2024 ICM
Problem D: Great Lakes Water Problem

Background

The Great Lakes of the United States and Canada are the largest group of freshwater lakes in the world. The five lakes and connecting waterways constitute a massive drainage basin that contains many large urban areas in these two countries, with varied climate and localized weather conditions.

The lakes' water is used for many purposes (fishing, recreation, power generation, drinking, shipping, animal and fish habitat, construction, irrigation, etc.). Consequently, a vast variety of stakeholders have an interest in the management of the water that flows into and out of the lakes. In particular, if too little water is drained or evaporates from the lakes, then flooding may occur and homes and businesses along the shore suffer; if too much water is drained, then large ships cannot travel through the waterways to bring supplies and support the local economy. The main problem is regulating the water levels such that all stakeholders can benefit.

The water level in each lake is determined by how much water enters and leaves the lake. These levels are the result of complex interactions among temperature, wind, tides, precipitation, evaporation, bathymetry (the shape of the lake bottom), river flows and runoff, reservoir policies, seasonal cycles, and long-term climate changes. There are two primary control mechanisms within the flow of water in the Great Lakes system – Compensating Works of the Soo Locks at Sault Ste. Marie (three hydropower plants, five navigation locks, and a gated dam at the head of the rapids) and the Moses-Saunders Dam at Cornwall as indicated in the Addendum.

While the two control dams, many channels and canals, and the drainage basin reservoirs may be controlled by humans, the rates of rain, evaporation, erosion, ice jams, and other water-flow phenomena are beyond human manipulation. The policies of local jurisdictions may have different effects than expected, as can seasonal and environmental changes in the water basin. These changes in turn affect the ecosystem of the area, which impacts the health of the flora and fauna found in and around the lakes and the residents that live in the water basin. Even though the Great Lakes seem to have a regular annual pattern, a variance from normal of two to three feet of water level can dramatically affect some of the stakeholders.

This dynamic network flow problem is "wicked" – exceptionally challenging to solve because of interdependencies, complicated requirements, and inherent uncertainties. For the lake's problems, we have ever-changing dynamics and the conflicting interests of stakeholders.
See Problem D Addendum for Additional Information.

Requirement

The International Joint Commission (IJC) requests support from your company, **I**nternational network **C**ontrol **M**odelers – **ICM**, to assist with management and models for the control mechanisms (the two dams – Compensating Works and Moses-Saunders Dam as indicated in the Addendum) that directly influence water levels in the Great Lakes flow network. Your ICM supervisor has given your team the lead in developing the model and a management plan to implement the model. Your supervisor indicates there are several considerations that may help to achieve this goal starting with the building of a network model for the Great Lakes and connecting river flows from Lake Superior to the Atlantic Ocean. Some other optional considerations or issues your supervisor mentioned were:

- Determination of the optimal water levels of the five Great Lakes at any time of the year, taking into account the various stakeholders' desires (the costs and benefits could be different for each stakeholder).
- Establishment of algorithms to maintain optimal water levels in the five lakes from inflow and outflow data for the lakes.
- Understanding of the sensitivity of your control algorithms for the outflow of the two control dams. Given the data for 2017, would your new controls result in satisfactory or better than the actual recorded water levels for the various stakeholders for that year?
- How sensitive is your algorithm to changes in environmental conditions (e.g., precipitation, winter snowpack, ice jams)?
- Focus your extensive analysis of ONLY the stakeholders and factors influencing Lake Ontario as there is more recent concern for the management of the water level for this lake.

The IJC is also interested in what historical data you use to inform your models and establish parameters, as they are curious to compare how your management and control strategies compare to previous models. Provide a one-page memo to IJC leadership communicating the key features of your model to convince them to select your model.

Your PDF solution of no more than 25 pages total should include:

- One-page summary sheet that clearly describes your approach to the problem and your most important conclusions from your analysis in the context of the problem.
- Table of Contents.
- Your complete solution.
- One-page memo.
- Reference List.
- AI Use Report (if used).

Note: There is no specific required minimum page length for a complete ICM submission. You may use up to 25 total pages for all your solution work and any additional information you want to include (for example: drawings, diagrams, calculations, tables). Partial solutions are accepted. We permit the careful use of AI such as ChatGPT, although it is not necessary to create a solution to this problem. If you choose to utilize a generative AI, you must follow the COMAP AI use policy. This will result in an additional AI use report that you must add to the end of your PDF solution file and does not count toward the 25 total page limit for your solution.

Files provided:

- ***Problem D Addendum*** – Additional background information.
- ***Data Examples*** – These are possible sources for data. Some of which were used to populate the *Problem_D_Great_Lakes.xlsx* data set. These examples can be found on page 4 of the *Problem D Addendum*. Note: These examples are not required to successfully formulate a solution.
- ***Problem_D_Great_Lakes.xlsx*** – Data for the inflows, outflows, and water levels for the lakes.

References (in addition to the included background data file):

1. **Explanation of the IJC's Efforts to Manage the Great Lakes Basin:** National Research Council; The Royal Society of Canada. (2006). *Review of Lake Ontario-St. Lawrence River Studies.* Washington D.C.: National Research Council of the National Academies. Retrieved from https://nap.nationalacademies.org/catalog/11481/review-of-the-lake-ontario-st-lawrence-river-studies
2. **Description of the Great Lakes Navigation Systems:** *Great Lakes Seaway Navigation System*. (2023). Retrieved from American Great Lakes Ports Association: https://www.greatlakesports.org/industry-overview/the-great-lakes-seaway-navigation-system/#:~:text=Lake%20Erie%20drains%20into%20Lake,in%20elevation%20approximately%20600%20feet

Use of Large Language Models and Generative AI Tools in COMAP Contests

This policy is motivated by the rise of large language models (LLMs) and generative AI assisted technologies. The policy aims to provide greater transparency and guidance to teams, advisors, and judges. This policy applies to all aspects of student work, from research and development of models (including code creation) to the written report. Since these emerging technologies are quickly evolving, COMAP will refine this policy as appropriate.

Teams must be open and honest about all their uses of AI tools. The more transparent a team and its submission are, the more likely it is that their work can be fully trusted, appreciated, and correctly used by others. These disclosures aid in understanding the development of intellectual work and in the proper acknowledgement of contributions. Without open and clear citations and references of the role of AI tools, it is more likely that questionable passages and work could be identified as plagiarism and disqualified.

Solving the problems does not require the use of AI tools, although their responsible use is permitted. COMAP recognizes the value of LLMs and generative AI as productivity tools that can help teams in preparing their submission; to generate initial ideas for a structure, for example, or when summarizing, paraphrasing, language polishing etc. There are many tasks in model development where human creativity and teamwork is essential, and where a reliance on AI tools introduces risks. Therefore, we advise caution when using these technologies for tasks such as model selection and building, assisting in the creation of code, interpreting data and results of models, and drawing scientific conclusions.

It is important to note that LLMs and generative AI have limitations and are unable to replace human creativity and critical thinking. COMAP advises teams to be aware of these risks if they choose to use LLMs:

- Objectivity: Previously published content containing racist, sexist, or other biases can arise in LLM-generated text, and some important viewpoints may not be represented.
- Accuracy: LLMs can ‘hallucinate’ i.e. generate false content, especially when used outside of their domain or when dealing with complex or ambiguous topics. They can generate content that is linguistically but not scientifically plausible, they can get facts wrong, and they have been shown to generate citations that don’t exist. Some LLMs are only trained on content published before a particular date and therefore present an incomplete picture.
- Contextual understanding: LLMs cannot apply human understanding to the context of a piece of text, especially when dealing with idiomatic expressions, sarcasm, humor, or metaphorical language. This can lead to errors or misinterpretations in the generated content.
- Training data: LLMs require a large amount of high-quality training data to achieve optimal performance. In some domains or languages, however, such data may not be readily available, thus limiting the usefulness of any output.

Guidance for teams

Teams are required to:

1. **Clearly indicate the use of LLMs or other AI tools in their report,** including which model was used and for what purpose. Please use inline citations and the reference section. Also append the Report on Use of AI (described below) after your 25-page solution.
2. **Verify the accuracy, validity, and appropriateness** of the content and any citations generated by language models and correct any errors or inconsistencies.
3. **Provide citation and references, following guidance provided here.** Double-check citations to ensure they are accurate and are properly referenced.
4. **Be conscious of the potential for plagiarism** since LLMs may reproduce substantial text from other sources. Check the original sources to be sure you are not plagiarizing someone else's work.

COMAP will take appropriate action when we identify submissions likely prepared with undisclosed use of such tools.

Citation and Referencing Directions

Think carefully about how to document and reference whatever tools the team may choose to use. A variety of style guides are beginning to incorporate policies for the citation and referencing of AI tools. Use inline citations and list all AI tools used in the reference section of your 25-page solution.

Whether or not a team chooses to use AI tools, the main solution report is still limited to 25 pages. If a team chooses to utilize AI, following the end of your report, add a new section titled Report on Use of AI. This new section has no page limit and will not be counted as part of the 25-page solution.

Examples (this is *not* exhaustive – adapt these examples to your situation):

Report on Use of AI

1. OpenAI *ChatGPT* (Nov 5, 2023 version, ChatGPT-4)
   Query1: *<insert the exact wording you input into the AI tool>*
   Output: *<insert the complete output from the AI tool>*

2. OpenAI *Ernie* (Nov 5, 2023 version, Ernie 4.0)
   Query1: *<insert the exact wording of any subsequent input into the AI tool>*
   Output: *<insert the complete output from the second query>*

3. Github *CoPilot* (Feb 3, 2024 version)
   Query1: *<insert the exact wording you input into the AI tool>*
   Output: *<insert the complete output from the AI tool>*

4. Google *Bard* (Feb 2, 2024 version)
   Query: *<insert the exact wording of your query>*
   Output: *<insert the complete output from the AI tool>*