for additional serviced lands to provide housing and services to accommodate population growth has been identified through the ongoing Regional Plan Review. In order to support the region's current and expected population growth, the Province has invested $2.3 million(External link) to enable the municipality to conduct a series of critical technical studies to inform the possibility of supporting fully serviced development in four study areas. Stantec has been awarded the contract to conduct the Future Serviced Communities Studies through a request for proposals process. Completion of the studies is targeted for March 2024. The four locations being studied are:

- Lands to the west of Sandy Lake in Bedford;
- Highway 102 West Corridor lands in Halifax;
- Lands southeast of Morris Lake in Dartmouth and Cole Harbour; and
- Lands including and immediately surrounding the former Nova Scotia Home for Colored Children (now owned by Akoma Holdings) in Westphal.

Completion of the studies is targeted for March 2024

From: Item No. 6, Halifax Regional Council, May 9, 2023
SUBJECT: Award of Contracts – Quarterly Report January 2023 to March 2023
https://cdn.halifax.ca/sites/default/files/documents/city-hall/regional-council/230509rci06.pdf

Tenders Title of Report: Award Request for Proposal- 22-373 Future Serviced Communities Background Studies **Name of Company:** Stantec Consulting* WSP CBCL **Total Bid Price** (net HST): $1,054,435** **Budget/Cost Estimate**: $2,200,000 D001 **Details/ Cost Share Amount**: Awarded to the highest scoring proponent

3. "**A large set of observations (data) pertaining to the current state of Sandy Lake obtained 2017-2024"**

Context: I retired from my position as Prof. of Biology at Dalhousie University in 2008. Since then I have been active in several natural history and trail organizations, and spend as much time as I can exploring my "bioregion", which I defined as lands within 50 km of my home on peninsular Halifax. Through these activities I have documented or helped to document the ecological values of four areas proposed for and that finally received formal protection: the Five Bridge Lakes Wilderness Area (Protected 2011), two Nature Trust properties on the Chebucto Peninsula (Protected 2019), and the Williams Lake Backlands, now the Shaw Wilderness Park (Protected 2020). It was in this context that in the spring of 2017 I received a message from Karen Robinson of the SLCA (Sandy lake Conservation Association) - who I didn't know personally - asking if I would do a "floral survey" of lands by Sandy Lake in connection with their efforts to see more of the area protected. I was hesitant to do so time-wise, but said I would have a look at the area… one visit enticed me enough to want to explore more of the area. I told K.R. that I could not do a floral survey as such because I am not proficient enough botany-wise to do so (re: ID of graminoids in particular), but I could do a general description of the plant communities; it would be an entirely voluntary exercise and, as I envisioned it at the time, along the lines of a study I had conducted of the Williams Lake Backlands in 2013*, for which the field work and report were completed in 9 months. I conducted 22 excursions in the Sandy Lake area June 14 to Nov 1, 2017, then realized that I had just scratched the surface of this diverse area of approx. 1800 acres/730 ha and 5 x the size of the Williams Lake Backlands (308 acres/154 ha). Clearly this would be an ongoing study for some time.

*See **"Ecological Assessment of the Plant Communities of the Williams Lake Backlands".** A REPORT to The Williams Lake Conservation Company by Nick Hill & David Patriquin. 2014. 108 pages. Available at https://dalspace.library.dal.ca/items/56d67273-f64f-47cb-bd58-6731485e52e2 I asked Nick Hill to assist on the wetland aspects, WLCC covered Nick's travel expenses and costs for some laboratory analyses; I was responsible for the overall project, writing up etc.; my activities were entirely voluntary (unpaid).

So rather than have the SLCA wait several plus years for a report, I created a website and posted my observations, interpretations, related lit. etc. on an ongoing basis - with no prior review, approval etc. from the SLCA. It was made publicly available in keeping with my efforts to promote interest in natural history more broadly - I had previously developed and maintained information-oriented websites for the NS Wild Flora Society, the Halifax Field Naturalists, the Woodens River Watershed Environmental Organization/The Bluff Trail and the Backlands Coalition. As with my other conservation-related reports, my studies of Sandy Lake & Environs have been conducted as an entirely voluntary activity, expenses included.

Conducting limnological observations was entirely my initiative; they were not requested by the SLCA. I had conducted a set of limnological observations on Williams Lake and associated surface waters in 2015* so I was familiar with the procedures, borrowing equipment etc. I was assisted at Sandy Lake by 3 volunteers who are lakeside residents and members of the SLCA; they provided boat transportation; as well, one (Ed G.) had a detailed knowledge of the lake bathymetry which he had mapped in 2006 (see map at https://versicolor.ca/sandylakebedford/maps/).

*"Water quality measurements on Williams Lake and Colpitt Lake (Halifax, N.S.) Dec 7-13, 2015 with reference to possible impacts of road salt". Report to Williams Lake Conservation Company (WLCC) by David Patriquin, January 6, 2016, 39 pp. Available at https://dalspace.library.dal.ca/items/80f4323a-8f5f-404c-bf59-0ad80c37e82d

The website/ongoing report,
"Sandy Lake & Environs (Bedford, Nova Scotia *A Natural History Perspective*".
is available at www.versicolor.ca/sandylakebedford

The limnological data are available in a top level section/menu item of the website labelled "Surface Waters" (https://versicolor.ca/sandylakebedford/waters/). For example, all of the limnological profile data are provided under Surface Waters/Sandy Lake/Limnological Profiles (https://versicolor.ca/sandylakebedford/waters/lakes/limnol-profiles)

On my communications with Stantec
I participated in meetings organized by the Sandy Lake Sackville River Regional Park Coalition and Stantec personnel on May 2 (in person) and June 22, 2023 (online), presenting my concerns related to "The Precarious State of Sandy Lake"; those are detailed in this document:
https://versicolor.ca/sandylakebedford/wp-content/uploads/2024/05/PatriquinSandyLkLSA22May2024.pdf
In those meetings and in related correspondence with John Haseltine (Senior Planner at Stantec) subsequently I directed Stantec to the observations cited above and to significant updates.

At no time did Mr. Haseltine or others at Stantec question the validity of the observations or indicate that they were not of interest, quite the reverse, the meetings were cordial, thanks all around etc.

The first indication I had that perhaps my observations were going to be discounted was provided when a Draft LSA was released Apr 18, 2024. I wrote Ben Sivak, Manager Of Planned Growth, Strategic Projects | Planning & Development, HRM about these concerns on May 22, 2024*; subsequently I was invited to a meeting with HRM staff to discuss them, along with members of the steering committee for Sandy Lake-Sackville River Regional Park Coalition who had other concerns about the Draft LSA. We were assured by Staff that our various concerns with the Draft LSA would be passed on to Stantec.

Re: HALIFAX REGIONAL MUNICIPALITY - FUTURE SERVICED COMMUNITIES DRAFT REPORT - VOLUME 2: SANDY LAKE STUDY AREA REPORT – LAND SUITABILITY ANALYSIS

Comments on Watercourses, Wetlands and Water Quality

by David Patriquin
(Prof of Biology, Dalhousie University, retired)

May 22, 2024

Above: From title page of 8 page Comments Document sent to Ben Sivak, Manager Of Planned Growth, Strategic Projects | Planning & Development, HRM on May 22, 2024*;

*For details see

- **Comments Document** at https://versicolor.ca/sandylakebedford/wp-content/uploads/2024/05/PatriquinSandyLkLSA22May2024.pdf;

- **Covering Letter** at https://versicolor.ca/sandylakebedford/wp-content/uploads/2024/05/PatriquinSandyLkLSAcoveringLetter22May2024.pdf

4. 1971 and 2021 data obtained by other observers brought to the attention of Stantec

1971:

- **Metropolitan Area Planning Committee 1971-1972: Water Quality Survey for Selected Metropolitan Area Lakes**; this document includes data for Sandy Lake on temperature, specific conductivity, chloride and oxygen near lake surface, and near bottom (18m) at or close to the deepest spot in the lake. See https://versicolor.ca/sandylakebedford/waters/lakes/#limno for my first reference to these data. Curiously, Stantec comments, p3 in their Watershed Study: "Data collected prior to 1980 was not included in this study in the detailed analysis due to the sparsity of measurements and their potential limitations in representing temporal trends accurately. Data prior to and including 1980 are generally limited to one measurement per year, which makes the data less reliable for detecting nuanced patterns or changes over time", yet they cite the deepwater oxygen level for 1998, (p. 8) which would have been subject to the same limitation; and they fail to mention the depth of the measurement or the related surface value (see https://versicolor.ca/sandylakebedford/waters/lakes/#limno)

- 2021: Doucet, C. 2022. "Identifying Lake Water Quality Trends and Effective Monitoring Strategies in a Rapidly Urbanizing Region." Masters thesis Dalhousie University, Halifax, Nova Scotia. November 2022. Available on DalSpace: https://dalspace.library.dal.ca/items/4b3b81e9-452c-43c0-8a0e-d63f829bd3db Chapter 3 in this thesis "...presents the findings of a supplementary study where trophic state parameters in a subset of the SWQS lakes [including Sandy Lake] were tracked (5 times) over the 2021 open-water season to examine nutrient and productivity dynamics and evaluate the utility of existing models and indicators that are widely used to characterize lake trophic state". In the Stantec Sandy Lake Watershed Study, they cite this

document, but make use only of data for 2 samples collected in March (Stantec Watershed Study, Table 1.1, p4), and they ignore entirely the deepwater profiles given in Doucet's Supplement 3, including profiles of Total P which provide evidence of Internal P Loading.

5. **The Stantec Reports pertaining to Sandy Lake and Stantec's use of information on Sandy Lake that I shared with them**

The Stantec Reports are available on the Future Service Communities webpage at https://www.shapeyourcityhalifax.ca/futureservicecommunities, specifically
Sandy Lake Summary Report.pdf (6.15 MB) (pdf)
Sandy Lake Land Suitability Analysis.pdf (64.9 MB) (pdf)
Sandy Lake Watershed and Stormwater Management Study.pdf (88.7 MB) (pdf)

On page 17 of the summary report, Stantec comments "**The Coalition** is opposed to development in the Study Area and would prefer all the proposed development lands to be incorporated in the proposed regional park. Failing its acquisition as parkland, they emphasized the need for generous wildlife corridors through the area and substantial riparian buffers around all watercourses. They were critical of past water quality assessments and **provided a study of local water quality prepared by member Dr. David Patriquin, a retired biology professor from Dalhousie University**."

Some clarification on my relationship to the Sandy Lake/Sackville River Regional Park Coalition: I am not a member of the Coalition, rather I have served as a representative/contact person on the Coalition for 3 member organizations in which I am a member (Woodens River Watershed Environmental Organizations, Halifax Field Naturalists and NS Wild Flora Society). I was asked and volunteered to be a co-chair of the Coalition when it was formed in Dec of 2018 just to help it get going but resigned shortly thereafter to maintain the appearance as well as the fact of my independence as a scientific observer. I, not the Coalition, forwarded the studies to Stantec; my reports on Sandy Lake observations are my own, I place them directly on the versicolor.ca/sandylakebedford website to make them publicly available ASAP after they are obtained; these reports are prepared without any consultation with Sandy Lake advocacy organizations and individuals. Regardless, except for observations I made/samples collected for the Halifax LakeWatchers program with assistance of volunteers from the Sandy Lake Conservation Association in August of 2022 and May and August of 2023 (which Stantec attributes to HRM-Lake Watchers alone), none of the data I forwarded were made use of in the Stantec Reports.

6. "**The development(s) would occur in an area of concentration of headwater streams and 24 associated wetlands close to the lake**". The wetlands are identified in the Stantec Sandy lake LSA (Landscape Suitability Analysis).

"**Those watercourses have a disproportionately large influence on the Water Quality of Sandy Lake, providing well over 50% of flow into Sandy Lake**" - see https://versicolor.ca/sandylakebedford/waters/lakes/limnol-profiles/2024-limnological-profiles-return-to-historic-trends/in-conclusion-the-precarious-state-of-sandy-lake/#major. " In 2020, I made an estimate of the proportion of water going into Sandy Lake that comes from settled landscapes, versus water coming from intact (unsettled) landscapes based on my measurements of the EC (salt) values for lake water, surface waters coming from settled areas, and surface waters

coming from intact (unsettled) landscapes. My estimate: 78% comes from settled areas, those mostly to the west and southwest of Sandy Lake; and 22% comes from currently intact landscapes. This conclusion is consistent with the comment in AECOM 2014: "The greatest flow into Sandy Lake is from Bobs Brook and other tributaries from the western portion of the watershed."

The 74 ha Sandy Lake supports a high diversity of wildlife, and is valued recreationally...
See website at www.versicolor.ca/sandylakebedford, e.g. Overview (https://versicolor.ca/sandylakebedford/overview & Nature NS Appeal to Save Sandy Lake (https://versicolor.ca/sandylakebedford/misc/nature-ns-appeal-to-save-sandy-lake/). The larger area (including forests, wetlands etc.) supports 15 Species-at-Risk.

Diagram at www.versicolor.ca/wildlife/species-lists/

7. **" I am not a specialist in limnology but I do have some related background."** I have MSc and PhD degrees in Marine Science from McGill University, 'participated in many oceanographic measurements as a summer employee with the Fisheries Research Board 1962-1965, and in part time employment during my graduate studies 1964-1970. I worked part time as an Environmental Consultant 1975-1976 designing, directing and writing up a comprehensive survey of the Marine Resources of Kouchibouguc National Park in New Brunswick (Report available at https://dalspace.library.dal.ca/items/8d80de32-2d80-4551-9c5f-53cd2df3395e). My PhD research involved studies of nutrient cycling/microbial ecology in seagrass beds; as a Killam researcher (1973-1975) and faculty member (1975-2008) in the Biology at Dalhousie University, I conducted

research on nutrient cycling/microbial ecology in coastal marshes, and agricultural systems. Details at https://versicolor.ca/davidGpatriquin/index.html

I retired in 2008. Since then I have been active in several natural history and trail organizations, and spend as much time as I can exploring my "bioregion", which I defined as lands within 50 km of my home on peninsular Halifax. Through these activities I have documented or helped to document the ecological values of four areas proposed for and that finally received formal protection: the Five Bridge Lakes Wilderness Area, two Nature Trust properties on the Chebucto Peninsula, and the Williams Lake Backlands (now the Shaw Wilderness Park). I have similar ongoing conservation-related activities in the Halifax Backlands and at the French Village Conservation Woodland as well as at Sandy Lake & Environs (Bedford, NS).

Reports or extracts from my reports documenting ecological values of areas finally given formal protection

Five Bridge Lakes Wilderness Area (Protected 2011)
- "CWC Steering Committee reviews the case for Legislated Protection", Chebucto Wilderness Committee Newsletter #10, Aug 17, 2009, available at https://versicolor.ca/wrweo2014/wrweoFiles/CWC/reports/CWC10_Aug_17_2009.pdf
- "Old Growth Red Oak and Red Spruce stands on the Chebucto Peninsula (Nova Scotia), posted 2009 at https://versicolor.ca/forest/index.html
- "Multi-aged old growth red oak stand on the Chebucto Peninsula" Slide presentation to the Mersey Tobeatic Research Institute Old Forest Conservation Science Conference, Debert, Nova Scotia, Oct 19-21, 2016 Available at https://dalspace.library.dal.ca/items/04194323-a03c-462d-bc27-29995b5aeebc

Nature Trust Properties on Chebucto Peninsula (Protected 2019)
- "Cranberry Lake Lands" a Submission to Nova Scota Environment Protected Areas and Wetlands from David Patriquin & Richmond Campbell on behalf of Woodens River Watershed Environmental Organization (WRWEO). Posted at https://versicolor.ca/cranberry/ January 31, 2012. This property was protected in 2019 following purchase of the land by the Five Bridges Trust. - "Frederick Lake Peninsula Land", Documentation by David Patriquin & Richmond Campbell on behalf of Woodens River Watershed Environmental Organization. January 19, 2012. Protected by NS Nature Trust in 2019. Available at https://versicolor.ca/fredericklakepeninsula/

- Williams Lake Backlands/Shaw Wilderness Park (Protected 2020)
"The park was established in 2020 by the Nature Conservancy of Canada, The Shaw Group and Halifax Regional Municipality (HRM)." https://www.natureconservancy.ca/en/where-we-work/nova-scotia/featured-projects/Shaw-wilderness-park.html Background Ecological Studies: -
"Ecological Assessment of the Plant Communities of the Williams Lake Backlands". A REPORT to The Williams Lake Conservation Company by Nick Hill & David Patriquin. 2014. 108 pages. Available at https://dalspace.library.dal.ca/items/56d67273-f64f-47cb-bd58-6731485e52e2
- "A Rare, Fire-Dependent Pine Barrens at the Wildland-Urban Interface of Halifax, Nova Scotia". Nick Hill and David Patriquin, 2014. Slideshow presentation to the Wildland Fire Canada 2014 Conference, Halifax, N.S. Oct 6-9, 2014 Available at https://dalspace.library.dal.ca/items/6c80a27d-dd91-4175-9b12-a6d1cb5bd803

- "backlandscoalition.ca" A website I set up in 2013 and have maintained for the Backlands Coalition since then in support of community and conservation activities in the Halifax Backlands. See www.backlandscoalition.ca

Water Quality Observations in the Williams lake Watershed (2015)
In 2015, I borrowed a YSI probe from St.Mary's and conducted measurements on Williams Lake and Colpitt Lake as a voluntary activity for the Williams Conservation Co, so I was familiar this equipment when I later used it for observations on Sandy Lake. (View Report to WLCC - "Water quality measurements on Williams Lake and Colpitt Lake (Halifax, N.S.) Dec 7-13, 2015 with reference to possible impacts of road salt" at www.versicolor.ca/williamslake.)

8. **AECOM 2014: "Sandy Lake Watershed Study Final Report"**, 131 pages. Available at https://sandylake.org/wp-content/uploads/2017/11/SandyLakeFinalReport26Aug20141.pdf

9. **"Those initial observations raised significant concerns about the state of the lake".** See https://versicolor.ca/sandylakebedford/waters/lakes/limnol-profiles/#3oct2017 This page with the 2017 data and comments was created on Dec 29, 2017.

On location of the deepest spot in Sandy Lake. See Bathymetric map at https://versicolor.ca/sandylakebedford/waters/lakes/limnol-profiles/#background

10. **Follow-up surveys of Sandy Lake and feeder streams for salt levels (measured as Specific Conductivity):** See subpages under Surface Waters/Streams and Wetlands at **www.versicolor.ca/sandylakebedford/**

Further limnological profiles: All profile data (2017-2025 and ongoing) are given on this webpage: https://versicolor.ca/sandylakebedford/waters/lakes/limnol-profiles/

11. **" Beginning in the fall of 2022, we conducted the limnological profiles in collaboration with the Halifax LakeWatchers Program...it involved observing the same limnological profiles at the deepest spot plus some additional sampling."** See Halifax LakeWatchers at https://www.halifax.ca/about-halifax/environment-climate-change/lakes-rivers/lakewatchers. View sampling results via https://data-hrm.hub.arcgis.com/ (requires some database skills); those for Sandy Lake are also available on the Limnological Profiles webpage https://versicolor.ca/sandylakebedford/waters/lakes/limnol-profiles/

12. **Halifax LakeWatchers 2023-2024 Report**
Available with the related ESSC Report on its release on Oct 3, 2024 at https://www.halifax.ca/sites/default/files/documents/city-hall/standing-committees/241003essc1312.pdf
See ESSC Presentation PDF at https://cdn.halifax.ca/sites/default/files/documents/city-hall/standing-committees/241003essc1312pres.pdf

See my initial review (Oct 6, 2024) of the report at
https://versicolor.ca/sandylakebedford/2024/10/06/hrm-lakewatchers-state-of-the-lakes-2022-23-sampling-years-report-released/

13. **Sources for Fig 2: Historic Deep Water Oxygen values for Sandy Lake (Bedford) during or close to peak the peak summer stratification period.** See legend to Table 1 in "2024 Limnological Profiles – return to historic trend of declining oxygen" (webpage on www.versicolor.ca/sandylakebedford)
https://versicolor.ca/sandylakebedford/waters/lakes/limnol-profiles/2024-limnological-profiles-return-to-historic-trends/#long

14. **The freshening in 2023 occurred during a period of exceptionally high precipitation and flooding in the area of Sandy Lake.** See
-"2023 Limnological Profiles, effects of episodic precipitation, and occurrence of a Metalimnetic Oxygen Minimum in Sandy Lake (Bedford, NS)", webpage at
https://versicolor.ca/sandylakebedford/waters/lakes/limnol-profiles/2023-limnological-profiles-effects-of-episodic-preciptation/

On exceptionally high rainfall in July and Aug of 2023, see comment with links at
https://versicolor.ca/sandylakebedford/waters/lakes/limnol-profiles/#2023pptn

15. **Hypolimnion of circa 6 to 15°C and oxygen levels above 3-5 mg/L are required to support salmonids**. Summer temperatures in the hypolimnion of circa 6 to 15°C and oxygen levels above 3-5 mg/L are required to support salmonids (Doudoroff & Shumway, 1970, CCME, 1999, Jacobson et al., 2010) . In Sandy Lake, salmonids include brook trout and Atlantic salmon; salmon have been returning to the Sackville River Watershed including Sandy Lake through the efforts of the Sackville Rivers Association. Warmwater fish species and other aquatic life are also affected by oxygen levels: "DO is considered an important measure of water quality as it is a direct indicator of an aquatic resource's ability to support aquatic life...While each organism has its own DO tolerance range, generally, DO levels below 3 milligrams per liter (mg/L) are of concern and waters with levels below 1 mg/L are considered hypoxic and usually devoid of life."- US-EPA. Brylinski 2002 (Nova Scotia Lake Hypolimnion Project) defined "Suitable cold-water habitat" as "water temperature ≤15 °C and dissolved oxygen saturation ≥50 % [to maintain oxygen ≥5 mg/L]".

Refs:
- **Doudoroff & Shumway, 1970** "Dissolved oxygen requirements of freshwater fishes" FAO Technical Paper No 86. Available at https://ir.library.oregonstate.edu/downloads/rv042t98q?locale=en.

- **CCME, 1999**: "Canadian Water Quality Guidelines for the Protection of Aquatic Life DISSOLVED OXYGEN". Canadian Council of Ministers of the Environment, 1999 Available at https://ccme.ca/en/res/dissolved-oxygen-freshwater-en-canadian-water-quality-guidelines-for-the-protection-of-aquatic-life.pdf

- **Jacobson et al., 2010**. "Coldwater fish oxythermal habitat in Minnesota lakes: influence of total phosphorus, July air temperature, and relative depth." *Canadian Journal of Fisheries and Aquatic Sciences*. https://doi.org/10.1139/F10-115

- **Salmon Parr spotted at the top of Peverills Brook June 24, 2024**, post on www.versicolor.ca/sandylakebedford at https://versicolor.ca/sandylakebedford/2024/06/28/salmon-parr-spotted-at-the-top-of-peverills-brook-june-24-2024/

- **US EPA: Indicators: Dissolved Oxygen** https://www.epa.gov/national-aquatic-resource-surveys/indicators-dissolved-oxygen

- **Brylinski 2002. "Nova Scotia Lake Hypolimnion Project"** https://acer.acadiau.ca/tl_files/sites/acer/resources/PDF%20Files/67%20ACER%20Publication.pdf

16. **Internal P Loading as "phosphate released from anoxic sediment ...":** Nürnberg, G.K and B LaZerte, B.D. 2016. "More than 20 years of estimated internal phosphorus loading in polymictic, eutrophic Lake Winnipeg, Manitoba" *Journal of Great Lakes Research*, Volume 42, Issue 1: 18-27, https://www.sciencedirect.com/science/article/abs/pii/S0380133015002257

2 mg L^{-1} 1 m above sediment coincides with anoxic conditions in sediments: Nurnberg, G.K. 2004. "Quantified hypoxia and anoxia in lakes and reservoir". In *The Scientific World Journal*, 4:42-54 https://pmc.ncbi.nlm.nih.gov/articles/PMC5956421/pdf/TSWJ-2004-4-276509.pdf

Hypoxia classically defined: Tellier,J.M. et al., 2022. "Widespread prevalence of hypoxia and the classification of hypoxic conditions in the Laurentian Great Lakes". In *Journal of Great Lakes Research,* Volume 48, Issue 1,13-23 https://www.sciencedirect.com/science/article/pii/S0380133021002458

Internal P Loading in shallow areas: Zhao et al., 2023. "Elevated internal phosphorus loading from shallow areas of eutrophic boreal lakes: Insights from porewater geochemistry." In *Science of the Total Environment* https://www.sciencedirect.com/science/article/pii/S0048969723065774

Some selected references explaining/reviewing lit. on Internal P Loading

- Lewis, ASL et al., 2023. "Anoxia begets anoxia: A positive feedback to the deoxygenation of temperate lakes" in *Global Change Biology* https://doi.org/10.1111/gcb.17046
- Orhiel et al., 2017. "Internal phosphorus loading in Canadian fresh waters: a critical review and data analysis." In *Canadian Journal of Fusheries and Aquatic Science*. https://cdnsciencepub.com/doi/10.1139/cjfas-2016-0500
- Huser et al., 2023 "Handbook – a decision support tool for measures against internal phosphorus loading in lakes". Full text available at https://www.richwaters.se/handbook-a-decision-support-tool-for-measures-against-internal-phosphorus-loading-in-lakes/
- Tammeorg, O., Nürnberg, G., Niemistö, J. *et al.* 2020. "Internal phosphorus loading due to sediment anoxia in shallow areas: implications for lake aeration treatments." *Aquat Sci* **82**, 54. https://doi.org/10.1007/s00027-020-00724-0.

For a comprehensive, fully referenced and freely accessible treatment of the practical issues involved in addressing Internal P Loading, see "**Handbook – a decision support tool for measures against internal phosphorus loading in lakes**" by Brian Huser et al., 2023 in Rich Waters (Swedish Agency for Marine and Water Managemnt) developed with the support of the European Union. It consists of a 56 page Report and 6Appendices . Available at https://www.richwaters.se/handbook-a-decision-support-tool-for-measures-against-internal-phosphorus-loading-in-lakes/

17. **More recent, deep water phosphorus values obtained by SRV/HLW* in 2022...**
See webpage with Limnological Profiles for Sandy Lake at
https://versicolor.ca/sandylakebedford/waters/lakes/limnol-profiles/

18. **A response to the Draft LSA**
See:
- "Re: HALIFAX REGIONAL MUNICIPALITY - FUTURE SERVICED COMMUNITIES DRAFT REPORT - VOLUME 2: SANDY LAKE STUDY AREA REPORT – LAND SUITABILITY ANALYSIS Comments on Watercourses, Wetlands and Water Quality" by David Patriquin
(Prof of Biology, Dalhousie University, retired) May 22, 2024. Available at
https://versicolor.ca/sandylakebedford/wp-content/uploads/2024/05/PatriquinSandyLkLSA22May2024.pdf
- Covering Letter available at https://versicolor.ca/sandylakebedford/wp-content/uploads/2024/05/PatriquinSandyLkLSAcoveringLetter22May2024.pdf

19. **On estimating how much further salt levels might may rise with and without new development.** See
- "Addendum 1: Trends in Conductivity/Salt Content", Webpage at
https://versicolor.ca/sandylakebedford/waters/lakes/limnol-profiles/2024-limnological-profiles-return-to-historic-trends/addendum-1-trends-in-conductivity-salt-content/
- "Mirror Lake – Sandy Lake comparison" Webpage at
https://versicolor.ca/sandylakebedford/waters/lakes/sl-report-more-details/mirror-lake-sandy-lake-comparison/

20. **Comments in AECOM 2020 and Halifax LakeWatchers 2023-2024 Report on salt effects on lake turnover, Anoxic Conditions & Internal P Loading etc,**

AECOM 2020 "Halifax Regional Municipality Water Quality Monitoring Policy and Program Development", Prepared by: AECOM Canada Ltd., Sep 2020 , 99 pages + Appendices. Available at https://www.halifax.ca/sites/default/files/documents/city-hall/boards-committees-commissions/210211rwabsp911.pdf See pp.46-47, Sections 6.3.1 Eutrophication and 6.3.2 Chloride Enrichment

Lake Watchers on Anoxic Conditions and Internal P Loading
See p 9, 22, 28-29 in Halifax LakeWatchers 2023-2024 Report Available with the related ESSC Report on its release on Oct 3, 2024 at https://www.halifax.ca/sites/default/files/documents/city-hall/standing-committees/241003essc1312.pdf

p 24 "...anoxic conditions were observed at 58 of 77 lake basins during either the summer sampling of 2022 or 2023, while 36 lake basins exhibited anoxic conditions during both summer sampling periods. This is concerning because anoxic conditions near the lakebed can lead to the release of nutrients, such as phosphorus, and other harmful contaminants trapped in the lakebed in a process known as internal loading. Anoxic layers ranged from as small as 0.5 m to as large as 16 m at First Lake..."
p28: "As stated previously, prolonged periods of anoxia at the lakebed can result in a process known as 'internal loading' by creating conditions favorable for the release of previously sediment-bound nutrients and other harmful contaminants from the lakebed back into the water column. This process has already been documented in some of the municipality's lakes (Doucet 2022, Doucet et al. 2023, Bermarija et al. 2023, and Sivarajah et al. 2024) and the LakeWatchers dataset supports the assertion that internal loading is occurring. In both summer 2022 and 2023, most of the lake basins exhibiting de-oxygenated conditions also showed higher total phosphorus levels from the deepwater sample when compared to the surface water sample."

21. "**Ongoing monthly measurements of conductivity of lake water..."**
See www.versicolor.ca/sandylakebedford, page on **Seasonal Monitoring**
https://versicolor.ca/sandylakebedford/waters/streams-wetlands/ec-salt/more-monitoring/

22. **On the Metalimnetic Oxygen Minimum (MOM) in Sandy Lake.**
See "2023 Limnological Profiles, effects of episodic precipitation, and occurrence of a Metalimnetic Oxygen Minimum in Sandy Lake (Bedford, NS)", webpage at
https://versicolor.ca/sandylakebedford/waters/lakes/limnol-profiles/2023-limnological-profiles-effects-of-episodic-preciptation/

23. **On exceptionally high rainfall in July and Aug of 2023**
See comment with links at https://versicolor.ca/sandylakebedford/waters/lakes/limnol-profiles/#2023pptn

24. **Casey Doucet Profile during Aug 16-23 period, 2021** See Note [4] above; her chart is reproduced at https://versicolor.ca/sandylakebedford/waters/lakes/limnol-profiles/#doucet2021

25. **Metalimnetic Oxygen Minimum in Sandy Lake Profiles** - see "Limnological Profiles", webpage at https://versicolor.ca/sandylakebedford/waters/lakes/limnol-profiles/

26. **Brylinski's 2002 report on the Nova Scotia Lake Hypolimnion Project**
Available at
https://acer.acadiau.ca/tl_files/sites/acer/resources/PDF%20Files/67%20ACER%20Publication.pdf

27. **About the Metalimnion Oxygen Minimum, Mi et al. 2020**
Mi et al. 2020: "The formation of a metalimnetic oxygen minimum exemplifies how ecosystem dynamics shape biogeochemical processes: A modelling study" In *Water Research*
https://www.sciencedirect.com/science/article/abs/pii/S0043135420302372

28. **Canadian Water Quality DISSOLVED Guidelines for the Protection of Aquatic Life: OXYGEN**
Available at https://ccme.ca/en/res/dissolved-oxygen-freshwater-en-canadian-water-quality-guidelines-for-the-protection-of-aquatic-life.pdf

29. **Extensive shallower areas in the South Basin of Sandy Lake.** See
- Sandy Lake Bathymetric Map at https://versicolor.ca/sandylakebedford/maps/
- WAM Predicted Flows at https://versicolor.ca/slbfiles/maps/dnrmaps/WAMglow.jpg

30. **Massive flow of wood chips into the northern basin of Sandy Lake** See description, photos at https://versicolor.ca/sandylakebedford/waters/streams-wetlands/wetlands/lake-fringes/karens-brook-nw-beach/

31. **Sandy Lake closed on Aug 6, 2019 due to algal bloom** See "Sandy Lake inundated by unpleasant, suspended, reddish, soapy material Aug 6, 2019; and lake level falling quickly", post on www.versicolor.ca/sandylakebedford at https://versicolor.ca/sandylakebedford/2019/08/07/sandy-lake-inundated-by-unpleasant-suspended-reddish-soapy-material-aug-6-2019/

32. **Some controversy about whether there have been any BGA Blooms in Sandy Lake.** A list of past "reports" of BGA blooms is maintained by NS Gov (https://novascotia.ca/blue-green-algae/documents/Confirmed%20blue-green-algae.pdf)
At a meeting of NW Community Council on June 12, 2023, Councillor Outhit maintained that I misrepresented the blooms in Sandy Lake; I address his comments in Note # 40 on this webpage: https://versicolor.ca/sandylakebedford/waters/lakes/limnol-profiles/2024-limnological-profiles-return-to-historic-trends/in-conclusion-the-precarious-state-of-sandy-lake/notes/#forty A report of a BGA Bloom in Sandy Lake in September of 2024 is listed on the NS Gov website (https://novascotia.ca/blue-green-algae/documents/Confirmed%20blue-green-algae.pdf), but I think was not confirmed (or not) by formal testing.

33. **Confirmed Blue Green Algae Bloom in Sandy Lake, Nov 6, 2024**
- "Curious BGA bloom on Sandy Lake (Bedford, NS) in early November". Post on versicolor.ca/sandylakebedford on Nov 11, 2024
https://versicolor.ca/sandylakebedford/2024/11/11/curious-bga-bloom-on-sandy-lake-bedford-ns-in-early-november-11nov2024/
- Linda Campbell, David Patriquin, Michael Agbeti, 2025. "Unusually late occurrence of a Dolichospermum bloom in a Nova Scotia lake" Published in *Harmful Algae News* (HAN): An IOC Newsletter on Toxic Algae and Algal Blooms. Open Access. 78:10-11. https://doi.org/10.5281/zenodo.14883731. PDF available at https://www.ap.smu.ca/~lcampbel/%5b87%5dCampbell_SandyLake_Bloom_2025-02-19_HAN_78.pdf

34. **Water quality objectives adopted under the current (2014) Regional Plan** As cited by Erin McIntyre in a presentation on Sep 7, 2023: "Fall River- Lakes Secondary Plan Policy", slide 4. View September 7, 2023 Environment and Sustainability Standing Committee, item **13.1.1 Current Policies for the River-Lakes Secondary Plan – Update**

https://www.halifax.ca/city-hall/standing-committees/september-7-2023-environment-sustainability-standing-committee

35. **NNIP is a developing strategy for HRM lakes and watersheds more broadly.**
See: Item No.13.1.2 Environment and Sustainability Standing Committee
August 1, 2024 SUBJECT: Municipal Watershed Management Framework.
https://cdn.halifax.ca/sites/default/files/documents/city-hall/standing-committees/240801essc1312.pdf
From PDF page 26 (bolding inserted):

> In surface water in the Halifax region, phosphorus and chloride are the two primary contaminants of concern. Chloride contamination mostly comes from road salt application, which is transported into surface water when it rains or when snow melts. Phosphorus contamination can come from a variety of sources, including stormwater runoff, chemical fertilizer application, soil erosion or disruption during construction activities, wastewater cross- connections, malfunctioning or poorly decommissioned on-site septic systems and wastewater overflows.
>
> **Any plan for urban watershed management will likely consist of limiting further phosphorus and chloride contamination** and remediating affected lakes and streams through habitat restoration. In a plan for a rural watershed, management will more likely consist of working with landholders to maintain and conserve natural vegetated conditions wherever possible, especially in wetlands and riparian areas

36. **The procedures to achieve NNIP were introduced to HRM…**
See: "Proposed River-lakes Secondary Planning Strategy", a Presentation to Regional Council For First Reading – October 2, 2012.
https://legacycontent.halifax.ca/council/agendasc/documents/121023ca91pres.pdf

37. **The policy is currently formally applied only in Planning Districts 14/17 (Shubenacadie Lakes).**
- See "Municipal Planning Strategy for Planning Districts 14/17 with amendments to October 13, 2023" at https://www.halifax.ca/media/83903 .

Extracts
p.98: "One of the most important natural assets throughout the Plan Area is the lakes. On the eastern side of the Plan Area, is Lake Thomas and Fletchers Lake and on the western side of the Plan Area is Kinsac Lake which forms part of the Shubenacadie Lakes System. It is the desire of the community to protect the relatively pristine nature of this lake system and controls will be established to limit the amount of phosphorus and pollutants entering the lakes through the retention of pervious surfaces, retention of natural vegetation on steep slopes, provision of landscaping, regulation on the amount and scale of development and management of stormwater. Consideration shall also be given to the establishment of a Wastewater Management District during Phase II of the Planning Process to provide for the collective management of wastewater management systems in this Plan Area as intended by the Regional Plan."

p. 112: "In order to determine if it is feasible to develop these sites, studies shall be required before a development agreement is approved by Council to determine if the development can proceed without exceeding the limits for phosphorus export, pursuant to Policy RL-22..."

p 126:
Policy RL-22
The River-lakes Secondary Planning Strategy shall establish a no net increase in phosphorus as the performance standard for all large scale developments considered through the provisions of policy RL-13 and development agreement (RC-Mar 5/19;E-Apr 6/19) policies RL-4, RL-5, RL-11, RL-12, RL-14 and RL-15 of this Secondary Plan. This Policy shall also apply to proposed developments pursuant to policies S-14A and S-15A (RC-Oct 12/22:E-Nov 16/22) of the Regional Municipal Planning Strategy. A study prepared by a qualified person shall be required for any proposed development pursuant to these policies to determine if the proposed development will export any greater amount of phosphorus from the subject land area during or after the construction of the proposed development than the amount of phosphorus determined to be leaving the site prior to the development taking place. If the study reveals that the phosphorus levels predicted to be exported from the proposed development exceed the phosphorus levels currently exported from the site, then the proposed development will not be permitted to take place unless there are reductions in density or other methods that (RC-Feb 23/16;E-Apr 2/16) to reduce phosphorus export levels to those current before the proposed development. Any stormwater management devices designed to treat phosphorus must be located on the privately-owned land included in the proposed development agreement. (RC-Feb 23/16;E-Apr 2/16) The cost of the study shall be borne by the applicant. The study may rely on phosphorus export coefficients derived from existing studies if they can be justified for application to local environmental conditions. All existing and proposed development within the affected area shall be taken into account and the consultant shall undertake Wet Areas Mapping to help define the ecological boundaries associated with the flow channels, accumulation points, and riparian zones to restrict any high impact development in those areas.

38. **Emergence of Internal P Loading as a prominent concern appears to be related to increasing anthropogenic eutrophication and** to **increased strength and duration of lake stratification associated with climate warming.**

From the Introduction to **Anoxia begets anoxia: A positive feedback to the deoxygenation of temperate lakes,** Abigail S. L. Lewis 2023 et al. in *Global Change Biology* https://onlinelibrary.wiley.com/doi/10.1111/gcb.17046 , bolding inserted:

> Declines in bottom water DO concentrations are often attributed to climate change and/or increased nutrient inputs (Bartosiewicz et al., 2019; Jane et al., 2023; Jenny, Francus, et al., 2016). Increased air temperatures have been shown to drive increased duration of thermal stratification (Foley et al., 2012; North et al., 2013; Oleksy & Richardson, 2021; Woolway et al., 2021), which reduces or inhibits mixing of oxygen to the bottom waters (hypolimnion). Consequently, increases in stratification duration may provide more time for hypolimnetic DO depletion to occur, resulting in lower late-summer DO concentrations and increased duration of anoxia. **Changes in stratification duration appear to be a particularly important driver of DO declines in recent decades** (ca. 1950–2020; Jane et al., 2023). **However, historical nutrient inputs have likely also played a role in deoxygenation by increasing phytoplankton biomass and consequently oxygen demand** (Jenny, Francus, et al., 2016; Jenny, Normandeau, et al., 2016). The relative importance of these two pathways to deoxygenation (i.e., greater stratification duration due to climate change and greater oxygen demand due to eutrophication) likely varies both among lakes and within lakes over time. Consequently, understand- ing interannual DO dynamics across many lakes may be critical to disentangling the independent effects of stratification duration and eutrophication amidst ongoing changes in global climate and land use (e.g., Moss, 2011; Parmesan et al., 2022).

Abstract From "Widespread deoxygenation of temperate lakes" by, SF Jane et al., 2021. in *Nature*. https://www.nature.com/articles/s41586-021-03550-y

> The concentration of dissolved oxygen in aquatic systems helps to regulate biodiversity[1,2], nutrient biogeochemistry[3], greenhouse gas emissions[4], and the quality of drinking water[5]. The long-term declines in dissolved oxygen concentrations in coastal and ocean waters have been linked to climate warming and human activity[6,7], but little is known about the changes in dissolved oxygen concentrations in lakes. Although the solubility of dissolved oxygen decreases with increasing water temperatures, long-term lake trajectories are difficult to predict. Oxygen losses in warming lakes may be amplified by enhanced decomposition and stronger thermal stratification[8,9] or oxygen may increase as a result of enhanced primary production[10]. Here we analyse a combined total of 45,148 dissolved oxygen and temperature profiles and calculate trends for 393 temperate lakes that span 1941 to 2017. We find that a decline in dissolved oxygen is widespread in surface and deep-water habitats. The decline in surface waters is primarily associated with reduced solubility under warmer water temperatures, although dissolved oxygen in surface waters increased in a subset of highly productive warming lakes, probably owing to increasing production of phytoplankton. By contrast, the decline in deep waters is associated with stronger thermal stratification and loss of water clarity, but not with changes in gas solubility. Our results suggest that climate change and declining water clarity have altered the physical and chemical environment of lakes. Declines in dissolved oxygen in freshwater are 2.75 to 9.3 times greater than observed in the world's oceans[6,7] and could threaten essential lake ecosystem services[2,3,5,11].

39. **Internal P Loading is well recognized by researchers at Dalhousie and in NS Environment**
See, e.g. :
- Van Heyst et al., 2022 "Application of phosphorus loading models to understand drivers of eutrophication in a complex rural lake-watershed system" in *Journal of Environmental Management*, https://www.sciencedirect.com/science/article/abs/pii/S0301479721020727;
- Johnston et al., 2021, "Trophic triage: a tiered eutrophication vulnerability screening tool for lakes in sparsely monitored regions". In *Lake and Reservoir Management* . https://doi.org/10.1080/10402381.2020.1857481
- Doucet, 2022 (note [4] above)

Recent monitoring has indicated Internal P Loading may now be quite common in HRM lakes and elsewhere in Nova Scotia lakes.
HRM: See Halifax LakeWatchers 2023-2024 Report, at https://www.halifax.ca/sites/default/files/documents/city-hall/standing-committees/241003essc1312.pdf Extracts:
p24: "...many of the lakes that exhibited strong to moderate thermal stratification also exhibited hypolimnetic dissolved oxygen depletion leading to anoxia. In fact, anoxic conditions were

observed at 58 of 77 lake basins during either the summer sampling of 2022 or 2023, while 36 lake basins exhibited anoxic conditions during both summer sampling periods. This is concerning because anoxic conditions near the lakebed can lead to the release of nutrients, such as phosphorus, and other harmful contaminants trapped in the lakebed in a process known as internal loading. Anoxic layers ranged from as small as 0.5 m to as large as 16 m at First Lake."

p 34 "...prolonged periods of anoxia at the lakebed can result in a process known as 'internal loading' by creating conditions favorable for the release of previously sediment-bound nutrients and other harmful contaminants from the lakebed back into the water column. This process has already been documented in some of the municipality's lakes (Doucet 2022, Doucet et al. 2023, Bermarija et al. 2023, and Sivarajah et al. 2024) and the LakeWatchers dataset supports the assertion that internal loading is occurring. In both summer 2022 and 2023, most of the lake basins exhibiting de-oxygenated conditions also showed higher total phosphorus levels from the deepwater sample when compared to the surface water sample. **"**

Elsewhere in Nova Scotia e.g.,
- Van Heyst et al., 2022 "Application of phosphorus loading models to understand drivers of eutrophication in a complex rural lake-watershed system" in *Journal of Environmental Management*, https://www.sciencedirect.com/science/article/abs/pii/S0301479721020727; "Several lakes in southwestern Nova Scotia, Canada have experienced reoccurring algal blooms and possess concentrations of phosphorus (P) that are in the eutrophic to hypereutrophic range (>35 µg/L). In this study a mass balance modeling approach was used to evaluate the relative contribution of P sources within these watersheds and lakes. Primary sources of P included land runoff, septic systems, agricultural activities including mink fur farming, aquaculture, as well as internal loading...Internal loading of P from lake sediments was also identified as an important potential P loading mechanism, which will likely be exacerbated by climate change."
- Johnston et al., 2021, "Trophic triage: a tiered eutrophication vulnerability screening tool for lakes in sparsely monitored regions". In *Lake and Reservoir Management* . https://doi.org/10.1080/10402381.2020.1857481 "Internal P loading was also confirmed as an important factor affecting eutrophication vulnerability and included within Tier 3 of the screening process."

40. **Internal P Loading can exceed External P Loading,**
- S. S. Borah et al., 2025 "Quantifying Summer Internal Phosphorus Loading in Large Lakes across the United States".In *Environmental Science & Technology*. https://pubs.acs.org/doi/10.1021/acs.est.4c13431 Internal phosphorus loading (IPL) can be a significant phosphorus (P) source in freshwater systems, often causing water-quality improvement delays. Despite its importance, IPL estimates are missing for many freshwater systems due to several large-scale measuring and modeling challenges. ..In this study, we develop a modeling framework to estimate summer anoxic sediment release rates (SRRs) for P in 5899 large lakes and reservoirs (surface area > 1.0 km^2; mixing depth < maximum depth) across the contiguous US (CONUS)., concluding "IPL is likely to be higher than external loading in 26% of watersheds. Overall, our results reveal where IPL can be a critical factor in watershed nutrient management."

41. **Anoxia begets anoxia: A positive feedback to the deoxygenation of temperate lakes** Paper by A.S.L. Lewis et al., 2023 in *Global Change Biology*, https://onlinelibrary.wiley.com/doi/10.1111/gcb.17046

42. **Internal P loading is not controlled or is not readily controlled by reducing External P Loading and can delay lake recovery for decades, if not longer.**

> From "Internal P Loading: A Persistent Management Problem in Lake Recovery" by Willaims James, 2016. Posted on nalms.org (North American Lake Society) at https://www.nalms.org/wp-content/uploads/2017/01/36-1-3.pdf
>
> Simply reducing watershed P loading to eutrophic lakes without also managing internal P loading may not be enough to reverse impaired water quality. Even though internal P loading is ultimately derived from the watershed, it can take years to decades to flush sediment P out of the system after watershed BMP implementation, resulting in delayed recovery and continued impairment. In addition, a symptom of decades of P retention as sediment in lakes is the buildup of a surface sediment P concentration bulge that is usually difficult to bury over time and persists as an important internal P source during hypolimnetic anoxia, stimulating and sustaining algal blooms despite other efforts of remediation... Unless controlled directly via P-adsorbing technologies such as aluminum salts, lanthanum-modified clays, or other measures, internal P loading from profundal sediments can provide a form of ecosystem feedback that maintains a eutrophic equilibrium that is resistant to management efforts.

For a comprehensive, fully referenced and freely accessible treatment of the practical issues involved in addressing Internal P Loading, see "**Handbook – a decision support tool for measures against internal phosphorus loading in lakes**" by Brian Huser et al., 2023 in *Rich Waters* (Swedish Agency for Marine and Water Management) developed with the support of the European Union. It consists of a 56 page Report and 6Appendices . Available at https://www.richwaters.se/handbook-a-decision-support-tool-for-measures-against-internal-phosphorus-loading-in-lakes/

43. **Woodchips are not a significant source of P** See Wood chips and applications of wood chips in stormwater in Minnesota Stormewater Manual at https://stormwater.pca.state.mn.us/index.php?title=Wood_chips_and_applications_of_wood_chips_in_stormwater

44. **Climate warming has contributed to declining lake oxygen levels**
See, e.g., lit reviewed in intro to "Anoxia begets anoxia" [Note [40] above]: "Increased air temperatures have been shown to drive increased duration of thermal stratification (Foley et al., 2012; North et al., 2013; Oleksy & Richardson, 2021; Woolway et al., 2021), which reduces or inhibits mixing of oxygen to the bottom waters (hypolimnion). Consequently, increases in stratification duration may provide more time for hypolimnetic DO depletion to occur, resulting in lower late-summer DO concentrations and increased duration of anoxia. Changes in stratification duration appear to be a particularly important driver of DO declines in recent decades (ca. 1950–2020; Jane et al., 2023)".
- Jane, S.F., Hansen, G.J.A., Kraemer, B.M. et al. *Widespread deoxygenation of temperate lakes*. Nature 594, 66–70 (2021). DOI: https://doi.org/10.1038/s41586-021-03550-y

45. **"Other Measures" that have been used or suggested to address hypoxia/Internal P Loading** See **-** Almstrand et al., "Detailed description of measures" in "Handbook – a decision

support tool for measures against internal phosphorus loading in lakes" by Huser et al., 2023 full text available at https://www.richwaters.se/handbook-a-decision-support-tool-for-measures-against-internal-phosphorus-loading-in-lakes/
- Bomans et al., 2015. "Controlling internal phosphorus loading in lakes by physical methods to reduce cyanobacterial blooms: a review" In *Aquatic Ecology*, https://link.springer.com/article/10.1007/s10452-015-9564-x

46. Remedial actions assumed by the surrounding community as at Oathill Lake in Dartmouth

- **Oathill lake Conservation Society,** website at https://www.oathilllake.ca

- **DataStream: Oathill Lake Conservation Society Water Monitoring.** 'Can view their monitoring data 2013-2025 "The Oathill Lake Conservation Society is a group of concerned neighbours of Oathill Lake, a small urban lake in Dartmouth Nova Scotia. It started when changes were noticed in the lake ecosystems, including increased fish stocking and fishing activities, loss of amphibian populations, and erosion of the lake shore. A measurement program was started to provide baseline depth profiles of oxygen, temperature, salinity/conductivity and pH, and was followed by by-weekly (during open water periods) sampling to track the effects of a number of changes in the lake environment intended to correct the problems noted, as well as the impacts of natural and other man-made events and activities on the lake habitat...."

- **Oathill Lake Restoration**
PDF of slide set for presentation by Bob Rutherford and Terry Rowell of the Oathill Lake Conservation Society to the Halifax regional Watersheds Advisory Board on Mar 14, 2018. Topic: Protecting and restoring the ecological health of the Oathill Lake. Available at https://www.halifax.ca/sites/default/files/documents/city-hall/boards-committees-commissions/180314rwab831.pdf

From the presentation:

Oathill Lake Conservation Society

• http://www.oathilllake.ca

- membership is comprised of volunteers–all dedicated to improving and maintaining the health of this small lake and its parkland as a resource for walking, swimming, boating, skating, CC skiing and fishing.
- Education is the key to getting people involved and invested in our cause.
- But we also conduct environmental monitoring, and make scientifically-based recommendations to government agencies, whose policies and activities are seen to have the greatest influence on the health and integrity of the lake.

Water sampling

- Water temperature, conductivity, oxygen, and pH on random dates 2010 to 2012
- 3 sites bi-weekly from mid August 2013 to Nov 2017 on going – WetPro YSI meter
- Water samples to the lab for analysis of a range of parameters. Twice this year in April and October.

- Water temperature data loggers each 1m in depth were not in in 2017 but had been since 2012

- At some point in the past this loading tipped the nutrient balance over a threshold resulting in too much plant growth leading to loss of oxygen in the bottom and the release of P from the Fe an Mn bound sediments which greatly accelerated more growth and oxygen depletion.

Aquago

- Solar powered water circulator
- 56 cm impeller draws water to the surface during the daylight
- The nutrients are taken up quickly by phytoplankton during the day when they are producing oxygen – not at night when they are consuming oxygen.
- Draws from above the thermocline so as not to break down summer stratification. So about 3 to 4m down.
- Diffusion during summer and spring and fall cycling will raise O_2 to the bottom

- **Oathill Lake in Dartmouth has its ecosystem restored** Natasha MacDonald-Dupuis · CBC News · Posted: Jul 06, 2015 https://www.cbc.ca/news/canada/nova-scotia/oathill-lake-in-dartmouth-has-its-ecosystem-restored-1.3137882

47. "Set the target for Total P at the estimated predevelopment level" :Estimates of the Predevelopment Total P value for Sandy Lake

From AECOM 2014, Fig 9:

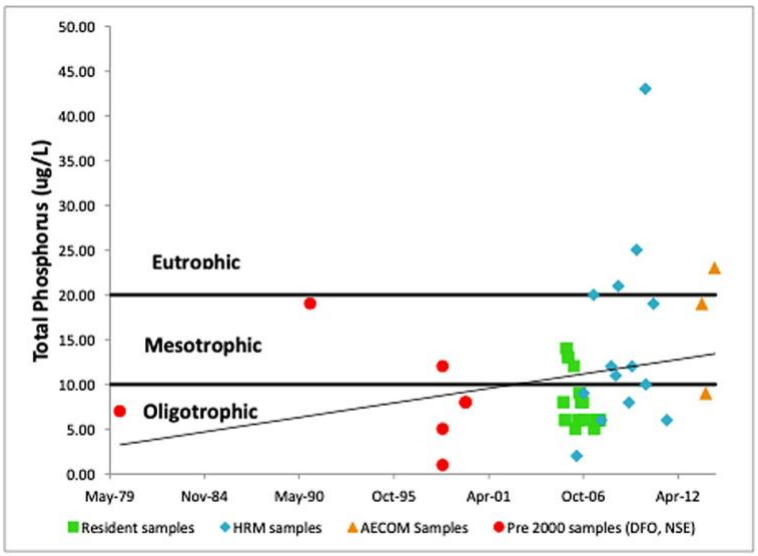

Figure 9: Sandy Lake Total Phosphorus - All Samples

- **Estimated from all five pre-2000 values in 2009**, the level would be **8.8 ug/L** (Six pre-2000 values are shown in AECOM (2014) Fig 9, but I could locate only 5 of those in AECOM (2014) Appendix C. It makes little difference; if the interpolated value from Fig 9 for the missing value is included, the estimate is 8.7 ug/L)
- The earliest value available in AECOM 2014 (from 1 Jan 1980) was **7 ug/L**

- Paleolimnological Estimate for Sandy Lake (Rajaratnam, 2009; Ginn et al., 2015): The inferred values: **5.62 ug/L** for sediment surface (reflecting conditions in 2005-2006 – note that value is within the range of Total P in lake water samples taken at the time, re: AECOM 2014 Fig 9 reproduced above) and **8.91** ug/L for the deep sediment sample (100-150 yr earlier). It is curious that the historic (100-15) years earlier value (8.91 ug/L) is higher than the inferred sediment surface value (5.62 ug/) for 2005-2006. A possible explanation: increased total P due to logging activity in the watershed and on the lake in the earlier period. "Logs cut in the Sandy Lake area floated through Sandy Lake to Marsh Lake and Peverell's Brook to the Sackville River. Upon reaching the Basin, they were boomed until being processed in the mill. Dams for gathering logs were constructed in the stream connecting Sandy and Marsh Lakes, and below Marsh Lake. These dams remained into the mid-twentieth century, local residents recalled. L." As well "The early 1800s saw the development of many shingle and saw mills along the streams leading to Sandy Lake".
Quotes and photo below from "Sandy Lake Community Profile "by Dalhousie and Nova Scotia College of Art and Design, 2002
https://cdn.dal.ca/content/dam/dalhousie/pdf/faculty/architecture-planning/school-of-planning/pdfs/studentwork/SandyLake/community.pdf

Rajaratnam, Thiyake. 2009: "Assessment of long-term changes in water quality from Halifax region lakes (Nova Scotia, Canada) using paleolimnological techniques", MSc thesis Queens Univerity available at https://central.bac-lac.gc.ca/.item?id=MR65256&op=pdf&app=Library&oclc_number=774092980

Ginn et al., 2015. "Establishing realistic management objectives for urban lakes using paleolimnological techniques: an example from Halifax Region (Nova Scotia, Canada)" in *Lake and Reservoir Management* https://www.tandfonline.com/doi/full/10.1080/10402381.2015.1013648

Logs on Sandy Lake in summertime.

- **Professional limnologist Shalom Mandeville's Hindcast Value: 6.3 ug/L SANDY LAKE, Bedford:- Accelerated eutrophication signs, and suggested restoration parameters,**
Letter to Chair & Members, North West Community Council, HRM Oct 30, 2013
https://versicolor.ca/sandylakebedford/wp-content/uploads/2021/05/2013-Our-submission-to-HRM.pdf

48. Sedimentation at Southdale development in Dartmouth

See "We Spoke To Concerned Resident Bill Zebedee About A Concerning Environmental Issue Stemming From The Development Of Eisner Cove" Article with photos,. Apr 27, 2025 in Waterfront Media at https://waterfrontmediahfx.the902hxir.ca/88340-2

49. Erratic rainfall further increase the risk

E.g., see:

- "**Synergistic effect of drought and rainfall events of different patterns on watershed systems**" by Jiali Qiu et al., 2021 in Nature Scientific Reports https://www.nature.com/articles/s41598-021-97574-z "Sustained droughts followed by intense precipitation could cause complex interactions and mobilize accumulated sediment, nutrients and other pollutants into surface water "

- "Clear-cutting forests linked to 18-fold increase in frequency and size of floods" By University of British Columbia on phys.org, July 17, 2025 at https://phys.org/news/2025-07-forests-linked-frequency-size.html "Clear-cutting can make catastrophic floods 18 times more frequent with effects lasting more than 40 years, according to a new UBC study. In one watershed, these extreme floods also became more than twice as large, turning a once-in-70-years event into something that now happens every nine years."This research challenges conventional thinking about forest management's impact on flooding," said senior author Dr. Younes Alila, a hydrologist in the UBC faculty of forestry. "We hope the industry and policymakers will take note of the findings, which show that it matters not only how much forest you remove but also where, how and under what conditions." References this scientific paper: "Stochastic framework reveals the controls of forest treatment – peakflow causal relations in rain environment" by Henry C. Pham et al., 2025 in Journal of Hydrology https://www.sciencedirect.com/science/article/pii/S002216942501042X

50. On widths of Riparian Buffers, Wildlife Corridors

- Stoffyn-Egli & Duinker, 2013. "**An Ecological Approach to Riparian-Buffer Definition, and Implications for Timber Harvests in Nova Scotia, Canada**" in *Journal of Sustainable Development*; https://ccsenet.org/journal/index.php/jsd/article/view/28106 A comprehensive review, and some field studies in Nova Scota,"...In summary, **the unique physical and biotic characteristics of riparian areas suggest that their width is commonly on the order of 50 m, at least in North America**. This width spans (1) the estimated riparian width necessary to ensure the aquatic health of the watercourse, (2) a large part of the biophysical gradients (e.g. microclimate, vegetation) characteristic of the riparian area, and (3) the home range necessary to sustain the majority of riparian obligate species. Therefore, we propose that in order to preserve the multiple ecological functions of riparian areas, the riparian buffer should be at least 50 m on each side of the watercourse...The proposed 50-m buffer width is measured uphill from the land-water boundary, and is a horizontal distance (i.e. map projection), not a slope length...The holistic approach of implementing a buffer that encompasses the majority of the riparian area supports the concept of a single-width buffer because it recognises the multiplicity of functions (Luke et al., 2007) of any portion of the riparian area and thus the multi-purpose (Buttle, 2002) nature of the buffer. ..The advantage of the proposed riparian buffer delineation is that its implementation does not require advanced training or site-specific surveys and thus can be applied with little investment of time and money by everyone, from the forestry professional and the natural resources manager to the local resident or woodlot owner.

- Robert L. France et al., 2019. "**Modeling Reforestation's Role in Climate-Proofing Watersheds from Flooding and Soil Erosio**n". In *American Journal of Climate Change*. https://www.scirp.org/journal/paperinformation?paperid=95101 Abstract: The mitigation potential of reforestation for offsetting the deleterious effects of increased flooding and soil erosion

projected to occur in Atlantic Canada through future climate change was investigated. Modelling determined a strong but non-linear relationship between extent of vegetative cover and runoff volume and discharge rate for a Nova Scotian watershed, suggesting that reforestation will reduce, but not completely prevent, flooding. Predicted erosion rates were found to be progressively reduced in relation to the extent of upland reforestation. Of three scenarios examined in which 60%, 65%, and 85% of the entire watershed are randomly reforested, only the latter would reduce the elevated erosion expected to occur through climate change back to present-day existing levels. Additional modelling revealed that comparable mitigation of soil erosion can ensue through implementation of **70 m streamside buffer strips**, which would only take up 19% of the total surface area. Prioritizing riparian zones for reforestation will therefore subsume less of the overall productive land area and therefore enact a less severe socio-economic impact on agriculture and forestry.

- B.R. Collison and A.G. Gromac. 2022. **Importance of riparian zone management for freshwater fish and fish habitat protection: analysis and recommendations in Nova Scotia, Canada**. Canadian Technical Report of Fisheries and Aquatic Sciences 3475. https://www.researchgate.net/profile/Ben-Collison/publication/360846986_Importance_of_riparian_zone_management_for_freshwater_fish_and_fish_habitat_protection_analysis_and_recommendations_in_Nova_Scotia_Canada/links/628e55d96886635d5ca1c5b1/Importance-of-. "The following riparian management recommendations were developed based on a comprehensive review of relevant riparian management scientific and grey literature, and current or anticipated future riparian buffer regulatory/best management practice regimes in Nova Scotia and other jurisdictions that have been outlined above. Additional considerations include land cover, use and ownership, sensitive areas, future threats of climate change, and cumulative effects. In addition, recommendations were informed by advice and feedback provided by DFO staff from various regions/programs and staff from the Province of Nova Scotia...7.1. Crown Land The following recommendations are provided for the management of riparian areas on Crown land:Broad-scale (watershed) application: **A cumulative buffer width of 60 m (Figure 12) is recommended.**

- McCallum Environmental Ltd. 2022. **Sandy Lake Ecological Features Assessment.** 72 page document prepared for HRM Announcement and document at https://cdn.halifax.ca/sites/default/files/documents/city-hall/regional-council/220712rc15110.pdf

From the HRM staff summary: "Water Quality In considering water quality preservation, the report identifies that the aquatic and riparian features in the study area generally scored highest in the overall analysis of the various environmental features. Figure 6 of Attachment B shows all identified wetlands with a **50 metre buffer for riparian areas, and all identified watercourses with a 100 metre buffer for riparian areas**. The Assessment identifies the importance of Sandy Lake, Marsh Lake, Jack Lake and the Sackville River and their associated tributaries and riparian areas in protecting water quality

"Landscape Connectivity Corridors that allow wildlife to move through the study area were also analyzed. The relationship to wildlife movement at a regional scale is considered through the Halifax Green Network Plan, the Sandy Lake Ecological Features Assessment also considered the Wildlife Corridor Landscape Charette, which can be found on the Regional Planning website, and is catalogued as submission C1142. **The Sackville River was identified as an important and essential corridor for its role in providing aquatic connectivity downstream. An important corridor was also identified along the west side of Sandy Lake that provides a connection for**

wildlife from the south of the study area to the Sandy Lake Regional Park. The Green Network Plan identifies that wherever possible, a width of 100 m should be maintained for Important Corridors and 1,000m for Essential Corridors"

Nova Scotia Crown Share Land Legacy Trust, 2021. "Wildlife Corridor Landscape Design Charrette: Chebucto-Timberlea-Sandy Lake area of Halifax, NS. Summary Document"
https://cdn.halifax.ca/sites/default/files/documents/city-hall/regional-council/230124rci05.pdf

From the HRM Summary "The Charrette Report seeks to build on the existing wildlife corridor work of the HGNP, looking more closely at possible terrestrial and aquatic wildlife corridors within and connecting to the Chebucto Peninsula that were not identified within Maps 5 & 9 of the HGNP (Green Network Ecology Map & Green Network Map, respectively). The intention of the Charette Report is to identify wildlife corridors that would increase landscape connectivity and proposes that these corridors be considered for addition into the HGNP and the Regional Plan as part of the current review process…The Charrette Report examined four core areas within and connecting to the Chebucto Peninsula, identifying additional primary corridors, secondary corridors, aquatic corridors, and pinch points that were not included within the HGNP mapping…The suggested additional corridors and connections identified in the Charette Report frequently show connection between an identified HGNP corridor to another, or an identified park space, while in some cases the suggested connections are outside of any lands identified in the HGNP…

& from the HRM Response:

Aquatic Corridors: While the HGNP identifies the need to monitor and protect aquatic systems, no aquatic corridors have been identified within Map 5 or 9 of the HGNP. Staff will assess the feasibility of incorporating consideration of aquatic corridors into future planning policy and regulations. Staff will examine jurisdictional considerations to understand what power the Municipality has to control development surrounding an aquatic corridor, beyond the existing minimum requirement pertaining to riparian buffers. This work will help to inform the ongoing review and implementation of the HGNP Action 6 (increase standard watercourse buffer width to 30m), being examined in Phase 4 of the Regional Plan review

Examination of Corridor Widths: The Charrette Report identified several corridors that were narrower than the widths described in the HGNP (100m for important corridors & 1000m for essential corridors). Using the mapping described above, staff will determine where it is feasible to achieve the recommended corridor width, where only narrower corridors may be possible, and identify pinch points that should be prioritized for future widening.

From the Charette Report:

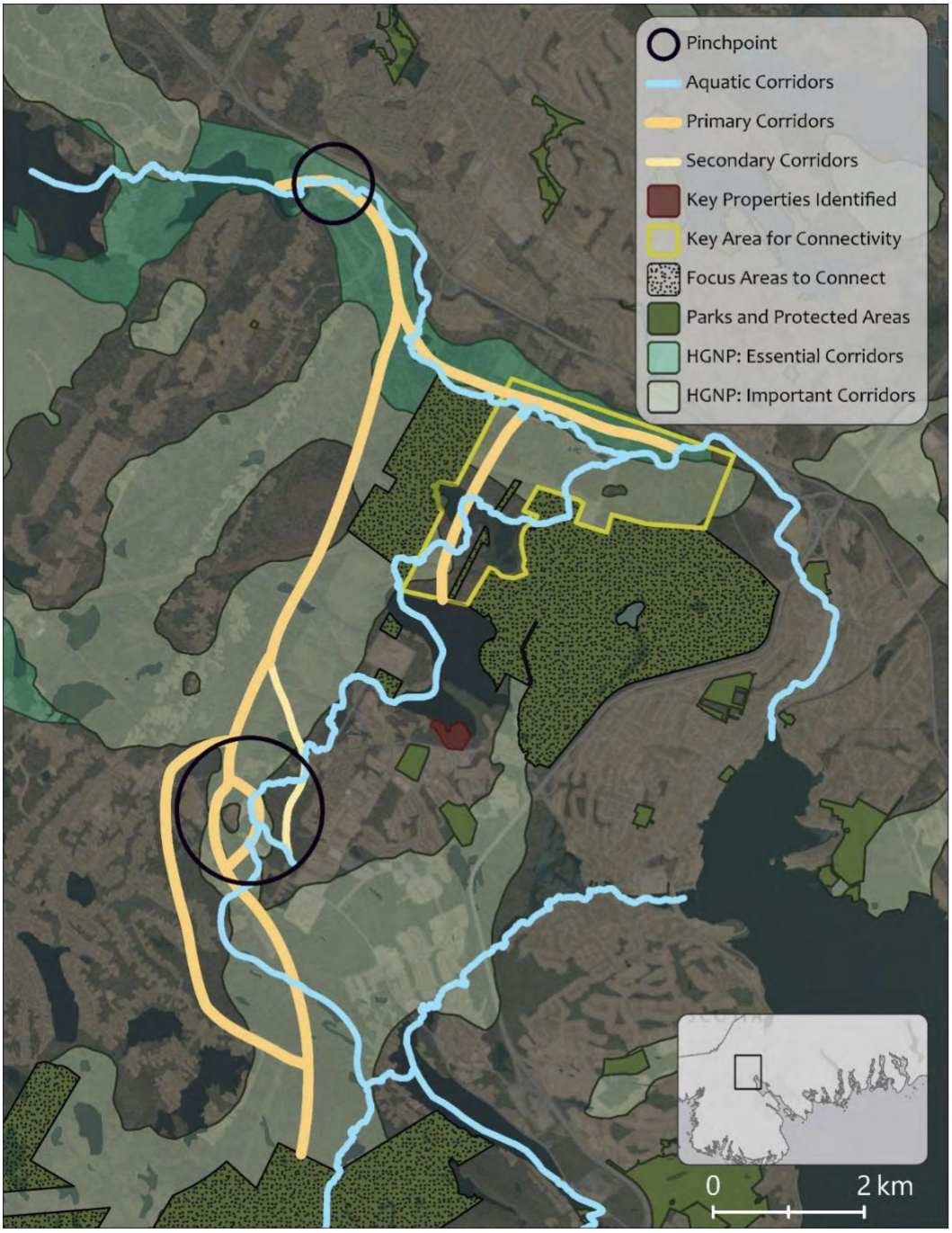

Figure 8. Summary map for the Sandy Lake to Blue Mountain Birch Cove Lakes group

Primary Connections

The group identified a primary corridor that runs from Webber Lake along the Sackville River Valley into Sandy Lake Regional Park, through an essential corridor identified in the Halifax Green Network Plan (Figure 3). Between the two larger protected parts of Sandy Lake Regional Park lies Marsh Lake, which the group identified as being critical habitat to protect and an important area for aquatic connectivity. The important corridors identified in the Halifax Green Network Plan actually go around much of this critical area rather than incorporating it.

Another primary connection identified by this group runs along the west side of Sandy Lake to the intersection of Hammonds Plains Road and Larry Uteck Boulevard, which was identified as a major pinchpoint for connectivity between Sandy Lake and BMBCL (Figure 4). At this juncture, there are a few options for connectivity, which could also point to potential candidate spots for wildlife crossing structures. It was noted that there are a number of wetlands around this intersection which are important habitat and should form the basis of the corridors in the area.

The group largely focused their identification of corridors on aiming to preserve the areas around streams in order to maintain both aquatic and terrestrial connectivity, incorporating known corridors of wildlife movement to refine corridor placement. A corridor along a powerline right of way was also identified through the Uplands Park subdivision, which is known to be used by wildlife currently. From the Black Duck Wetlands there is a relatively undeveloped path that connects to BMBCL (Figure 5).

Aquatic Connectivity

The entire Sackville River Valley was identified as being critical to protect, from McCabe Lake to the Bedford Basin, most of which is also designated as an essential corridor in the Halifax Green Network Plan (Figure 6). The group also noted that there is a pinchpoint for aquatic connectivity where the river meets Lucasville road, near Webber Lake (Figure 7).

As was noted above, Marsh Lake is an important area for connectivity, providing a direct linkage between the Sackville River and Sandy Lake via. Peverills Brook. Other streams and their tributaries flow from the BMBCL Wilderness Area into Sandy Lake, flowing around the intersection of Hammonds Plains Road and Larry Uteck Boulevard. As was noted above, this is a critical area for connectivity, and the group first identified the aquatic connections and then widened them to incorporate terrestrial connectivity as well. Several wetlands and streams connecting them were identified, including Black Duck Brook, which eventually flows into Kearney Lake and links up with an aquatic connection also identified by the group focused on connectivity between BMBCL and Five Bridge Lakes Wilderness Area.

Across the study area, the corridors identified by the group largely followed those in the Halifax Green Network Plan, but there were some differences, as noted (Figure 8).

51. Stantec's comments on "Internal Loading"... portray some lack of or a very limited understanding of, the process.

From Stantec Sandy lake Watershed Study, pp 3-4, 1 Introduction... 1.3 Surface Water Quality Data Collection

> Contaminant models were developed to assess key parameters that are particularly sensitive to changes in land use within a watershed, such as when forested land is developed to residential or commercial use. Probable causes of water quality impacts may be identified by examining changes to these key parameter concentrations. Total phosphorus (TP), fecal coliform (represented by *E.coli),* and sediment (represented as total suspended sediments (TSS) were identified as key parameters that will be used to assess changes in trophic level/nutrients, water clarity, and anthropogenic inputs, respectively. **A description of existing conditions of parameters that may affect the internal loading of the lake including pH, dissolved oxygen (DO), temperature, and conductivity is provided in Section 1.3.4.**

From Stantec Sandy lake Watershed Study, pp 3-4, 1 Introduction... 1.3 Surface Water Quality Data p6, 1 Introduction...1.3 Surface Water Quality Data Collection... 1.3.1.1 Internal Loading

> Internal P loading is the process by which P trapped in the sediment of a lake becomes resuspended in the water column **(Sondergaard 2003)**. During periods of increased external loading of a lake system, organic and inorganic P can become bound in the sediment. The increased loading of P within the lake during the internal loading process often leads to eutrophication and deterioration of the ecosystem health such as an increase in cyanobacterial blooms, dissolved oxygen depletion, turbid water, and poor aquatic habitat. Factors that can influence P solubility and release back into the water column include redox reactions (P sorbed onto iron (III) compounds is released as iron (III) is reduced to iron (II)), resuspension of sediment, temperature, pH, chemical diffusion, microbial processes, and mineralization (Sondergaard 2003).

COMMENT: The Sondergaard 2003 paper cited by Stantec focusses on shallow eutrophic lakes that are "are usually well mixed and oxidized throughout the water column", and on efforts to reverse eutrophication. Neither of these apply to Sandy Lake. There is an immense literature on Internal P Loading. Stantec makes no mention that Internal P Loading is a phenomenon that typically occurs in the hypolimnion in stratified lakes such as Sandy Lake when the oxygen drops to very low levels which can occur in mesotrophic lakes. In contrast, AECOM 2014 provides extensive description/ discussion of lake stratification, impacts on oxygen levels, Internal P Loading, and gives a diagram showing stratified lake zones etc, (AECOM 2014, pdf page 94). AECOM 2014 also cites some evidence from historical data for occurrence of Internal P Loading in Sandy Lake priori to 2014, this evidence is not cited by Stantec - although the raw data are included in the Stantec Watershed Study Appendix A (copied apparently from Appendix C of AECM 2014).

From AECOM 2014, pp22-23 (re: some evidence for occurrence of Internal P Loading in Sandy Lake priori to 2014)

Most of the samples reported in Tables 3 and 4 were taken from near the lake surface, but samples have also been taken periodically from the deeper part of the lake. Table 5 compares the phosphorus concentrations of shallow (epilimnion) to deep (hypolimnion) samples from three sampling events. Total phosphorus concentrations in the shallow surface (epilimnion) samples are less than in the deep (hypolimnion) samples in two of the three examples. Although the data are limited, this suggests that the deeper portions of Sandy Lake may be fully or partially oxygen- deprived during certain times of the year, a situation that may arise when decomposing organic matter consumes available oxygen at depth. This in turn promotes the release of phosphorus from lake sediments, which is recorded in the water samples.

Table 5. Sandy Lake Shallow and Deep Total Phosphorus

Sample Name	Sample Date	Total Phosphorus (1 m depth)	Total Phosphorus (deep)
		µg/L	µg/L
Sandy Lake	Sept 3, 2008	11.0	15.0
	May 24, 2010	10.0	26.0
	August 19, 2011	6.0	5.0

From Stantec Sandy Lake Watershed Study 1.3.1.1 Internal Loading

> Anthropogenic watershed runoff is the primary source of external P loading into a lake (James 2016). Without the implementation of low-impact development (LID) or mitigation measures, runoff from the surrounding watershed can result in the deposition of P-rich sediment in lake basins.

Comment: The implication is that implementation of low-impact development (LID) or mitigation measures as Stantec has recommended will stop any internal P Loading. That could or would be the case if the hypolimnion was well oxygenated now and there was no evidence for Internal P Loading, but neither is the case. See my related remarks in Section **7. Internal P Loading is not addressed by most NNIP models and policies/why it is relevant.**

From Stantec Sandy Lake Watershed Study pp 8-10, 1 Introduction...1.3 Surface Water Quality Data Collection... 1.3.4 Internal Loading

As described in section 1.3.1.1, the internal loading of phosphorus in a lake system has the potential to deplete dissolved oxygen levels, resulting in the decrease in water quality of a lake environment. There was only one measurement of historical dissolved oxygen levels prior to 2000, in September 1998 with a value of 3 mg/L, which is below the CCME Canadian Water Quality Guidelines for the Protection of Freshwater Aquatic Life (CWQG-FAL) of 6.0 mg/L for early life stage aquatic life and 5.50 mg/L for other life stages. Dissolved oxygen values from 2000-2010 have an average value of 10.61 mg/L which indicate a more oxygenated environment. Dissolved oxygen profiles of Sandy Lake were measured throughout the 2023 monitoring period. DO and Temperature readings are presented in **Figure 1-3** for the period of April to October 2023; it should be noted that while temperature readings were taken in October, the DO probe malfunctioned, and DO readings were not collected during that monitoring event. The DO values for Sandy Lake reached a minimum of 2.2 mg/L during the September monitoring event at a depth of 8 m below surface. The September and July sampling events had the lowest average DO concentrations with values of 5.35 and 5.88 mg/L, respectively. The lake would be considered to be hypoxic during these months, especially at depths below 4 m. This increases the potential for internal loading of P within the water column as anoxic conditions can induce the release of sediment-bound P (Deeds et. al. 2021).

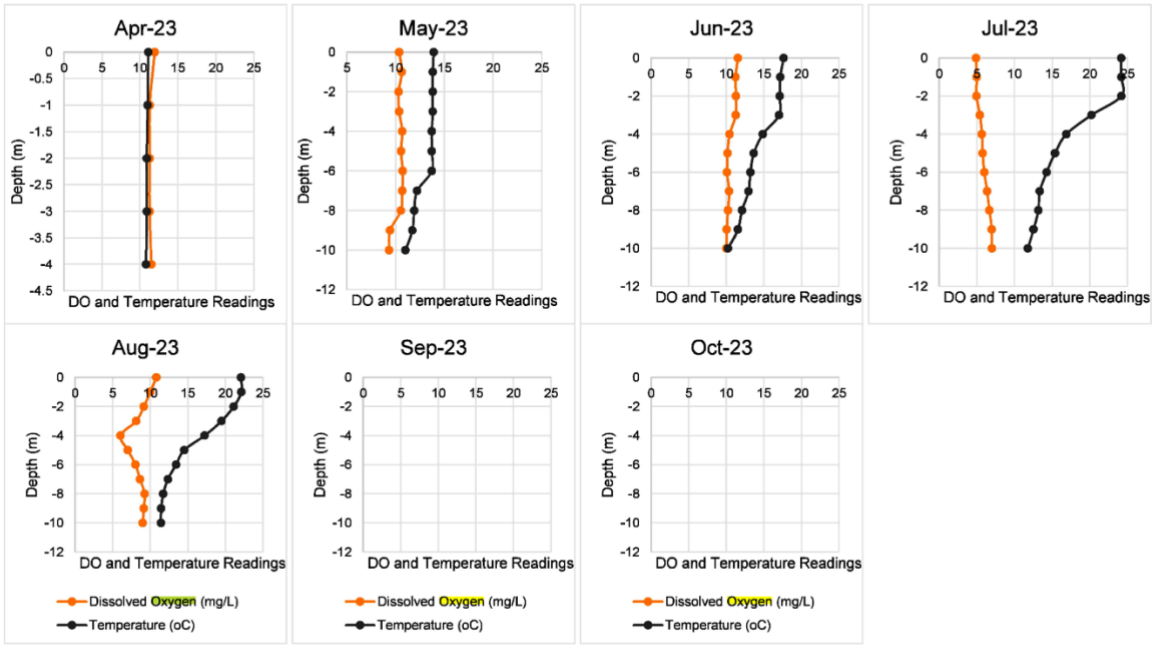

Figure 1-3 Dissolved Oxygen and Temperature Profiles of Sandy Lake

Comment. The oxygen value Stantec cites for Sep 1998, 3 mg/L, was from 19 m depth (which they do not state). In Appendix A, they do not cite the surface for that date which was 8.6 mg/L. Most or all of the values for 2000-2010 are surface samples. Then they compare an average number for those values with the values they observed in 2023 in their 0-4 m depth (April sampling) and 0-10 m depth (May-Oct samplings). So they are comparing stats that are not scientifically comparable. "The DO values for Sandy Lake reached a minimum of 2.2 mg/L during the September monitoring event at a depth of 8 m below surface." There are no data on the Sep. plot (above) and unless I missed something, I couldn't find the raw data in Appendix A. Regardless, they did not sample deeper than 10m so they can't say the value is a minimum value for Sandy Lake. A very confused discussion. They reference the Dodds 2021 paper, which is highly relevant to Sandy Lake - a model to predict anoxia in the hypolimnion of temperate lakes of TP < 15 µg/L and max depth > 10 m, but they don't really make use of it; rather they cite it as evidence that the DO levels they observed could induce release of sediment-bound P, but the paper does not use O2 levels as a predictor and anoxic conditions in sediments are associated with values less than 2 mg/L

Not discussed in 1.3.4 are the effects of pH, temperature and conductivity on internal loading, re the statement under Introduction... 1.3 Surface Water Quality Data Collection: "A description of existing conditions of parameters that may affect the internal loading of the lake including pH, dissolved oxygen (DO), temperature, and conductivity is provided in Section 1.3.4".

From Stantec Sandy Lake Watershed Study 1.3.4 BASELINE WATER QUALITY

> The pH of Sandy Lake range between 6.28 to 7.45, with an average value of 6.52 throughout the 2023 monitoring period. A value of 7.00 represents neutral pH, and the mean pH value is within the CCME CWQG-FAL guidelines (6.5 to 9.0). Conductivity in Sandy Lake ranges between 0.108 to 0.203 mS/cm. Maximum conductivity value of 0.203 was observed in July which is expected due to increased temperature.

Comment, re underlined statement. That's nuts. The temperature effect is small in comparison to the variation overall, and these were Specific Conducitivity values which are standardized to a single temperature.

From Stantec Sandy Lake Watershed Study p 37, 3. Water Quality Results 3.3 Phosphorus Lake Model

> Phosphorous input sources are partitioned into four categories: input from upstream waterbodies (as Sandy Lake is a headwater lake, this is considered to be 0 g/yr), atmospheric deposition, overland runoff, and development. Phosphorous exits the lake system through either in-lake sedimentation or lake outflow. Phosphorous, however, can become re-suspended into the water column through internal loading during periods of anoxic lake conditions. As Sandy Lake is prone to anoxic events, this should be taken into consideration of potential loading within the lake.

Comment. Oon the right track but Stantec provides no evidence that "Sandy Lake is prone to anoxic events", that's what missing. Also, it's not the whole lake prone to anoxic events, but rather bottom sediments in the hypolimnion.

52. **Volunteers play a big role overall in water quality monitoring in Nova Scotia.**
Such volunteer activity is well documented in appendices to AECOM 2020: "Halifax Regional Municipality Water Quality Monitoring Policy and Program Development", Prepared by: AECOM Canada Ltd., Sep 2020 , 99 pages + Appendices. Available at https://www.halifax.ca/sites/default/files/documents/city-hall/boards-committees-commissions/210211rwabsp911.pdf

53. **Citizen Science**

See: **The Science of Citizen Science, K. Vohland et al.,** Eds, 2021, 520 pages. Springer. Download at https://link.springer.com/book/10.1007/978-3-030-58278-4
Chapter 8 Data Quality in Citizen Science, Bálint **Balázs et al.** pp 141-155