

WATER LEVELS WEB SYMPOSIUM OCT 24, 2020

Registrants and Attendees Questions and Answers

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QUESTION A		
What's known and not known about water-level fluctuation cycles?		
Anticipated future levels		
	QUESTIONS	ANSWERS
1	Will the water levels continue to get higher or have they reached the highest?	<p>Water levels typically rise through the spring, peak in the summer and then drop through fall and early winter until the ice sets up. Forecasts are calling for high water levels for the next six months but likely below the extreme record levels of 2020. After 6 months water levels are expected to remain well above average and could possibly exceed the records that were set in 2020, but there is an equal expectation that 2021 water levels will be below the levels set in 2020.</p> <p>Some future modelling seems to indicate that the average water level will be increasing through the rest of the century with increases in fluctuation ranges. This means that, for managing risk, we will need to consider higher peaks on top of a higher mean (average) level, plus increased wind speeds generating more damaging energy over topping coastal infrastructure. The other side of that is that there may also be times of lower water level with higher winds causing undercutting damage to coastal infrastructure that was not designed to withstand these new conditions. This indicates that coastal infrastructure will need to be more robust and flexible in design to accommodate seven-plus foot swings instead of the historic 6.33 foot range we have experienced. ECCC is about to release a new model that will update these expectations ("ECCC Study").</p>
2	Is the water level still rising - when will it begin to drop?	
3	Potential further rise (dock and boathouse now swamped)?	
4	How much higher is water level going to get?	
5	Will the water levels be down next year - have we reached our limit?	

6	What are the future projections of the water levels? (Is the ground water level effected for shore line properties?)	Ground water has been highly charged increasing by 50 cubic kilometers over the period from 2013 to 2019 due to the record precipitation levels experienced in the basin especially over the past three years – the most precipitation on record. Surface water recharge will also impact recharge of the ground water systems. With the expectations of increasing precipitation, we would expect groundwater reservoirs to remain at or near capacity.
Q: 7-26 Answered collectively above and below.		
7	Water levels and the future?	
8	What can we expect in the near future?	
9	Are there any prediction for what future water levels could be?	
10	What is the 2021 water level projection?	
11	What is the prediction for 2021?	
12	I know this is probably a hard question to answer, but what is your prediction about the water level for 2021?	
13	Projected water levels for 2021 (and following years)?	
14	What is the forecasted water levels for the next two years?	
15	Predictions for next 3 years?	
16	What is the forecasted trend for the 2021 to 2025?	
17	How high could the water go (5/10/20 years out)?	
18	What is outlook for levels in next 20 years?	
19	High water for how much longer?	
20	When [will] water go down?	
21	When do you expect the water to go down in the middle lakes?	

22	When will the water go down? (Our cottage is under threat.)	
23	When will the water levels finally go down and stop eroding our shorelines and bring our beaches back?	
24	How much has Georgian Bay's water level decreased? Is there a further decline expected?	
25	Is the water level going to fluctuate as much as it has previously done?	
26	How many years long is the high-low cycle? What are the projected cyclical max high and min low levels?	
27	Is it anticipated that levels will continue to rise?	
	QUESTIONS	ANSWERS
28	Do you believe recent high levels are just a retracement in a long term down trend?	Not necessarily. Conditions on the Great Lakes appear to be subject to a different energy and climate system so past trends are not be a reliable indication of future conditions.
29	My observation has been that in the last few years the water level does not drop in the fall, like it used to?	This is due to the record setting precipitation we have experienced and the increasing rainfall happening in October. This is also the same time of year that evaporation normally increases. With more moisture in the air there is less capacity to absorb water from the lake thereby maintaining high water levels. If these climatic conditions continue to follow this trend it would tend to elevate water levels. An overall increase in the Great Lakes net basin supply from 1953 to 2100 is projected by 28 climate change simulations from five NA-CORDEX regional climate models (Mailhot et al. 2019).
30	What is the water level forecast for the next five years?	Any forecast beyond around 6 months is subject to significant uncertainty. See answers to Q 1-27 above.
31	Forecast water levels for balance of year and 2021	These forecasts are issued by the USACE in coordination with the governments of the US and Canada.

GENERAL ANSWER TO ABOVE QUESTIONS

Water levels are the visual result of the sum total of all inflowing and outflowing water to a water body such as those of our Great Lakes. This sum total is referred to as the total net basin supply. Historically water levels followed the precipitation as the major determinant, but since the 1990s, some studies show that this may have changed towards evaporation.

As the two major water levels determinants, the balance between evaporation and precipitation is what is determining where the water levels will go in the future.

Below you will find information on the potential for adjustments to human controlled inflows and outflows to Georgian Bay and the extent to which these can mitigate extreme highs and lows.

On a day-to-day basis the weather is what we see when we look out the window. In the near-term we can forecast water levels conditions based upon the things that impact our weather like the jet stream, and ocean circulation patterns such as El Niño and La Niña. This forecast is accurate at the time it is issued but increasingly uncertain as it looks into the future. In general, these forecasts are only useful when looking into the future to a maximum of six months at which time the uncertainty in the forecast becomes so large that the forecast is no longer meaningful.

The long term (thirty or forty years) trends are what establish the climatic conditions. It is changes in the energies in the atmosphere that are changing our climate. Global heating is resulting from the human activities that increase “green-house” gasses such a carbon dioxide, nitrous oxide, methane and others that we are dumping into our atmosphere. These gasses inhibit the radiative heat loss the planet experienced in its normal state.

What we know about the future climatic conditions is that this increasing energy in our atmosphere **is** causing changes in precipitation and evaporation – both expected to increase and become more intense and variable according to present models. In this respect the ECCC Study referred to above is expected to show that these changes will increase the extreme water levels conditions (both extreme highs and extreme lows) and the speed of transitions of water levels between those extremes leading to increasing water levels variability in the coming decades.

Predicting future water levels in this apparent new climate regime is done using modelling systems. These models can’t predict a specific water level on a specific future date, but they can predict a range of water levels with a specified confidence range. For example, models can say that average water levels will range between one metre above or below an average level ninety-five percent of the time. This is known scientifically as the 95th percent confidence interval. If we report the 50th percent confidence interval it means that we would expect the water levels to be within that range half the time.

Water levels also lead to a variety of challenges at both the high and low ends of their range. For example, at high levels properties may be flooded and fixed structures such as docks and boathouses may be damaged by wave action. At low water levels there may be increasing navigational hazards from rocks and shallow water or undercutting of shoreline hardening structures or shoreline bluff “toes” by wave action that will result in bluff erosion when water levels return to average or high conditions.

These impacts depend on the shoreline type and the conditions it experiences. In some cases, these processes are natural but appear to be impacted by increasing energies induced into the system by human induced global warming.

Drivers of water levels

	QUESTIONS	ANSWERS
32	As a long-time resident of the Bay, I have witnessed these cycles, obviously there is a scientific root cause analysis?	See: The Canadian Hydrographic Service (waterlevels.gc.ca) . “More than a century of records in the Great Lakes basin indicate no regular, predictable cycle. The intervals between periods of high and low levels and the length of such periods can vary widely and erratically over a number of years, and only some of the lakes may be affected.” This supports there being no discernible cycles for the last 100+ years. Climatologists look at patterns that might emerge across spans of 30 or 40 years. The past observed fluctuations existed within a climate regime that many studies show is changing to a new and different regime. This view is also supported by traditional knowledge holders. If correct, this change will continue as climate change impacts build, and has already resulted in changes to the way that major water level components such as evaporation and precipitation interact. The expectation from these studies is that water levels will increase beyond their historic range, with the extreme levels increasing and decreasing at high and low levels respectively, and the speed of transitions between water levels increasing, as we experienced in 2014 when water levels rose from an extreme low to an extreme high faster than ever before recorded.
33	Water temperatures and growth of species	Small changes in water temperature can be significant stressors on organisms living in the water. In the deep water the temperature and oxygen saturation is remarkably stable. Water at four degrees Celsius is the densest and settles to the bottom of our deep lakes. That cold water holds more dissolved oxygen than warm water. Many organisms have evolved in that stable temperature regime. Increasing water temperatures decrease the oxygen saturation levels. If oxygen levels change it can lead

		<p>to loss of habitat and the death of these organisms. Other organisms proliferate in warmer waters.</p> <p>Some like blue-green algae may grow rapidly and produce nerve or liver toxins fatal to fish, fowl, other animals and humans. The ecosystem is a balancing act and nudging it in one direction or another may cause it to wobble, but it returns to an equilibrium that sustains the organisms that evolved within those prevailing conditions. However, if significant enough disruptions in those conditions occur and persist it will drive the ecosystems to a new place. Significant temperature increases have already been measured over the past forty years in the waters of Lake Michigan-Huron. The ecosystem has changed dramatically over the past 70 years due to numerous invasive species that have entered the lakes through the St. Lawrence Seaway. Adding temperature effects will continue to exacerbate those stresses.</p>
34	<p>To what extent has climate change impacted the wind, waves, water levels and shoreline erosion?</p>	<p>Climate Change appears to have already impacted wind, waves, water levels and shoreline erosion – also known as natural coastal processes. Measured increases in surface windspeeds of ~5% per decade since the 1980s means about an 18.8% increase in average windspeeds over the last 40 years. <i>(References for studies & research on this are available upon request.)</i> These larger wind energies act on the higher water levels to produce more run-up on the shoreline causing inundation of low-lying coastal zones. These coastal zones are where we find coastal infrastructure like docks, boathouses, piers, marinas, seaplane ports and other places where humans and our lakes meet, such as beaches. In areas where sand dunes and bluffs exist, coastal processes are always naturally at work eroding these elements of our coastlines and replenishing the coastal sediments that eventually wash into the deep basins, or are transported down the reaches or connecting channels to lakes further downstream. These natural processes are often resisted by humans through construction to harden the shoreline, which are always finite in effect and duration.</p> <p>Times of low water levels also lead to shoreline erosion, exposure of wooden cribbing leading to rotting and undercutting of coastal infrastructure and shoreline hardening.</p>
35	<p>Last October 31 there was a very big storm. Are the storms going to be bigger and more often?</p>	<p>Studies of the impacts of climate change show that storm energy and frequency will increase over time. See: http://glisa.umich.edu/gl-climate-factsheet-refs. The gasses already in the atmosphere will persist for a century and we are still releasing more and more heat trapping emissions. The effects of this heat trapping will therefore continue to grow.</p>

		That storm was the result of high northerly winds along the major fetch of Georgian Bay and high-water levels leading to high wave heights causing shoreline damage. Also see: Severe Weather Caused \$1.3 Billion in Insured Damage in 2019 (ibc.ca)
36	Water levels... even exacerbated by winds which amplify the extremes - is this taken account in the database?	Answered above.
37	Ice projection for 2020 into 2021?	<p>Specific daily conditions depend on near term impactors like water and air temperatures, the interaction between those two volumes (i.e. winds and relative humidity). Dry cold air over warm water will saturate drawing moisture and heat from the lake. Wet cold air over warm water is already saturated and will not draw moisture or as much heat from the lake. These are weather conditions. Therefore, ice projections are made in the near term starting in December. Daily forecasts are produced by the Canadian Ice Service and are available here https://www.canada.ca/en/environment-climate-change/services/ice-forecasts-observations/latest-conditions/products-guides/iceberg-bulletin-overview.html#forecasts).</p> <p>Some studies on the long-term trends of climate conditions (see Answer to Q. 48) show that it is possible that the Great Lakes may be ice free in forty years. <i>(Details of applicable research/studies are available upon request)</i></p>
38	How do high water levels affect snow falls in west Parry Sound and east - is streamers off the bay?	Streamers off the bay result from evaporating water entering the cold air. As the water vapour condenses (changes state) to solid snow it releases heat into the air increasing the convection energy in the atmosphere resulting in more cold air falling towards the lake surface. This can lead to increasing levels of lake effect snow versus what would occur without the climate changed energy. High water levels result in a higher total of heat energy stored in the lake water -- just as a full pot of hot water has more heat calories in it than a half pot of hot water. So higher water levels can also continue to power this cycle longer than lower water levels would.
39	What affects evaporation (i.e., ice, sun, heat, stormy wavy conditions)?	Evaporation is driven by three factors: water temperature, air temperature and relative humidity. For this reason, most evaporation from the Great Lakes occurs in the cooler months when the air is dry and cold and the water is relatively warmer than the air. Imagine a mass of cool dry air (say at 5 degrees Celsius) sitting stagnant over a warmer water body (9 degrees Celsius). The air will receive moisture from the lake until the relative humidity reaches 100 percent at which time evaporation will stop. Also, as the water vapor condenses back into liquid (rain) or solid water (snow), the relative humidity drops below 100 percent and more evaporation can occur. As the condensation occurs it also releases heat into the atmosphere also driving

		<p>convection mixing and more contact between the air and the water driving more evaporation. This introduces motion to circulate more moist air away allowing more dry air to be able to interact with the water surface and allowing more evaporation to occur.</p> <p>This continues until the water temperature drops to the point where ice forms (winter) or until the air warms and the water temperature and moisture content of the air starts to rise (spring).</p>
40	<p>What are the future projections of the water levels? Is the ground water level effected for shore line properties?</p>	<p>See answers to Q 1-31 above. Groundwater in the basin is at high levels due to record levels of precipitation over the past three years. Ground water repositories flow through subsurface rock formations at different rates resulting in sub-surface water entering the surface lakes from a variety of directions. In Lake Huron at Alpena, Michigan there are indications of freshwater infiltration entering from the lake bed. In other locations we can see ground water seep along the shore where the water enters the lake. More rain falling on the surface will increase runoff and ground water movement. When surfaces are saturated, the soils in some places become more mobile and there may be increasing sluffs of material into the lake. More surface rainfall that can't soak into the soils may also result in more surface stream volumes and energies and that may result in increases in erosion. All of these examples are driven by one simple rule – water flows downhill.</p>
41	<p>What's makes the latest water level fluctuations different from 1970 and 1987 high water marks?</p>	<p>Water levels historically tracked precipitation falling within the basin or onto the lake surface. Over the past century we are seeing a trend towards increasing precipitation and over the past three years we observed a record level of precipitation. However, in the late 1990s the tracking diverged from precipitation dominating that relationship and appeared to track more closely to evaporation rates. Accelerated rates of precipitation and evaporation add to the uncertainty of predicting future levels. The amount of volatility is directly related to the changing ratios of precipitation and evaporation and climate change appears to have changed this balance. So, the fluctuations we see today are the result of a far more energetic weather system (see page 4) than existed in the 1970s and 1980s.</p>
42	<p>We are obviously experiencing climate change; can modelling predict how it will affect water levels?</p>	<p>ECCC are currently studying this issue, the report is still being internally reviewed. The main results are that the projected range of water levels is greater than those seen over the past century, i.e., higher highs and lower lows. The final report will be distributed sometime in 2021.</p>

43	What are the weighted factors affecting Georgian Bay water levels?	All the factors we've listed in our Water Levels 101. Weighting would put precipitation and evaporation at the top. Inflows and outflows next, then regulatory modifications and diversions. At the bottom would be consumptive uses and process water losses.
44	What is causing the water levels to rise?	The increasing net water balance. Record rainfall over the past three years in the watersheds of the Great Lakes has resulted in more water entering the lakes than leaving. This increases the levels. These factors appear to be impacted by ocean temperatures and circulation patterns and the impact of those energies on the stability of air currents like the Jet Stream. Increasing atmospheric energy creates larger storms, so conditions can change more quickly. But these same conditions may result in changes to the balance between precipitation and evaporation. A shift towards more evaporation would lead to lower water levels in the future. The system appears to be becoming less predictable and less stable, so past conditions may be less useful in predicting future conditions and more rapid transitions between extremes are likely.
45	What percentage of the high levels are government controlled or [caused by Climate change]?	<p>An IJC 2012 study (See: https://legacyfiles.ijc.org/publications/IUGLS%20St%20Clair%20Report%20Summary.pdf) suggested that a minimum of 40-74 of the cause of record low water levels in the 1990s and early 2000s was due to climate change shifting the balance between precipitation and evaporation.</p> <p>If correct, that would mean that 26-60 percent was due to other factors, including changing flow conditions in the reaches connecting the lakes (such as the dredging of the St Clair River in the 1950s), the surface of the earth moving upwards following the melting of the glaciers and other conditions.</p> <p>Government control of the two control structures capable of impacting Great Lakes water levels are regulated. Those regulations include a balancing principle that mandates that decisions made by the Control Boards overseeing their operation must consider pre-project or natural flow targets. This consideration reduces the deviations that might otherwise exist in operating the control works solely for the benefit of human uses like power generation of shipping. An IJC analysis of their operation shows that water levels have been close to what they would have been had these structures not been constructed.</p>

46	Lots of theories over the years about what drives water levels. Is there one particular thing/event that impacts levels the most?	Yes, climate. Rainfall and evaporation are the predominant drivers and the balance between these two forces is the deciding factor on what direction water levels move. However, one other overlooked factor in the Great Lakes is that only about one percent of the water volume is replenished each year. So ultimately, if the glaciers had not melted and filled the basins, we wouldn't have ninety-nine percent of the water that is in the lakes.
47	What makes the water in SE Georgian Bay drop a foot before a storm?	Barometric pressure changes over the lake's surface will cause a bulge in the lake surface. Since the weather patterns predominantly move from west to east, a low pressure (i.e. storm) system moving across the lake will elevate the water levels in the low pressure zone in the west, with a resulting volume drop in the east prior to the storm. As the storm tracks across the basin, the bulge moves and the water levels in the east rise with the arrival of the storm. In severe storms such as hurricanes we call this a storm surge.
48	Discuss ice cover effect and lake level history.	<p>Ice cover has been declining for the past four decades. Analysis by the National Oceanic and Atmospheric Administration in the United States showed a 71% decline over that period. The year over year ice levels are variable and differences may be large, but the climate trend is downwards even towards zero ice in the lakes forty years from now. See: https://www.climate.gov/news-features/featured-images/great-lakes-ice-cover-decreasing-over-last-40-years.</p> <p>See Q 37. Ice cover affects lake levels because it both indicates and prevents evaporation.</p> <p>Evaporation removes heat energy from the surface of the lake so, the closer the lake is to freezing, the less evaporation will occur and the sooner the ice will emerge. Once the ice covers the surface of the water, evaporation stops and ongoing cold temperatures simply thicken the ice. Some sublimation (ice changing directly into water vapour) can occur, but the largest volume of water leaving the lake does so by evaporation.</p> <p>In the spring melting ice absorbs heat, so the more ice formed during the previous winter the more solar energy is needed to melt it – therefore it takes longer before the water temperature begins to rise. That means a lower water temperature when cool weather returns and less evaporation the following year. Conversely, less ice over the winter means less solar energy is absorbed melting that ice and the sooner water temperatures begin to increase leading (likely) to higher water temperatures over the summer and more evaporation that next fall and early winter before the ice sets up.</p> <p>So, less ice will mean more opportunity for evaporation unless we experience increasing moist air in the area at those times. These processes show the interconnection of ice cover, evaporation and water temperatures. See: http://glisa.umich.edu/climate/great-lakes-ice-coverage</p>

		When additional factors like rainfall are added into consideration it is easy to see why these relationships make it difficult to predict resulting lake levels.
49	Where does the water come from this year for example?	<p>Water in the Great Lakes comes from storm systems that typically pick up the moisture from the Gulf of Mexico and then move north over the United States into the Great Lakes Basin. Some weather tracks south east from the Northern Pacific Ocean down over the continent and into the Great Lakes basin, or from large weather systems in the Atlantic Ocean that track up the eastern coast of North America like hurricane Sandy.</p> <p>These weather systems all bring precipitation into the Great Lakes basin. As the atmosphere warms the size of these storms increases. For every degree Celsius increase in air temperature, there is a seven percent increase in the water vapour content in storm systems. So, climate change impacts are expected to increase as Global Warming continues.</p>
50	Effect of melting polar ice caps on inland lakes/ water.	<p>Ice effects in the polar areas result in a decreased albedo (reflective effect) of the white polar caps. These darker exposed waters and lands absorb more heat energy and appear to be leading to feedback loops that are accelerating global warming.</p> <p>Melting permafrost also reawakens natural processes that result in increasing methane emissions that add to the greenhouse effect. At some point these feedback loops could reach a tipping point and run away leading to significant climatic changes that could impact precipitation, storms, evaporation and the other processes that affect our water levels. See:</p> <p>https://www.epa.gov/climate-indicators/climate-change-indicators-atmospheric-concentrations-greenhouse-gases</p>
51	Can water levels be predicted and also altered in our area?	<p>Water levels can be accurately predicted in the short term based on current conditions and expected weather patterns. Water levels cannot be altered artificially in the short term, but over several years the operation of the control structures effecting water levels can make impacts as was the case in Lake Ontario during 2019 and 2020 following the record precipitation levels in the Lake Ontario and Ottawa River basins in the preceding year. Anticipating these conditions and proactively responding with counteractive management decisions is a very difficult proposition and at the present time not something that any government or agency is calling for. Work done by AECOM Technical Services does show that structural additions to the system could increase the climate resilience of the system especially in avoiding low water level periods, but further analysis of these solutions in light of emerging new climate modelling would be need to directly answer this question.</p>

52	How can natural variation in water level be told apart from that human induced variation?	The way to do this is through an analysis of the probabilities of a particular regime existing with or without human induced changes we can measure. In general, until this time, scientists have steered away from making claims that a particular storm event is the direct result of climate change. Attribution statement science has evolved to now allow such direct probabilistic claims. The first example of this was work performed in “Forecasted attribution of the human influence on Hurricane Florence” by K. A. Reed et. al. that showed that a storm was larger and more powerful than it would have been without climate change impacts.
53	Is nature the predominant arbitrator?	As described in detail in answers to questions in this document, it appears that human caused climate change is creating the conditions for future, wilder swings in water levels, which could be expressed as a reaction from nature. Conversely natural forces, as experienced to date with historical water levels fluctuations, were the predominant influence on water levels. However, either way, nature is the predominant arbitrator.
54	What are the three most important things to know as an islander about water levels?	They are: <ol style="list-style-type: none"> 1. At present increases in precipitation levels over the last few years has been the prime driver of the current higher levels. However, there is considerable uncertainty surrounding future water levels as no predictions are accurate beyond about 6 months, 2. There are indications that future extreme highs and lows may exceed past extreme levels and occur more often, and that past trends no longer inform future water levels; and 3. Given these uncertainties, and the potential for higher energy storms, it would be prudent to plan for wilder weather, lower lows and higher highs going forward.
55	What causes water surges? What causes the water go up and down six inches in a day?	This phenomenon is known as a seiche. Winds set up oscillations of standing waves in the lake. As water sloshes back and forth within the basin the levels can change significantly. These standing waves can be above the thermocline, below the thermocline or both above and below leading to more complex interactions and wave periods.
56	Why has the water gone up so rapidly in [such] a short period of time? Is it a question of government control of the lock system?	Water levels have increased very rapidly due to record levels of precipitation and lower evaporation rates over the past year...especially the past three years of record setting rain. Locks and other water level control capable structures have a minimal impact in comparison.

57	Why is evaporation so low in the past 10 years?	Evaporation rates on the Great Lakes are driven by complex relationships between lake water temperatures, air temperatures, humidity, and wind speed (among other factors). Drew Gronewold's group has not done a detailed assessment of the specific drivers behind the recent low evaporation rates, but suspect it is due to lower surface water temperatures following the cold air outbreak in 2014 (though it is also whether this event in 2014 propagated into cold temperatures in the years following). This is a high priority research area.
58	Where does Georgian Bay's evaporated water fall? How much goes back to the bay?	Evaporated water from Georgian Bay typically falls into the basin as lake effect snowfall, the watershed of Lake Ontario or the Ottawa River and sometimes directly into the Atlantic Ocean. Satellite images show these streamers leaving the watershed.
59	What affects rates of evaporation?	Rates of evaporation are driven by the temperature difference between the water and the air as well as the relative humidity of that air and how much mixing and surface contact exists to facilitate that energy transfer.
60	If we cannot control evaporation and precipitation then is it not reasonable to presume that we must take a multi-step approach to solutions utilizing all diversions available? While individual diversions may yield limited results the collective benefit of all could lead to an improved situation for all.	This is true. We cannot control precipitation or evaporation but clearly, we can influence them and water levels. This is an economic and political question of how to respond to the impacts of climate change.
61	What about outflow?	Outflow through the reaches connecting Lake M-H to Lake Erie is about double the average evaporative losses from Lake M-H. The flow of water out of the system is measured and modelled. The US Army Corps of Engineers has installed a Doppler Velocity gauge to measure the rate of flow of water in the upper section of the St. Clair River. Known measurement of the river bed at numerous locations allows the speed of the river along its course to be calculated. These measurements of the bathymetry of the river are periodically renewed.
62	Impact of ice cover on evaporation?	Previously answered - see question 48
63	Are there any human factors that are considered within your modelling?	All introduced greenhouse gas emission impacts are human factors and are the reason for these models in the first place. Emission scenarios called Representative Concentration Pathways (RCPs) and those arising from Shared Socioeconomic Pathways (SSPs) have been developed by the United Nations
64	What human impacts are	

	there on these water levels?	Intergovernmental Panel on Climate Change to facilitate impact studies based on these models of behaviour.	
65	Do any of the diversions have anywhere near the same impact as evaporation?	Diversions have a much smaller impact on water levels than evaporation or precipitation. For example, the diversion at Ogoki and Long Lac add 6000 cubic feet per second to the system and that at Chicago diverts about 3200 cubic feet per second out of the system. The average evaporation from the surface of Lake M-H is about 87,000 cubic feet per second or 29 times greater than the outflow from the Chicago diversion.	
66	Have the climate models you are using to predict precipitation and evaporation been calibrated and validated against historical data. If so, is there a report on the results. If not, why not?	The ECCC report on this will include links to other reports about the calibration and validation of the models. This report is currently being reviewed by ECCC prior to publication, which is expected shortly. The report will include probability weightings for the various outcomes, but please note that, as with all models, there will be a degree of uncertainty regarding future water levels predictions.	
67	On the "Future lake levels under a changing climate" slide - there seems to be a wide range of potential outcome in terms of water levels on lakes Michigan and Huron. Is there any way to understand how likely we are to see any of these various outcomes? In other words, is there any probability weighting for these various outcomes? Thank you.		
68	The Components method for NBS and calculating lake levels is based on the same precipitation and evaporation data Gronewold is using. We	There have historically been two main methodologies -- components and residuals -- used. There are differences between the results of the two methods from errors and uncertainties arising from both approaches. The literature is full of examinations of these differences. The binary wording of this question exposes a bias in the questioner for the latter approach, but the two methods are used for different reasons. "Residual NBS tend to work well in the development of regulation plans but are incapable of being used for the simulation of climate impacts on water levels" -- "Net Basin Supply Comparison Analysis", Frank H. Quinn. Further, Gronewold's work is a synthesis of both using measured elements and modelling. The components method is built from the bottom up by actually measuring all individual elements of the Basin Supply. In some cases, the measurement of these individual components is just starting, and in other cases it may be difficult or expensive. For that reason, some	

	<p>know there are problems with the Components method - does that mean there are problems or large uncertainty with the precip/evap data?</p>	<p>data is derived from a combination of measured and modelled data. For example, over-lake evaporation and precipitation has historically been estimated based on shore station measurements.</p> <p>Ultimately a component-based hybrid modelled data approach can use many actual measurements and allow the exposition of other details such as ground water infiltration that is difficult to determine in the residual approach. The Large Lake Statistical Water Balance Model (LLSWBM) reconciles discrepancies between model and measurement-based estimates of each component while closing the Laurentian Great Lakes water balance.</p> <p>The statement offered in the question isn't entirely true. There are multiple sources of data for evaporation, precipitation, and runoff across the Great Lakes. Some sources come from regional branches of federal agencies, some from regional academic institutions, and some from groups outside of the Great Lakes that have never been engaged in a formal assessment of "NBS".</p> <p>We encourage the audience to consider that any combination of these sources could be combined to calculate a value for net basin supply. Some of the data presented came from a recent study using the L2SWBM that almost certainly have never been used before in conventional NBS data records. The L2SWBM does explicitly quantify uncertainty in each water balance component, but we did not include those uncertainties in the presentation; they are unlikely to affect our overall findings.</p>
69	<p>Are there any studies being done to assess how the extensive melting in the arctic regions that we're seeing will have on the Bay water levels. As the melt is expected to continue (perhaps even accelerate), is there anyone currently assessing how it will affect the rising water levels and when might we see that happen (or is it happening already)?</p>	<p>See Answer to Q: 50 for Q: 69 and 70</p>
70	<p>Shelf Ice is collapsing on the North Side of [sic] Ellsmere Island. Will that have an effect on our water level problem on Georgian Bay?</p>	
71	<p>In hindsight, was our concern of low water levels, Stop the Drop, an over-reaction?</p>	<p>Extreme water levels are expected to continue to be an issue, as is the increasing rate of change in water levels expected due to climate change impacts. People will always be concerned about extreme water levels, whatever the cause. Therefore the "Stop the Drop" campaign should not be termed an over-reaction.</p>

72	Why is precipitation data shown today not up-to-date?	<p>Precipitation data shown is up to date. Some presentations may have been derived using previous data sets or only officially released data sets that sometimes lag behind raw measurements due to the additional verification steps. In any case, the nature of the data to illustrate the issue under discussion was valid.</p> <p>All data is available through online access if independent verification would be of interest.</p>
73	It is my understanding that hurricanes/storms forming over the Atlantic Ocean and Gulf of Mexico, ultimately end by transferring water from the oceans to the Upper Great Lakes Basin. Should we expect a correlation between the frequency and size of hurricanes and the amount of new water added to the basin?	<p>There is only a direct correlation if systems track courses that take them into the basin. The mechanisms of storm formation are based on the following physics. Increasing temperatures lead to increasing atmospheric water content and result in increased energy in the systems. Perturbations in the jet stream may form and stall weather systems leading to significant stationary precipitation. However, it is also possible that a weather pattern over the east coast of the US could stall dry weather systems over the Great Lakes leading to increasing drought-like localized conditions.</p>
74	For Gronewold's work how long is the historical record - only back to 1950?	<p>Each source of data has been characterized as to accuracy and utility. For example, the data record is verified back to 1918 for water levels, but over-lake evaporation measurements have only been taken from ship-based systems for the past 5 years and stations at lighthouses have been using new technologies.</p> <p>Data on the main components of the water balance prior to 1950 have a very high degree of uncertainty, in part because of the sparse meteorological monitoring network during the early part of the century. In 1950 (see Hunter et al, Journal of Great Lakes Research), the number of meteorological stations (particularly those for air temperature) increased dramatically across the country, allowing for improved calculation of several components (particularly overlake evaporation). So, for the purposes of the presentation, the water balance record extended only to 1950. There are plans to extend it further (while accounting for uncertainties) perhaps using the Large Lake Statistical Water Balance Model as a guide. It is also indeed true that water level records have been collected back to 1860 (and that federal agencies often consider 1918 as the beginning of the "official" water level record).</p>

75	What changes are we seeing in the sources of moisture that reaches the Great Lakes basin? i.e. are we getting more moisture from the Gulf or more from the Atlantic?		See Answer to Q 73
76	Any comment about tectonic plate shift over the next century? The "bathtub" effect?	<p>There was an interesting and new revelation based upon the research cited by Gronewold in "Rise of Great Lakes Surface Water, Sinking of the Upper Midwest of the United States, and Viscous Collapse of the Forebulge of the former Laurentide Ice Sheet." Donald Argus et. al. https://doi.org/10.1029/2020JB019739</p> <p>This complicates the story of Glacial Isostatic Adjustment included in the 2012 International Joint Commission report on the Upper Great Lakes. The plate elasticity is the issue here not a tectonic shift per se. The scale of lakebed drop is in the 8 to 23 mm range due to the increasing weight of water in the lakes from 2013 to 2019 and due to changes in the earth's crust. These changes can be measured by gravimetric means with the same GRACE (Gravity Recovery and Climate Experiment was a joint mission of NASA and the German Aerospace Center) and GRACE-FO (Follow On) satellites that are used to measure groundwater changes in the basin.</p>	
77	Can you predict ice thickness and coverage of Georgian Bay for 2020 into 2021?		See Answer to Q 37
78	Back in 2012 when water levels were low in Lake Huron and Georgian Bay, one school of thought was that the rebound of the earth's crust following glaciation was part of the reason for low water levels. Now as I understand, there is a school of thought that Lake Huron and Georgian Bay are in fact subsiding and this is part of the reason for high water levels of today. Is there a discrepancy here?	No discrepancy. See Answer to Q 76. These observations actually improve constraints on postglacial rebound as noted in the paper.	
79	In the previous lecture, posted online, the speaker attributed high evaporation to the early onset of cool times in the fall. That seems backward to me water evaporates faster at higher temps, so if it were a warm fall I would expect more evaporation. Did I misunderstand, or am I missing something?	The counterintuitive answer is explained in detail above in Q 39. Warm moist air and warm water provides no thermodynamic driver to support evaporation.	
80	Water surface elevations in the North Atlantic would affect WSE's in the St Lawrence River. But would that affect WSE's in the Upper Great Lakes?	Not directly due to the large elevation change at Niagara Falls. There is no hydrostatic influence of the lower Great Lakes on the Upper Great Lakes.	

81	Does the «Post-glacial or isostatic rebound» of the Great Lakes geographical area have a multiplier effect with the subsidence just mentioned?	See Q 76 above. Land subsidence of 3 – 14 mm was also measured due the post glacial “viscous collapse” of the bulge created at the leading edge of the Glaciers that once covered the Great Lake basin.
82	Re: observed subsidence of L Huron, it follows that when MH level decreases the observed subsidence will amplify the low water impact. Given this knowledge, does it not make sense to plan now for water retaining strategies and mechanisms in the St Clair River?	The deformations due to increased water mass are elastic according to the published paper. However, given the modelling showing increasing magnitudes of the variations and the possibility for future record setting extremes on the low-water and high-water levels, there is some argument to be made in support of such a conclusion from both the risk avoidance and cost reduction perspectives. These decisions also include a variety of other political, cost-benefit assessments and institutional and governance issues. Further discussion and study would be prudent given the likely increasing impacts of climate change in the basin.

QUESTION B
What’s known and not known about water levels control structures?

	QUESTIONS	ANSWERS
83	Are there methods or practices that could help normalize water levels reliably?	<p>Q 83 – 96 answered below: These questions were primarily answered by Rob Caldwell and John Allis’s presentations during the symposium under Question B “What’s known and not known about water levels control structures?” More background information was provided in David Sweetnam’s water levels presentation earlier in 2020 here: https://youtu.be/1C54Lp8-t_0</p> <p>Key slides in the morning session to review are:</p> <ul style="list-style-type: none"> • Page 46 which sets out who manages all the control structures throughout the Great Lakes system, and
84	Who controls water levels?	
85	What controls are currently in place to control the water level of Lake Huron/Georgian Bay?	
86	Are there any plans to keep water levels in Georgian Bay from going up any higher?	
87	What is current position on Great Lakes [International] Joint Commission re water levels?	

88	Did the government do anything to adjust water levels on Georgian Bay in the 1980s?	<p>their respective flow rates and purposes, which includes electricity production and fish migration.</p> <ul style="list-style-type: none"> Page 51 which demonstrates that Plan 2012 has been applied effectively to balance water levels between Lakes Superior and Huron/Michigan (M/H) to the extent possible. The key factors that affect water levels, and the reasons why adjustments at control structures are limited in their ability to control water levels, must be born in mind. This information was provided in pages 25 and 41. <p>Some of the questions assume that the government has absolute control over water levels. This is definitively not the case. Water levels are primarily dictated by changing weather patterns over the years – precipitation and evaporation levels being the most significant.</p> <p>Adjustments at control structure should however be applied to do the best job possible to mitigate extreme high/low water levels, as discussed in the afternoon session.</p>
89	Can something be done to stop the rising water on Georgian Bay?	
90	What if anything can be done to get levels back down several feet?	
91	How can the levels be controlled? (If it was two feet below the high water level it would be better.)	
92	Why are the levels so high - what can't you manage it to keep it a consistent level?	
93	How are maximum water levels set on Georgian Bay to determine flood contours? it seems the Conservation Authorities do not all.... [response cut off]	
94	To what extent does water level management affect Georgian Bay levels?	
95	Is there any ability to control lake levels? Is the St. Clair River getting deeper?	<p>Q 97 - 100 Answered below:</p> <p>Please refer to Rob Caldwell's presentation for the answer to</p>
96	Is it true we are being flooded out to keep Montreal from being flooded at all?	
97	What if anything has the government done in 2020 to reduce water levels on Lakes Huron Michigan? Are you willing to stop the diversions coming into Lake Superior and stop dumping water out of Lake Superior into the lower lakes until the levels drop?	
98	Erika mentioned Plan 2012 several times and the IJC policy of not transferring problems downstream. However, outflows from Superior to MH have been consistently over Plan 2012 recommendations. For example, all months from Dec to Mar 2020 were over Plan 2012. Does this not seem unfair to MH?	

99	It appears this year that the outflow from Lake Superior has exceeded agreed upon limits. Why is the 2012 Plan not being enacted?		these questions.
100	When will the govt stop the flow of water from Superior to Huron to stop all the erosion that is happening from wave action with high water levels? There is so much toxic material in the lake now from all the damage, not to mention the cost to the shoreline property owners.		
101	We are hearing a lot about climate change - which is definitely a great contributing factor. But what about the diversion of the water levels by use of "locks" as they did back in the late '90's?	The two locations where locks are relevant for the upper Great Lakes water levels influence are at the St. Mary's River and at the Welland Canal on the north-east shore of Lake Erie. In either case the contribution possible for diverting extra water out of the system is low. The canal uses about 225 m ³ /s to raise ships through the 8 locks between Lake Ontario and Lake Erie. This is a relatively small amount compared to the unregulated Niagara River average discharge of 5,796 m ³ /s. The outflow from Lake Erie is unregulated and directly related to the fall of the river to the lip of Niagara Falls. According to the September 1987 report on "POTENTIAL MEASURES TO ALLEVIATE PROBLEMS CREATED BY CURRENT HIGH LAKE LEVELS - TASK 3 DIVERSIONS MANAGEMENT" to the International Joint Commission, "the theoretical maximum flow through the Welland Canal in an extreme crisis situation was estimated to be 12,000 cubic feet per second (cfs) [340 m ³ /s]. The most significant physical impacts of this maximum flow would be the complete disruption of navigation between Lake Ontario and the upper lakes and the possibility of major damage to the canal itself. A reduction in Lake Erie levels of 1.3 inches would be achieved." The outflow through the locks is not very flexible due to their construction so their ability to be used in water level regulation is minimal.	
102	Have we considered inflow control structures to reduce spring peaks?	Altering the natural flows down rivers in the spring could adversely affect fish spawning habitat, so it is unlikely that this would be a viable solution to spring peak inflows into the Great Lakes. The management of the existing control structures do take account of spring peaks. Inflow structures would also limit the habitat available in the river or stream.	
103	What are the implications of increased flow in the Chicago canal on barrier function for Asian carp?	GBA and GBF will continue to raise the issue of whether adjustments can be made to the Chicago diversion in consort with Plan 2012. In this context no adjustments should be permitted that would adversely affect the functionality of the Asian carp barriers.	
104	When manipulating the diversion that may affect the water level - what is the implication to folks downstream or enjoying the electricity? Is that taken into the equation?	Answered in presentations	

105	Please discuss the deepening of the St. Clair River after 1909 as this would increase Lake Erie above 'natural' levels and hence not in agreement with the Boundary Waters Treaty.	The Boundary Water Treaty didn't lock a specific water level regime in place, but rather established an independent tribunal for the resolution of disputes or for consideration of applications to make changes impacting the boundary waters. The channelization of the St. Clair River had been economically justified for the purpose of moving freight through the river in larger vessels. According to the literature, the first major dredging of the river occurred for navigational purposes in 1855 resulting in a 4m deep channel. Subsequent sand and gravel mining from the river bed occurred undocumented until 1908 when record keeping began. This activity continued until 1925. The navigation channel was deepened in 1934 to 7.6m and again for the Seaway construction to 8.2m in 1960. These incidents each directly impacted water levels in the upstream and downstream lakes lowering Lake Michigan Huron by an estimated 27cm and a decrease in the difference in mean elevation of its surface and Lake Erie's surface.
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QUESTION C
Do we have all the data we need to understand water levels and, if not, what data and data-collection approaches should be prioritized?

	QUESTIONS	ANSWERS
106	What is the current status for real-time monitoring all the inflows sampled in small time increments including all the small rivers?	Answered in presentations
107	Will new and evolving SMART Great Lakes initiatives improve the availability of data? Are they being funded adequately?	Answered in presentations
108	Given the new upcoming 2022 NOAA-National Geodetic Survey (NGS) Vertical Datum; and the NRCan-Canadian Geodetic Survey (CGS), Canadian Geodetic Vertical Datum (CGVD) 2013; have there been considerations to use these harmonized vertical Datums rather than adopting a new IGLD2020 vertical datum in 2025?	Answered in presentations
109	To: Wendy: there is no data station on Georgian Bay (looking on your slide), you should establish one e.g. on the Christian Island Light House- GB is a critical component of the overall system.	Good suggestion. Federal agencies leading the deployment of eddy-covariance and meteorological stations include NOAA and ECCC. The recommendation is to contact NOAA via GLERL for deploying additional stations.

110	<p>Recent aerial photography has shown significant build up of erosion sediment in the St. Clair River. This must be changing conveyance. As the largest uncontrolled factor in NBS of Michigan Huron, should we not improve timeliness and accuracy of conveyance data on the St Clair River? Isn't this a huge data gap?</p>	<p>A river is not a static entity. Normal processes involve the transport of sediments along the river course. The “build up” of material follows year of starving the river, dredging materials from the riverbed for the construction and maintenance of the Seaway, and historic mining for aggregates. Conveyance data is collected through detailed ongoing bathymetric measurements that were implemented following recommendations arising from previous studies. The pace of changes in the river bed may not require increasing the measurement frequency. Further, there are continuous measurements of the water flow rate at the mouth of the river using doppler velocity sonar tools looking across the 800-foot wide river. These technologies can “see” through 2,400 feet of range.</p>
111	<p>I truly enjoyed the am session. I have a comment to make and would appreciate your thoughts regarding my comment. I think it is a worthy objective to increase the research around all the factors that affect water levels in the Great Lakes so that the experts can be more accurate about future impacts the water levels will have. I see a comparison here with weather forecasting. On a daily basis it is problematic how accurate weather forecasting is on a daily basis. The forecasters are much more accurate when it comes to major weather conditions - namely, hurricanes and tornados. I think that in the long run when all is said and done that the research on the water levels in the Great Lakes will provide some idea of what might happen with water levels in the future. I think the most powerful outcome of this research will be when a major impact will happen to the water levels. Thus, we need human intervention to deal with the major impacts when they occur. On a yearly basis we need human intervention too.</p>	<p>We agree with the need for human intervention. This was the primary purpose of the afternoon session in exploring the potential to improve coordination between all control structures, so that adjustments at control structures are applied to do the best job possible to mitigate extreme high/low water levels. Also see: “Covering Answer on additional control structures” below.</p>

QUESTION D		
How can existing and to-be-collected data be converted to a consistent format and presented to better inform decision-making?		
	QUESTIONS	ANSWERS
112	<p>Comment: Thank for a wonderful set of presentations. The flow from one presenter to another was well thought through. Question: This is one of the world's greatest resources, and in particular for Canada and the USA. I find it amazing that there are so many organizations working in an uncoordinated fashion. Would it not be much more cost efficient to create a single organization to more effectively coordinate research and management? We would be able to rid ourselves of lots of redundant top management in each organization use these savings to invest in teams working on specific areas of data gathering and model simulation.</p>	<p>We agree that this would definitely make sense and will bring this forward to the respective government agencies. In some respects, the IJC and the coordinating committee fulfill this function, but it is certainly the case that further avoidance of duplication of effort could be done to focus funding and reduce costs, and allow for additional work to be done within the same budgets.</p>
113	<p>Web based real time data is the way to proceed for property owners</p>	<p>Thank you for this suggestion. It is also something GBF and GBA would like to see and could be a spin-off benefit of applying a consistent format for gathering and presentation of water levels data.</p>
114	<p>Are you aware of the smart Great Lakes initiative?</p>	<p>Linden Brinks, GLOS: It's a regional initiative to improve Great Lakes data collection and decision making by building an information ecosystem that incorporates advanced data management, analysis, and tech. This includes building a new central technology platform for analysis and data discovery. glos.us/smartgreatlakes/</p> <p>GBF: We have been at the kick off meeting and on a progress reporting webinar and look forward to working with the initiative.</p>

QUESTION E

What improvements could be made to coordination between control boards and their coordination with other water levels control structures in the system to better address extreme high and low water levels?

	QUESTIONS	ANSWERS
115	In 1993 the IJC developed four action plans to mitigate high water - why aren't they using any of them?	<p>Covering Answer on Improved Coordination between Control Structures Q 115-125:</p> <p>Some of these questions are answered, or partially answered, by the covering answer to Question B (Q 83-96) above. In addition:</p> <ul style="list-style-type: none"> • It should be noted that the IJC can only make recommendations to the US and Canada federal governments to take action. It has no power itself to implement any of these action items. • We learned about the coordination between the three control boards, but it is clear that these 3 boards do not coordinate to any great extent with the other control structures on the Great Lakes. • GBF and GBA believe that some improved mitigation of extreme high/low water levels could be achieved by improved coordination between the control structures in the Upper
116	Can regulated parts of the Great Lakes-St. Lawrence System be better regulated to offset middle lakes shoreline degradation?	
117	A decision was made to reduce the September outflow from Lake Superior...who controls this and why has it taken so long?	
118	Is the IJC prepared to deviate and amend Plan 2014 to allow increased water flow through the St Lawrence and reduce spring flood?	
119	Why aren't governments and the IJC acting on solutions they have available to reduce Michigan/Huron water levels now??	
120	Why is Lake Superior held at 0.26 metres above long-term average while Huron is allowed to [be at] 0.83 metres?	
121	What can be done to better regulate the Lake Huron/Michigan water levels?	
122	Currently, lakes with controls are 10+ inches over mean. Middle lakes with no controls are 30+ inches over mean. Shouldn't we have a plan to more equitably distribute the water variability between lakes to minimize impacts?	
123	I appreciate about the discussion of the outflows. If we are considering the Georgian Bay, would we not be served to discuss the St. Clair flows?	
124	What is the government doing to lower the water levels on Lake Huron?	

125	What is being done to establish a system to address the extremes of water levels in Georgian Bay and Lakes Michigan and Huron?	Lakes. This was the purpose of initiating a conversation on this topic at the symposium. Follow up is needed to further explore how this could be done, in order to expand and improve the management of adjustments at all these control structures.
<p>QUESTION F</p> <p>Is there consensus on action that could be taken to improve coordination and ensure that we collectively use all available methods to mitigate future extreme high and low water levels?</p>		
	QUESTIONS	ANSWERS
<p>Covering Answer on additional control structures:</p> <p>The issue of whether additional control structures are needed in the system, particularly to provide some controls at the mouths of the St Clair and Niagara rivers, has long been considered by the US and Canada federal governments following recommendations from the IJC and others, but has never been approved by them. GBA and GBF will continue to call for this to be done to provide an improvement in the tools needed/available to better mitigate extreme high/low water levels. There may also be additional measures that could be taken and technologies applied which should be explored.</p>		
126	Currently, lakes with controls are 10+ inches over mean. Middle lakes with no controls are 30+ inches over mean. Shouldn't we have a plan to more equitably distribute the water variability between lakes to minimize impacts?	Answers to Q 126 - 127 are contained within the answers to Q 83-96; Q 115-123 and the above Covering Answer on additional control structures.
127	I appreciate about the discussion of the outflows. If we are considering the Georgian Bay, would we not be served to discuss the St. Clair flows?	

128	What changes should be made to local and provincial laws?	<p>Answer to Q 128 and 129:</p> <p>Neither provincial or municipal governments have any control over the implementation of the changes/improvements discussed in the symposium. Therefore, changes to local and provincial laws are not relevant in this respect. GBA/GBF does intend to hold a follow up event to discuss water levels impacts and adaption measures. Many coastal Georgian Bay municipalities attended the symposium, a deeper involvement by them at this subsequent event would be appropriate – many thanks for the recommendation.</p>
129	Shouldn't municipalities that issue building permits be deeply involved in this discussion? If they were well acquainted with this issue, many problems with high and low water levels would be alleviated.	
130	Is Ontario Power Generation listening? If not, why not?	<p>Answers to Q 130 – 137:</p> <p>OPG were invited to participate in the symposium but did not respond in time. They have now, and GBA and GBF held a meeting with senior staff at OPG in late November. In 2002, the Lakes and Rivers Improvement Act was amended to create a regulatory framework for existing dam operations and provide MNR with the power to require development of water management plans that contribute to the environmental, social and economical well being of the people of Ontario through the sustainable development of waterpower resources. As a result, two comprehensive water management plans (WMPs) were put in place in 2002 for the Long Lac/Ogoki watershed. Since neither the Aguasabon nor Nipigon WMPs define Lake Superior as part of the watershed, Lake Superior water levels are not considered in the management of the watershed. This is why prior to 2002 it was possible to make adjustments to the flow rate at the dams during high water eras, but since 2002 these adjustments are not provided for in the WMPs and have therefore not been made. Furthermore, in our discussion it was clear that the water management plans, which cover an enormous area, have</p>
131	What pressure is being placed on the various stakeholders to reduce the volume of water from the Ogoki/Long Lac diversions?	
132	OPG vastly increased LLO outputs in the first 6 months of 2020 vs same time in 2019. Also, OPG discontinued outflow information online this summer. So how can you estimate effects when OPG changes outflows at will?	
133	The hydro dam is bringing water into lake superior that NATURALLY would not normally flow into superior.....if this was shut down natural process may be sustainable.	

134	Not diverting Nipigon is doing more harm to more people than the few it would affect up north.	been very successful, particularly for the 6 First Nation (FN) bands in the area. Increases in fish populations, and access for commercial fishermen (a mainstay of the local FN communities), + generally improved fish and wildlife habitat throughout the systems are the key successes, together with improvements in FN quality of life.
135	Has GBA and GBF reached out to Ontario Power Generation asking them about reducing the diversion into Superior?	OPG also advised that power production issues were only about 10% of the overall considerations when putting together the plans. This points to a real desire by the OPG to address local issues and work productively with the local communities, which persists.
136	The reduction in Long Lac and Ogoki would reduce [increase] the flows in the Albany River by only 4%. THIS would not likely have any significant harm downstream i.e. flooding [in the Albany River basin]. Please include this point.	Making minor adjustments might still be possible, but would still present substantive challenges and extensive consultation, with a low chance of approval by the FN communities and other stakeholders. Minor adjustments are really not going to cut it for making any substantive difference to water levels in Lakes Superior and downstream to Lake M-H.
137	I understand that reducing the long Lac and Ogoki diversions could have an impact on lowering the rise in water levels in Georgian Bay, Lakes Michigan and Huron. Has anyone spoken to OPG?	Although the WMPs are considered “living documents” that can be reviewed at any time, the probability of achieving consensus amongst the stakeholders on making substantive changes to water levels within the watershed are, in our opinion, very low.

WRAP-UP Q&A
What are next steps for participating individuals and organizations based on what was learned?

SUMMARY OF NEXT STEPS

Data

A. Follow up with the relevant government agencies to explore how existing and to-be-collected water levels data could be converted to a consistent format and presented to better inform decision-making and provide more coherent real time information for the public.

B. Encourage further investment in increasing data collection points and the application of available technology to improve the quality/quantity of data input and reduce the cost of collecting it.

- C. Monitor and report on coordination between government agencies on water levels data collection and dissemination and progress towards achieving A & B.
- D. Hold further discussions on the St Clair River water levels data collection to review whether the frequency and methodology is sufficient to fully understand the flow rate, bathymetry and conveyance of the river.
- Improve mitigation of extreme high/low water levels**
- E. Continue discussions on expanding the membership and mandate of the Lake Superior Board of Control to encompass management of the and Chicago diversions and St Clair River conveyance issues and monitor the Long Lac/Ogoki diversions and associated water management plans.
- F. Examine the roll that GLAM could play in improving coordination between all control structures, including potential revival of the IJC 2013 recommendation to put in place a Great Lakes Water Levels Advisory Board.
- G. Continue to call for appropriate control structures to be put in place at the mouth of the St Clair, and also perhaps at the mouth of the Niagara river.
- H. Continue discussion for an improvement in the tools needed/available to better mitigate extreme high/low water levels, including additional measures, such as utilizing the Welland Canal, and applying new technologies and engineering advances to find innovative solutions.

	QUESTIONS	ANSWERS
138	How can all of the associations along the coast, including SSEA [Severn Sound Environmental Association], collaborate better to deliver information and help?	<p>Answers to Q 138 – 150:</p> <p>Answers to these questions have been provided in the above Summary of Next Steps or elsewhere in the answers to questions.</p>
139	Less time making the case. You are preaching to the choir. Focus on specific actions to mitigate short and long term.	
140	Feel, think, do; How do we get to effective doing?	
141	How fast will these recommendations be acted on?	
142	Are these webinars making any progress?	
143	Will the US commit to solving these issues re water levels and environmental concerns in a positive way?	
144	Has there been any progress in addressing this issue in 2020?	
145	will budgetary considerations prevent any action?	
146	I understand there is a possibility of some type of control structures in the Saint Clair or Detroit River to control levels?	
147	If climate change is driving more rainfall in Great Lakes Basin, are there plans to increase man-made controls?	
148	What is the best environmental infrastructure response to fluctuating water?	

149	What measures will help to manage rising water levels on a macro scale?	
150	There is a lot of talk about data collection, but what exactly is being done to fix the high water levels in Huron?	
151	If real action was called for. where are the funds/budget for it?	Both federal governments in Canada and the US have annual budgets to address Great Lakes issues, including water levels. If major investments are agreed this would be a long-term process which would require specific increases in funding over many years.
152	It's obvious Huron is way too high... we don't need any more studies or data collection.	Current indications are that water levels will be slightly lower next year and it is possible that we will be entering a period of declining levels. However, this is not certain, therefore analysis of future water levels in order to better understand the expected future changes in levels is key to informing the correct decisions/action to be taken. This is why GBF & GBA are calling for the public release of an ECCC projected water levels analysis that has been stalled for over a year now, and other specific action (see above).
153	Action needs to be taken NOW. What will be done to fix this? I think St Clair should be dredged right away and reduce the flow into Huron from St Marys... all this should be done now.. who has the power to make this happen?	USACE carries out annual maintenance in the St Clair River, including dredging where needed, but these minor changes have a negligible impact on flow rates. Please note that over-dredging would negatively impact the ability to retain water for the next low water cycle. Also, the flow down St Mary's has been reduced – see page 51 of the morning slides.
154	Earlier in the presentation, Andrew G. and Frank S. presented graphs of what future precip and evap to about 2100. Future lake levels will be dependent upon the balance between precip and evap. Based on this, the unwritten suggestion is that lake levels will be higher. If we look back at the upper Great Lakes study, their visionary attempt at graphing future lake levels suggested that by 2021 or so, lake levels would be tanking. The point here is that science is not at a point where predictions are dependable. Governments (IJC) need to act on extreme water levels because they have the mandate and solutions to do so. Even a few inches would help.	The time period in the 2012 Upper Great Lakes report was over the coming 80 years not 9 years. Drawing this conclusion with the rationale presented may be premature based on the fact that climate trending takes 30 or 40 years to emerge. Arriving at this conclusion from a risk avoidance perspective, however, might be completely justifiable. New modelling from ECCC will be a basis for analysing the next steps.

155	<p>a) Are there any practical structures that can be built on The Saint Clair River to lower the extreme fluctuations on Michigan & Huron? b) Is there hope of having them built?</p>	<p>a) Please see the AECOM study that can be found here: https://georgianbayforever.org/publications/#Water%20Levels b) The decision to build rests with the Canadian and US federal governments and any agreement to do so is likely to be a long-term process requiring a strong consensus amongst all stakeholders to encourage action.</p>
156	<p>Are there any affordable technologies which can either increase or decrease evaporation on the Great Lakes?</p>	<p>Yes. Decarbonizing the economy will help to reduce or eliminate the magnitude of potential future impacts. These impacts are expected to continue to increase as global warming continues. So, technologies that eliminate carbon releases ultimately impact evaporation. We need to stop the ad hoc geoengineering experiment that our society is imposing on the planet.</p>
157	<p>Is there the potential to develop new water diversions either before water reaches the Great Lakes or diversions to take water from the Great Lakes?</p>	<p>Please note that the Great Lakes Compact (see Q. 162) precludes any such diversions that would lead to water leaving the GL basin. We will continue to explore the potential for internal diversions to mitigate extreme water levels, but do not have a definitive answer at this time.</p>
158	<p>No participant seems to have decision making authority although all we have spoken about today is data collecting for decision making. When was the last decision ever made on Huron/Michigan?</p>	<p>Major decisions rest with the Canadian and US federal governments and any agreement to do so is likely to be a long-term process requiring a strong consensus amongst all stakeholders to encourage action. Decisions on adjustments under Plan 2012 are made daily.</p>
159	<p>Dr. Beland: Humans have made problems and humans can resolve some: e.g. it is possible to undertake actions that would affect conveyance of St. Clair River to allow some control over the Huron/GB/Michigan water levels. It will not resolve it, but yes, it can provide a guiding role but we must also consider what we can DO to make a positive change. I strongly recommend that you take this suggestion into your considerations.</p>	<p>Answer to Q 159-161: Please refer to the Summary of Next Steps and other answers to questions above.</p>
160	<p>It appears that there is a need for a Board that would make serious considerations on issues affecting Huron/GB/Michigan water levels and related issues. There is a separate focus on Lake Superior and there is one for Ontario-St. Lawrence: we need a Huron/GB/Michigan Board.</p>	

161	What is the point of all these studies if the powers that be continuously say there is nothing they can do or blame climate change for everything?	
162	Why can't we redirect some of the excess water from the Great Lakes?	Answer: The Great Lakes Compact https://gsgp.org/projects/water-management/great-lakes-agreement-and-compact/ prevents any such redirection.
163	Pierre Beland raises a key constraint. What is possible and what happens when Lake Superior is reduced by an inch? Huron goes up an inch and a quarter apparently and vice versa. And so on down to Montreal, where an inch from Lake Ontario becomes 10 inches at Montreal. How many years in a hundred, would additional system regulation improve things for some without harming others? And how many years would it make circumstances extremely difficult for some with only modest improvements for others? The answers to this condition [will dictate] the acceptability of increasing the ability to release and/or retain water in Lake Huron/Michigan.	1 inch of water taken from Lake Superior and spread over Lake Michigan-Huron would only result in a 0.7 inch increase in water levels. The one in a hundred year harm question would raise concerns of liability for the operating regulatory authorities, but that analysis would be interesting for someone to complete.
164	The slide shared by Erika Klyszejko was interesting. Extreme events etc. cannot be impacted. 2nd one change in one area of the Great Lakes chain will impact another area. Then the question is: Is there a possibility to build into a system human intervention mechanism that will alleviate the impact of a change in one area of the Great Lakes without impacting another area of the Great Lakes?	Many thanks for an interesting suggestion. This kind of innovative approach is part of what we would like to see develop – please refer to Next Steps H. above.
165	Can we follow up with Pierre Beland's creative taxation in regards to any modelling.	Pierre Beland was commenting on the potential impacts that the IJC needs to take into account with regard to any flooding of properties/ infrastructure that might occur from adjustments by the control boards. One of them being municipal costs and the potential effect on local taxation levels. We do not believe that there is any “creative taxation” idea to follow up on in this respect.
166	Is the IJC going to review plan 2012 as they did with Plan 2014??	Plan 2012 is currently being reviewed, we will follow up on provisions in the context of Next Steps above.

167	Why was action taken for Lake Ontario but not for Lake Huron?	Action was taken for Lake Huron, please refer to page 51 of the morning slides.
168	Erika: Please in the future include in your data of influences on the water levels of the Great Lakes registered permits on files for the seeding of clouds in United States of America and Canada. In the same light, the chemicals used for cloud seeding should be measured in all monitoring points of the Great Lake Basin.	
<p>Answer to Q: 168: Typically silver iodide or calcium chloride. Calcium chloride would be difficult to detect. Cloud seeding info: https://science.howstuffworks.com/transport/flight/modern/what-are-chemtrails.htm?utm_medium=share&utm_campaign=hs_w_share&utm_source=facebook</p>		
169	Do GBA and GBF have a working relationship with the Georgian Bay Great Lakes Foundation? I thought they may be co-sponsors of today's program.	<p>Answer to Q 169 - 170: This symposium was a joint venture between GBF and GBA. GBA does have ongoing communications with GBGLF, had extensive discussions with GBGLF before the event, and included some points they made. These discussions are ongoing. GBF continues to focus on the science and data relating to water levels.</p>
170	Why isn't Georgian Bay Great Lakes Foundation involved with your webinar?	
171	<p>Rick talked about the marinas around Georgian Bay that have and are being negatively impacted by the widely varying water levels. Is there similar data available for municipalities and cities around Lakes Huron/Michigan that identifies and quantifies the financial and social impacts of changing water levels?</p>	<p>Please note that this symposium did not address either impacts of or adaption measures to extreme high/low water levels, please refer to the details of the intended follow up event below. Please also note that GBF & GBA are calling for the public release of an ECCC projected water levels analysis that has been stalled for over a year now.</p>
172	Why won't the Conference board provide minutes of all meetings concerning the topic at hand?	We understand that this question refers to the minutes of the Coordinating Committee on Great Lakes Basic Hydraulic and Hydrologic Data. The committee is currently working on getting them released through the Freedom of Information (FOI) process. It is complicated since they are multi-agency documents and have to clear multiple agency FOI offices.

		For all future committee minutes, the committee has decided to modify the meeting minute structure to make them something that can be released to the public after each meeting and posted to the committee website.
173	Although the Board has no direct control over the diversions, in the past is it not true that government has intervened to persuade OPG to reduce Long Lac/Ogoki for example?	Please refer to the answers to Q 130-137
174	Outflow range for St Mary's from Superior in the last few years looks to be about 1/2 to 1/3 of the NBS - that is very significant!	That is correct.
175	KEY QUESTION - Rob Caldwell's slides show LOW NBS in the last few years for Superior and MH, how does that jive with Gronewold's "unprecedented" high net moisture index recently?? Or at least lower NBS.	The x-axis of the Caldwell graph is month of the year, not the year. The data presented is the aggregate total upper and lower monthly range limits from 1921 to 2019. There is no possibility of reading temporal trending of NBS from this graph. Gronewold is presenting net lake moisture flux over time and so the x-axis is year with the temporal trend visible.
176	This is a complicated question, but the long-term average for MH levels were changed significantly by dredging in St Clair in the late 1950s. Therefore, should we not be using long-term averages starting in 1960 under this new regime in the application of Plan 2012? This would recognize that we are now in a lower "regime" for MH due to dredging impacts of St. Clair.	Plan 2012 considers the flows before any canals or works were constructed (i.e. prior to 1887) known as pre-project flows. Plan 2012 also adjusts flows based on the difference in each lake's level from seasonal target levels based on average conditions. Plan 2012 replaced the previous Plan 1977 that was the first plan to consider Lake M-H water levels. These plans took into account the conditions present at the time of their development. Historic water level ranges are included as part of the analysis. The suggestion might be considered in future Plan reviews.
177	Regarding the surveying of the St. Clair River bathymetry, other major waterways in the US, such as the Lower Mississippi River are surveyed several times a year in some critical areas (segments say 10 to 20 miles in length).	The Lower Mississippi, and some other major US tributaries move a much larger volume of sediment through the system compared to the connecting channels of the Great Lakes. This stands out visually when you compare the blue waters of our connecting channels to the brown waters of those tributaries. The bottom of the channel in those rivers is much more dynamic than the bottom of the Great Lakes connecting channels, and those rivers require much more frequent monitoring. The bathymetry of some of the more dynamic

	<p>Why is the St. Clair River surveyed so infrequently in comparison?</p>	<p>locations in the connecting channels of the Great Lakes are collected more frequently, usually annually, to assist dredging activities to maintain commercial shipping channels.</p>
<p>178</p>	<p>Gronewold raises the uncertainty with respect to over-lake evaporation [calculations]. Again, does this not call into question his suggestion that current conditions are "unprecedented" - it relies on evaporation (and over-lake precipitation) - which is not well understood. This uncertainty bears out with respect to the inaccuracy of the Components NBS method. Yet these data are relied on by Frank and others in their models for forecasting future conditions! Can they be considered to have any level of confidence?</p>	<p>All measurements and modelling results have a certain amount of uncertainty. We are confident that we have taken this properly into account in our calculations of both current conditions and future projections. Please note that this uncertainty also feeds into the general issue that all future predictions contain a degree of uncertainty. Also: "Residual NBS tend to work well in the development of regulation plans but are incapable of being used for the simulation of climate impacts on water levels" -- "Net Basin Supply Comparison Analysis", Frank H. Quinn.</p>
<p>179</p>	<p>Session 4. Wendy's presentation: I wonder whether the watershed models are using spatially varying rainfall (and for that matter, spatially varying models - gridded vs. lumped approach) and also, how are they updating soil moisture through time? Where can we get more information on the watershed modeling and efforts to improve it for the Great Lakes?</p>	<p>The hydrological models used for simulation of the Great Lakes all use distributed (i.e. gridded) precipitation as they are distributed hydrological models. The soil layers are represented in various ways in the different models and their moisture content is a balance between the amount of water that leaves each layer each time step and the amount of water that enters those layers. Each of the models has different methods to represent the flow between the soil layers. Much of our work is part of the Great Lakes Runoff Inter-comparison Project for Lake Erie (GRIP-E). More information can be found here: https://water.usask.ca/events/2020/11/webinar-model-inter-comparison-studies-over-the-great-lakes.php. The project is now being expanded to all of the Great Lakes in the GRIP-GL project, which is currently underway.</p>
<p>180</p>	<p>I think Frank said that his models are calibrated/validated on historic levels - will that be shown in his report?</p>	<p>The report will include links to other reports about the calibration and validation of the models.</p>

181	I want to come back to some statements that Drew made regarding "unprecedented" conditions with respect to his net moisture index. What is the period of his record and how accurate are the data in the earlier part of that record?	1903 through present for precipitation. Drew showed 1950 to present for coincident precipitation and evaporation. Please also refer to Q. 74 for more information, including details on accuracy.
182	Session 3. I guess given Wendy's presentation, an earlier question could be asked here. The Components Method for NBS (by GLERL and in the last few years by EC) seems to be unreliable compared to the Residuals Methods for NBS on MH. That would suggest that the algorithms used to predict evaporation and precipitation over the lakes is not reliable. Yet I believe this is the same information that Gronewold and others are using to evaluate whether conditions are indeed "unprecedented". Also this question links to one of Rob Caldwell's slides where he showed NBS - was that NBS from Residuals or Components? The NBS he showed in the last few years was much lower than Gronewold 's net moisture index in the last few years? Is the inconsistency related to Gronewold using the same data that is used for the Components NBS method and Caldwell is showing the Residuals NBS data?	Please see Answer to Q: 68 regarding the multiple methods for calculating components of the water balance. It should be noted that there is not one approved estimate of NBS. Calculated NBS through the residuals method presumes that outflow estimates and water level estimates are accurate (it does not account for uncertainties). Also, traditional residual estimates can't really be 'verified' against an independent source; they were calculated using water level and flow data. Finally, traditional residual estimates of NBS don't help differentiate Precipitation, Evaporation, and Run-off; a critical step in understanding the water balance. "Residual NBS tend to work well in the development of regulation plans but are incapable of being used for the simulation of climate impacts on water levels" -- "Net Basin Supply Comparison Analysis", Frank H. Quinn.
183	So based on the current discussion, the methods for estimating evaporation/precip are changing so is the data consistent and is it reliable to compare?	Methods for estimating the hydrologic cycle are always improving; both in the Great Lakes and around the globe. It is incumbent on scientists to present their data within a context that is consistent and transparent. New methods can and should always be compared with old methods when time and resources allow; the recent symposium was excellent, but it did not include an intercomparison among different data sources. This is an ideal area for research, and one that is being taken on right now by the University of Waterloo through the Great Lakes Intercomparison Project (GLIP).

184	Two good speakers in the first session, but unfortunately they agreed with each other and thus only provided one perspective. It would have been valuable to have a discussion of historic levels - both recorded by gages and derived from various paleo data (tree rings, beach ridge dating, etc).	Please refer to the Answer to Q: 32.
185	Range in outflows is quite limited compared to what? It is in fact a large range and one that is controlled.	<p>The outflow of the St. Mary's river is approximately 2100 cms under Plan 2012. The recent operation of the St. Mary's control structure has reduced flows from the Plan by 500 cms. If sustained for a year, this deviation in outflow would result in an impact of 13 centimetres (5 inches) on Lake Michigan-Huron water levels.</p> <p>In addition to the inflows to Lake Michigan Huron from the St, Marys River there is an additional 5700 cms from precipitation and runoff in the basin. This equates to an impact of 153 centimetres (60 inches) on water levels in Lake Michigan-Huron. The speaker was referring to the limitations of outflow management on water levels compared to the impacts of precipitation and evaporation that can make changes of inches in a day. Also see Q: 174.</p>
186	What is Rob's definition of "very little benefit" related to diversions impact?	The diversions have a minor influence on the water supply to the Great Lakes. Altering the diversions may result in up to a few centimetres or inches of lake-level changes over the course of one or more years. Weather and climate factors are the primary drivers of lake levels. Consider that one night of evaporation can draw up to two centimetres or one inch of water from the lake, whereas one spring rainfall or one day of snowmelt runoff can easily contribute this much water to the lake.
187	Why was there so much deviation from Plan 2012 (with greater outflows to MH) through 2019 up to about March 2020?	Though deviations were observed in each month of this period, they were all relatively small. The largest equated to 19% of the total outflow. Most of the deviations were incurred to facilitate necessary hydropower unit outages for maintenance and inspections while minimizing the magnitude and frequency of changes in the discharges to the St. Mary's Rapids through the Compensating Works spill structure. This action maximizes fish-spawning opportunities and prevents disturbances to this fragile ecosystem during critical periods of species' life cycles. Deviations undertaken during the winter of 2019/2020 permitted extra water to be passed through the Rapids ecosystem while temporarily removing about a centimetre of water from Lake Superior. The net result of all the deviations undertaken during this period amounted to about a few centimetres less on Lake Superior and a few centimetres more on Lake Michigan-Huron.

		Plan 2012’s balancing principle adjusts the basic plan releases based on the difference in each lake’s level relative to their seasonal target levels (which are based on near-normal conditions). It is important to note that the balancing principle has reduced plan-prescribed releases significantly, resulting in a significant net lowering of Lake Michigan-Huron. (Deviations from Plan 2012 from April 2018 through November 2020 decreased outflows into MH.)
188	When John [analyzed the impact of reducing] reduced LLO diversions to zero did he then [analyze the impact of reducing] reduce the outflows at St Mary’s a similar amount? That makes a significant difference in the impact to MH levels.	During this analysis, Plan 2012 (the regulation plan/algorithms that determine how much flow to release from Superior) was not modified to reduce outflow by the additional amount of the LLO reduction. The regulation plan has a balancing principle built in that adjusts flows based on Superior and Michigan-Huron’s level and this balancing principle naturally starts to lower outflows as and when Superior’s level is influenced by any reduction in the lack of LLO inflow. If we were to also modify the plan code to specifically further reduce the flow by the LLO amount, that would introduce a second change to this analysis of changing the regulation plan to a new balance between Superior and Michigan-Huron.
189	When John says "We don't have a good historical understanding of the St Clair River bathymetry", this underlines the need for more frequent bathymetric surveys for the St. Clair, at least annually.	Prior to 2007, there was no routine collection of bathymetry of the St. Clair and Detroit Rivers. This critical data gap was identified by the International Upper Great Lakes Study, and the Corps has since put together a routine monitoring program. From previous analysis of the bathymetric data sets the channel bottom has not been changing very rapidly, and the 5-7 year frequency of data collection has been sufficient. If future analyses show more rapid changing of the river bottom, we may increase the frequency of the data collection. However, note that collection of bathymetric data covering the entire river is very expensive, and agency budgets will also play a role in frequency. Please also note Q 177 above.
190	Has the flow through the St Mary’s River been measured using Acoustic Doppler Current Profilers (ADCP) tows or side-looking ADCPs to evaluate whether current methods	Yes, flow through the St. Mary’s River is measured using both methods. The USGS operates a side looking ADCP downstream of the Soo that gives real time flow information in that area. US and CA staff also perform routine boat mounted ADCP verification measurements at least every 5 years to verify that the equipment at the hydropower plants are still reporting correct flows, and that ratings for the flow through the

	of estimating flows (using stage-discharge curves) are accurate?	compensating works gates are still appropriate. These measurements have confirmed the accuracy of the current estimations methods used by the Board.	
191	Regarding Gronewold's point on crustal change, it is only the change at the outlet that has an impact on water surface elevations on MH and I think his slide showed very little change at the outlet.	No, the lake bed elastic drop impacts capacity, volume and lake level. See the published paper for discussion. The outlet elevation is changing due secondarily to this elasticity along with the primary component of Glacial Isostatic Rebound (viscous collapse). See detailed discussed in "Rise of Great Lakes Surface Water, Sinking of the Upper Midwest of the United States, and Viscous Collapse of the Forebulge of the former Laurentide Ice Sheet." Donald Argus et. al. https://doi.org/10.1029/2020JB019739	
192	How can Frank say there are no large data gaps yet in the next bullet acknowledge over-lake precip and particularly evap are difficult to measure?	Frank was referring to data derived from models and measurements as reasonable and accurate for the purposes studied. Also, please refer to Qs: 57, 68, 74 & 178.	
193	Soil moisture changes monthly - the difference shown by Gronewold is not surprising.	GRACE-FO data is referenced in the same paper as mentioned in the answer to Q: 191.	
194	Is Large Lake Statistical Water Balance Model (L2SWBM) output available publicly?	Yes. The L2SWBM is available at Large Lake Statistical Water Balance Model (L2SWBM): NOAA Great Lakes Environmental Research Laboratory - Ann Arbor, MI, USA . The new model reconciles discrepancies between model and measurement-based estimates of each component while closing the Laurentian Great Lakes water balance. "Model Hydrological drivers of record-setting water level rise on Earth's largest lake system", A. D. Gronewold, J. Bruxer, D. Durnford, J. P. Smith, A. H. Clites, F. Seglenieks, S. S. Qian, T. S. Hunter, and V. Fortin	
195	Where can the Quarterly NOAA Great Lakes Climate Impacts and Outlook be found (that Wendy referred to)?	Great Lakes Quarterly Climate Impacts and Outlook NOAA CoastWatch & OceanWatch . https://binational.net/annexes/a9/	

QUESTIONS ABOUT IMPACTS AND ADAPTION

FUTURE WATER LEVELS EVENT:

GBF and GBA intend to hold a further water levels event which will focus on the impacts of extreme high/low water levels and discuss adaption strategies. Given that improvements in mitigation of extreme high/low, using the existing tools available, will only have a limited effect, it is important to consider how to adapt to these potential impacts, particularly in the context of the predicted effect that climate change will have on future water levels.

Accordingly, this event will look at the impacts and adaption strategies relating to the issues below and also the relevant roles of the Ministry of Natural Resources and Forestry, municipal bylaws (such as setbacks) and conservation authorities:

- The health of wetlands, other important habitat and the flora and fauna that depend upon them;
- Managing and locating septic systems and alternative sewage disposal systems;
- Commercial and residential docks and ports;
- Coastal buildings and other infrastructure, including new coastal developments;
- Commercial operations on the coastline, particularly marinas; and
- Navigation

The predictions are that there will be higher highs and lower lows, with a shorter duration between extremes, plus more extreme storms, stronger winds and other weather events. All of these will exacerbate erosion, property damage and access issues, and present challenges for flora and fauna to adjust to more frequent water level fluctuations.

Time constraints did not allow for addressing these issues in the Oct 2020 symposium, as it was important to focus on what can be done to improve: the available tools to address water levels; and cooperation/coordination between the various control structures in order to optimize mitigation of extreme high/low water levels.

A number of questions (Q: 196 – 248) were raised as below which relate to the topics that will be covered in this follow up session. We will therefore save these questions and address them at that time.

QUESTIONS	
196	Is there a suggested source to get clarity on Ministry of Natural Resources and Forestry and municipal rules on shoreline?
197	Why are the Conservation Authorities the governing body used to issue permits for shoreline work?
198	What actions can be taken to decrease damage related to waves/wakes from power boats?



199	Controlling large boat wake eroding shorelines dramatically with this high water?
200	Bay levels and winds produce strong damaging waves which seem stronger and more sustained than prior years. Please comment?
201	What are the issues facing beach geographies and are there mitigation measures?
202	Does one really think that they can control nature - or is it better to try to work with and nurture it?
203	Do you recommend building up our shoreline to prevent further damage and how?
204	Best solution to protect shoreline for extreme high levels?
205	How to protect land from further erosion?
206	How to protect the shore from erosion till the high water level will last in Georgian Bay?
207	Would using brick or interlock stone for walkways, gutters, etc. rather than asphalt or concrete have any impact?
208	Limiting bylaw and provincial/federal regulations to allow homeowners to protect shoreline erosion?
209	The water has risen high enough that beachfront lot lines are now under water - does this [mean] I lose part of my property?
210	Rumours of the high water mark used to calculate how far back new homes must be is being reviewed, true?
211	Need for improved break walls in Parry Sound harbour/Seguin tributary?
212	Recommendations on repair/replacement of docks and boathouses? (Legislation efforts to allow US citizens access to their property?)
213	Best boat house structures to consider?
214	In planning for the next 20 years, what maximum and minimum water levels should be used?

215	I am seeking a best advice answer for cottagers: "When repairing or building on the Bay shoreline, what maximum and minimum water levels should be considered in the design for a 20 year timeline?"
216	How does the high water affect building codes/allowances when dealing with such things as boat houses on cribs?
217	Are there new regulations for building in terms of distance from water due to water levels increasing or are they the same?
218	Could we see, in the years ahead, a new high-water mark a foot or more above the current high-water mark?
219	Flexibility needed in building codes to mitigate damage?
220	We are all concerned about Town of The Blue Mountains ignoring some wetlands and allowing developers to build so close at bay.
221	Insurance companies covering rising water damage?
222	Why is there opposition to gabion wire basket cages for shoreline protection.
223	The back channel is higher than my back yard which is full of water up to the back steps. Does it threaten my poured concrete?
224	Is there any govt funding (municipal/prov/fed).. available to help with expense of beach front erosion?
225	Does it harm the lake to do shoreline protection?
226	How is waterfront cottage property determined? [Defined??]
227	What short term actions are necessary to prepare the local communities from further long-term impact?
228	We have a condo that is part of Simcoe County Condo Corporation 86 in Collingwood along the edge of the UNESCO Biosphere Reserve... <i>[comment cut off]</i>
229	From an ecosystem point of view, are there ways people/organizations can help Georgian Bay adapt or even take advantage of the variations?
230	What can Wasaga Beach Provincial Park do better help manage water levels?

231	How can harbours like Parry Sound's adapt to the swings in water levels and avoid flooding?
232	How can ratepayers groups whose members experience shore damage and loss of enjoyment of property best advocate for change?
233	What can taxpayers in Georgian Bay municipalities do to influence better mitigation of damaging high and low water levels?
234	What can be done about the 3 places on Georgian Bay in Tiny Township...one has put 500 tonnes of boulders on the shore, one has placed an Iron structure and filled it with gravel and the last is a 50-foot boat house now in the water? All three are an eyesore to the magnificent shoreline.
235	As far as the water levels being too low, I understand why a reduced supply is an issue, difficult for fish and other fauna etc. However, apart from the effects on homeowners and cottagers, what are the downsides of having elevated water levels, i.e. too much water? Erosion of the water edge I understand.
236	We use filtered bay water at our cottage in Cognashene, what are the effects of the warming temperatures of the water of the great lakes and how do we obtain information on what additional protections we should implement to ensure continued safe water. (i.e. increased micro-organisms?, algae?, etc.). Thank you.
237	What kind of structures are allowed on the shore to defend against heavy water surges coming between the islands at the mouth of Colpoy's Bay?
238	Will Wasaga Beach ever get their beach back to what it was 4/5 years ago? We have lost most of it in the past couple of years?
239	Will you be addressing the range of impacts of the fluctuation in the water levels (current and future)
240	To date How have some human implementations /interventions ultimately had negative impacts and what is learned from this.
241	What water level range variations are safe for wetlands?
242	Why has the Canadian IJC chair not mentioned their obligation to address environmental impacts?
243	Could a model study be done on the water flow past the islands at mouth of Colpoy's towards the shore of Mallory Beach Rd beyond the s -turn and the end of the road as this length of shore has been drastically altered/damaged last year?

244	The massive erosion is damaging not only to property owners and communities, but the quality of lake water and the ecosystem that has been destroyed along with all the destroyed habitats	
245	low water levels don't cause any of the damage that is done when levels are high they must be regulated to keep them low...we don't need any more studies, we need action.	
246	While it may not eliminate highs and lows could you not mitigate the damage. For instance this year even an inch or two would have made a great difference to our property which is flooded to the extent we have a sand bag perimeter and sump pumps barely keeping up.	
247	Do you want to give something of a preview of topics that you are thinking about for your next seminar? The list might include, shoreline hardening measures including groynes, consequences for adjacent properties, which government bodies regulate in this area, are such measures/permitting subject to stakeholder consultation, how important is tree cover, are beach geographies different than the rocky shores along some parts of the Bay?	
248	What resources are currently publicly available to help riparian owners and other stakeholders make informed decisions?	
249	Can Drew review the slide on what causes the change in evaporation and precipitation. The part about cold air from north and warm air from south?	Answered above in Q: 44. Drivers of evaporation relate to the energy difference between the water and the air. Cold air and relatively warmer water creates the conditions for evaporation. The air and water circulate energy. The pattern of thermohaline circulation also known as "meridional overturning circulation" is a global ocean-connecting pump that also influences surface phenomenon such as El Niño and La Niña that in turn influence air and water temperatures. The weakening of the Jet Stream means that instead of the historic sharp line separating cold arctic air from warm tropic, today that weakening demarcation allows for a meandering Jet Stream that can even lock storm systems in place. An example of this is Hurricane Harvey that stalled over Houston, Texas and dropped the equivalent rain of 495 days of Niagara Falls in 3 days.
250	Is it possible another major factor to the net moisture flux is winter evaporation during the last 3 years.	It is a major factor. Most evaporation occurs in the coolest months of the year when the air temperature is colder than the water. However, over the past three years the ice coverage has fluctuated: 2018 - 69%; 2019 - 80.9%; and 2020 - 19.5%. Over the past three years record setting precipitation has been the driving factor.

251	Are there opportunities for citizen science? i.e. taking evaporation measurements?	There are some measurements that can be made or augmented by citizen science. For years, dedicated citizens operated weather stations across the country. More sophisticated instrumentation that is deployable with telemetry provides consistency over a long timescale and is ideal for climate studies due to the removal of induced error. Evaporative gauging over the middle of the Great Lakes would not be an opportunity for citizen scientists. Water quality measurements, invasive species observations and reporting, and other scientific studies would provide appropriate opportunities for such participation.
252	Great question from David Sweetnam regarding trying to better understand how we should potentially be thinking about the go-forward range of fluctuation in lakes Michigan and Huron. If the historical range of low vs. high is approximately 6 ft, over say the next 20, 30, 50 years, how should we be thinking about the potential low vs. high range? 8ft, 10ft, 15ft, etc.? Thank you.	Upcoming modelling seems to suggest that mean water levels will continue to increase and that water level fluctuations will become more transient and larger in amplitude. Currently, the historic record shows a 6.33-foot range. Some modelling of future ranges shows that five percent of the time levels may be 15 inches more than that. This range information will be important to consider when making investments in developing resilient coastal infrastructure.
253	How do [western] science and Indigenous peoples' theories about water levels differ or align?	First Nations do not propose theories about past or future water levels. They consider the answers that nature provides to intuit what they believe is likely to happen in the short term, such as predicting the winter temperature and how much snow is likely.
254	Have grass carp been spotted in the Bay?	These questions are off topic and consequently no answers will be provided.
255	How has the quality of sport fishing changed in the Georgian Bay over the past 20 years?	
256	Would you like to take the next step and have washing machines with built-in microfiber filtration systems?	Yes. We have been working to move in this direction based on the preliminary effectiveness we have seen. We are awaiting further analysis prior to making definitive statements.
257	How would conversion to electric vehicles globally impact on water levels?	See above answer to Q 156 relating to reducing the carbon load and reducing and possibly eventually reversing the impacts we have introduced.



258	<p>Has any consideration been given to allowing corporations like Nestle given permission to draw water from the lakes in lieu of drawing water from aquifers as they are doing today?</p>	<p>One of the key conditions in the Great Lakes Compact https://gsgp.org/projects/water-management/great-lakes-agreement-and-compact/ is to not commoditize water withdrawals from the Great Lakes (i.e. give withdrawals a monetary value). The rationale is that doing so would open the door for water withdrawals from the basin. Since water withdrawals for bottling purposes have a value attached for the amount of water withdrawn this would breach that condition.</p>
259	<p>It is terrific to hear that a great deal of research is being conducted on the future water levels in the Great Lakes, more specifically Georgian Bay. I would hope that human intervention measures will be an important aspect of this research. Right now we have historic levels of high water. Why are we not admitting human intervention strategies to impact the water level?</p>	<p>Please refer to the Summary of Next Steps above and other answers to questions.</p>