GLOBAL WATER FUTURES
SOLUTIONS TO WATER THREATS
IN AN ERA OF GLOBAL CHANGE

Summary of the GWF 2021 Online Operations Team Meeting

Held virtually on Zoom, December 9–10, 2021, from 1100-1230h and 1300-1430h EST each day.
https://gwf.usask.ca/events-meetings/otm2021.php

Executive Summary

The GWF Operations Team[1] met online over two days (December 9–10, 2021) to catch up and strategize on important matters as we move into the final years of the GWF program, and to explore synthesis opportunities on how GWF is contributing to understanding and predicting Canada's water future over the 21st century. 123 people registered for the meeting, representing 23 different organizations. The meeting included an overview presentation by the GWF Director and Associate Director, updates on all GWF core teams presented by the leads or staff of these teams, and prepared written updates by GWF projects to highlight their activities and outcomes. The presentations and project reports are available on the meeting webpage.

One of the anticipated outcomes was to identify areas of synergy that could lead to supported synthetic activities across projects. Most of the meeting was devoted to break-out discussion sessions, focusing on the following:

1. Climate scenarios and extremes
2. Water quality stressors
3. Ecosystem change
4. Hydrological change
5. Human and health dimensions

Each breakout was assigned discussion co-leads, including an Indigenous co-lead for each, and a rapporteur to summarize the discussions and report back.

A number of **proposed actions** were raised during the discussions:

- Regarding climate scenarios and extremes, it would be good to bring people together to discuss some issues further, and two meetings were envisioned: 1) the role/use of artificial intelligence/machine learning; 2) increase the accessibility of stochastic methods and climate products.
- The water quality stressors discussions led to suggestions including accelerating exchanges of data, methods, and experiences, integration within and among projects, and reinforcing linkages with Indigenous communities. More details are provided on p. 10.
- All ecosystem-related info should be collated (western and Indigenous knowledge) across GWF in a high level, led by the data management team.
- A synthesis idea to cover all of GWF was proposed, specifically, to put all the sites into a climate space, a people space, and a problem space (see p. 3 and p. 12).

[1] The Operations Team consists of GWF project principal/co-principal investigators and project managers, the GWF core team leads, young professional executive, secretariat, and core knowledge mobilization, outreach, data management, and communications staff. The purpose of this team is to facilitate interactions among all projects and core teams, identify program gaps and opportunities, track progress, and enhance communication, knowledge mobilization, and data sharing.

- There is an opportunity for a paper on human data and data sharing similar to the recently published GWF paper best practices in data management.
- Another opportunity at the GWF level is to engage with people and places to inform models (Indigenous knowledge often relayed through experiences and oral histories, while most models are often defined by quantitative measures); ongoing engagement and dialogue could help to connect the two.
- The need for being proactive about engagement with end user communities was stressed, and building core competencies in social science research was noted as important for GWF.
- There is an opportunity for more science features and stories for people to learn from the projects across GWF.
- We need a further call for affiliate projects and we need to make the process clear on our website.
- We need to explore options and possibilities for giving credit and recognition to Indigenous community members for their contributions to research undertaken in communities.
- We need to make our research outputs open and available, in a form that reaches people where they are and in ways they can access it. This can involve multiple approaches with our outreach and knowledge mobilization staff, including getting information into the school system.
- A synthesis activity could focus on a given region(s) and how "change" was occurring historically and how this has shifted more recently, with climate along with other factors as drivers, and then following up with our integrated projections of future change.
- We need to consider and share how to braid Indigenous and academic knowledge to frame the water crisis in Canada and globally; this is being undertaken by an Indigenous advisory group.
- A synthesis of user tools could be undertaken, focusing on how we support models and technical tools; the task force leading this and developing a strategy and plan to enhance user uptake should be expanded.

Below are brief summaries of each of the breakout sessions, while more detailed reports are available in the appendix at the end of this report.

Climate scenarios and extremes

co-chairs: (day 1) Roland Duquette, Al Pietroniro; (day 2) Roland Duquette, Martyn Clark
rapporteur: Mohamed Ali Ben Alaya

Discussion focused on data availability, including statistically downscaled climate data and outputs from the Climate-Related Precipitation Extremes project. CMIP6 data are now available and can be used as well. Some work in GWF has also focused on stochastic downscaling approaches for use across a range of watersheds (small to large) and there was some discussion around the possibility of developing artificial Intelligence approaches to downscale these data as well. Conus II WRF data will be available and another opportunity will be to consider multiple model ensemble simulations at small scales for a target of small watersheds. A small working group on downscaling, stochastic and AI approaches is recommended.

There was further discussion on how to effectively communicate knowledge and products generated from this work. It was noted that direction is needed on how to use the data and for what purpose, which involves close collaboration and communication with knowledge users. Elder Roland Duquette joined this conversation and expressed a need to fully engage Indigenous Peoples to exchange knowledge about the climate and environment. This can help Indigenous communities understand what changes and risks they may face, while at the same time academic scientists need to learn about how

Indigenous People interact with the land and use waters, and also about what their knowledge indicates about misuse of water. This can help reduce risks in future and Indigenous knowledge is key to solving problems. A big issue is the communication of uncertainty as part of the knowledge transfer process.

Water quality stressors

co-chairs: (day 1) Lori Davis Hill, Nandita Basu; (day 2) Dawn Martin-Hill, Helen Baulch
rapporteur: Philippe Van Cappellen

Many projects across GWF were represented in the water quality breakout and this was an exciting discussion with a wide variety of topics presented. Available water quality data were reviewed; many projects have been synthesizing existing data and generating their own new data. There have been advances in modelling, new concepts, frameworks, and syntheses, development of new sensors and sensing systems, and engagement of Indigenous knowledge and communities. It was noted there is a need for mapping of Indigenous knowledge together with western science and to engage in meaningful communication, raising awareness of water quality issues through the lens of health and environmental impacts. By the end, several priorities and collective activities were suggested to pull together GWF outcomes, including accelerating exchanges of data, methods, and experiences, integration within and among projects, and reinforcing linkages with Indigenous communities through formalized training, community internships, and long-term relationships.

Ecosystem change

co-chairs: (day 1) Anthony Johnston, Mark Servos; (day 2) Anthony Johnston, Jennifer Baltzer
rapporteur: Cherie Westbrook

This discussion addressed several issues and challenges relayed to the linkages between ecosystems and hydrology. The project reports indicate there has been surprisingly little focus on how ecology drives hydrological cycling. The terms ecosystem function vs ecosystem services were discussed – What was available in the project reports indicates a focus of GWF on hydrology variables important to ecological services. Despite a considerable amount of observational data across GWF, much of this is disjointed across space and even areas of observations. Leaning into Indigenous knowledge and perspectives, in which interactions between ecology and hydrology are more holistic, could help overcome many of the outstanding challenges. Learning must be two-way, that we must braid western and Indigenous knowledge systems, and that the focus should be on educating youth – both Indigenous and non-Indigenous to see real paradigm change in the future.

The group also discussed a range of ideas to advance synthetic and integrative work across GWF in ways that would be meaningful to ecosystems. First, it would be very useful to collate all of the ecosystem info (western and Indigenous knowledge) across GWF in a high level, spatially explicit tool that it can be used to identify opportunities to synthesize and integrate that would be best led by the data management team. A synthesis idea to cover all of GWF was proposed, specifically, to put all the sites into a **climate space**, a **people space** – who (e.g., urban centres underrepresented in GWF) and a **problem space** – what types of societal challenges has GWF address, who are the communities represented. A few other specific ideas were presented as well (see detailed notes in appendix), and in the end it was emphasized that in any of the perspectives, how will all this work impact government policy and focus must be kept in mind so that it has uptake in practice.

Hydrological change
co-chairs: (day 1) Gary Carriere, Sean Carey; (day 2) Gary Carriere, Dave Rudolph
rapporteur: Chris Spence

The focus of the discussion was, in part, on the model results and outputs—there are a vast amount of runs being completed at catchment to continental scales, requiring considerable data management effort, and the core modelling team has made great progress. The visualization team need to continue to be engaged to reach the full potential of this activity. It was also noted that the virtual art gallery has been a useful mechanism to convey some of the outcomes in a different way, and this will continue with further planned activities. In terms of future projections and their confidence, a key is the communication of uncertainty—an achievement in GWF has been to unravel many of the sources of uncertainty and thereby better explain what we didn't know before and how we addressed that (e.g., improvements in understanding processes, representing them in the models, etc.).

Engaging Indigenous knowledge was discussed and some of the essential elements noted were to co-develop research, start early, work together on issues that are of mutual interest (this may not always be hydrological change directly, but the influence on other things as well—e.g., taking a more holistic view). Gary Carriere suggested that a lot of what they do on the land could be incorporated into university courses and that people could begin to be taught at a younger age (high school and elementary school)—perhaps then the next generation will be better stewards. Indigenous communities are vulnerable to the impacts of hydrological change. The Saskatchewan River Delta was used as a prime example of how changes to the flows and river morphology work their way through the entire environmental system with a loss of environmental quality. This must be placed at a higher priority than it is now.

There are several ways to pull this together. At present flooding is front of mind given the events in B.C., but there are others such as agricultural impacts. We will need to provide some specific statements around solutions and mitigation activities and pitch these at the right level (government, public), perhaps using the art as a conduit for information. Conceptual models can be a good way of conveying the impacts of choices to be made.

Human and health dimensions
co-chairs: (day 1) Diane Giroux, Corinne Schuster-Wallace; (day 2) Deborah McGregor, Corinne Schuster-Wallace
rapporteur: Laila Balkhi

There were contributions from a number of projects, including those co-led with Indigenous partners where the research questions are very much community driven. There was first a recognition that Covid has had a large impact on social science research efforts and community-based work, and then a recognition that a lot of social science work has happened through affiliated projects under the GWF umbrella, and these need to be better recognized and given higher profile. The discussion included many different opportunities for synthesis. First was an opportunity around human data and data sharing agreements that could perhaps lead to a joint publication—there has recently been a paper on best practices in data management (https://doi.org/10.1002/hyp.14385), dealing mainly with physical sciences data issues, but perhaps there might be an opportunity for something similar on the human/social science data side (see appendix for more details). Another opportunity at the GWF level is to engage with people and places to inform models (Indigenous knowledge often relayed through experiences and oral histories,

while most models are often defined by quantitative measures); ongoing engagement and dialogue could help to connect the two. Use of online visualization tools could be another opportunity, for example, efforts to include Indigenous languages and histories to support integration with modelling efforts. The need for being proactive about engagement with end user communities was stressed, and building core competencies in social science research was noted as important for GWF. Finally, there are many success stories and examples of good work happening, but it is not necessarily making its way across the network, so there is an opportunity for more science features and stories for people to learn from the projects across GWF.

General Discussion following the rapporteur summaries

One of the first points of discussion was on how to bring in more affiliate projects and raise the profile of the work done in these, following from the points made in the human and health dimensions breakout. There are other Indigenous community-based activities and underlying programs, for example, that are ongoing in conjunction with GWF-funded projections. It was noted that we need to go back to the information on our website and make it clear how to participate. This would involve no requirement for data sharing from affiliate projects and is flexible, the interest could be expressed in a two-page letter explaining what the project is, what the proponents would like to get from GWF, and what the project could contribute to that.

The discussion continued and addressed the issue of Indigenous community member knowledge contributions to research/training that often go largely uncredited. There is an inequity of recognition. We should look for ways to formalize the work that community researchers are doing for our projects, and to create opportunities for them (e.g., they would like accreditation for their work). There are ways to do this; for example, the Canadian Water Resources Association has provided accreditation for hydrology courses. We can take this back to our institutions and look for ways, and there may be many other options for non-academic accreditation. We need to move forward and open doors between institutions to remove financial barriers and bureaucratic barriers, under reconciliation. We need to create a network across institutions and recognize credits from work in the community. Speaking to the Deans of Graduate Studies and Science may be an effective channel to work through.

We need to make our research outputs open and available, in a form that reaches people where they are and in ways they can access it. We also need to reach people early and get our information into schools. User-friendly, plain language information products can be powerful tools for conveying the science. These can be regional efforts and we can look at getting these out in some way—these can be useful for communities, for sectors, and for students who want to get into the science, and are good summaries for policy-makers. We may need to bring in some extra capacity to work with our outreach and knowledge mobilization teams, particularly someone Indigenous and/or who has worked with Indigenous elders and youth doing communication and outreach. This is an opportunity for synthesis across the program, pooling our resources and capabilities. We can also work with outside groups to help get things done. It is also worthwhile to try and expand our interactions with schools and teachers, helping develop science curriculums, and working with the students with sensors, observations, and data collection.

Many of the questions in the breakouts were directed towards synthesis, and we need to work at bringing together key messages and pulling together information in a coherent way. One thing that came across in the various discussions was “change”—we are all dealing with systems that are changing rapidly

and in different ways than they have historically. The interactions amongst the stressors and drivers are pushing certain water systems in new and unanticipated directions. We can pick any region and come up with an interesting set of stories about how change was occurring historically and how this has shifted more recently, with climate along with other factors as drivers. Also considering governance and management issues, we can put the lens of reconciliation on this.

Another topic is the future; we have advanced climate models that we are running with hydrological models, and eventually water quality, health, and policy models. There are some aspects of synthesis for the future changes that will be occurring across Canada in the water environment and water-related topics, and this is of course a key product that will be expected of us.

There is ongoing work focused on the 2021 extreme summer events across Canada. The situation flipped in September from some of the lowest flows to some of the highest flows recorded in many rivers, and the flood event in November had initial conditions set by the heat event in summer. There is certainly an opportunity to look at floods, the meteorological aspects, hydrological aspects, impacts on the ecosystem, and impacts on humans and health and communities.

Through the Indigenous group we can focus on how we achieve water sustainability using a braided knowledge approach, how do we do this as a society, and how does this address reconciliation? We need to further promote the principles of UNDRIP and reconciliation—western science alone will not solve the water and climate problems we find ourselves in.

There was some discussion on bridging the knowledge to practice gap and the engagement of partners and end users. It was suggested that we make our future plans and the mechanisms to support the tools we develop clearer. A synthesis of user tools could be done, focusing on how we support models and technical tools for the user community, what government support and community of practice and training opportunities exist, and how these tools can be put in the hands of users in the most effective fashion. A task force to address this was suggested in terms of developing a strategy and plan to enhance user uptake, to find a group of commercial users to take this on in the hope there is commercial benefit, and to work with whoever in government and/or the Canadian Water Resources Association will help facilitate this. The importance of our data legacy was also discussed, along with our strategy to archive it and make it accessible; the possibility of data publication and a special issue of Earth System Science Data was again raised.

At the end, Elder Roland Duquette provided some remarks, noting that the inclusion of Indigenous voices and perspectives was a positive aspect. In particular, he recommended that GWF continue beyond its funding end date. There is a fear that the process of engagement GWF has been building may be cut and some progress may be lost.

Appendix: Rapporteur Summaries from Breakout Discussions

Climate scenarios and extremes

What observational data and model results are/will be available? What insights, conceptual, and process-level understanding can be contributed? What future projections can be made and how confident are these?

The group focused on what we already know is available based on core-modeling presentation, but we solicited others to see what was happening in the community. We really focused on technology in the first half our and explored what was existing and some potential for new products.

- Work being done out of PCIC looking at current downscaling techniques and stability of some of the downscaling in future climates
- PCIC (Francis) mentioned that new 10 km Tmin , Tmax and Precip downscaled data was recently made available.
- Some discussion on the applicability of stochastic methods from Simon and the advantages of stochastic methods in preserving storm motion and high frequency.
    - Noted computation limits to more traditional downscaling efforts.
    - Stochastic downscaling efforts are readily available and easily generated with R-based software
- The question around potential for AI/ML was discussed with Jimmy.

Actions from the discussion :

1) Some new products and approaches are available and there is a need to evaluate and use these (New PCIC downscaling and GWF stochastic methods)
2) Does AI/ML hold promise. We should strike up a team to investigate.

How might this feed into or relate to other atmospheric-cryospheric-hydrological-ecosystem-human systems and their changes?

In this section the group focused on the user community, knowledge mobilizations and translation of these data sets int useable information. Simon pointed out that the user community, don't understand the notion of uncertainty. By not effectively communicating uncertainty, we fail. Patrick pointed out that from a user perspective, they need to focus on what are often perceived as simple question but end up being rather complex. Entities such as PPWB want understand impacts of droughts, as an example, in a tangible way. There is lack of clarity how these downscaled scenarios are providing the information they need for these assessments. Debra had an overarching comment so if you're going to look to communities – can we take this to a community level of usability. As an example, the work on research and climate can help the consideration of the new Lake Diefenbaker irrigation project and for communities from here now and into the future. The knowledge translation seem lacking. Khaled pointed out that there are very many products and it is difficult for practioners who need to answer important policy and planning question, which of the many products they should use.

Action:

Clearly we need to support the practioners and the communities in the utility of these products, which one may be applicable in certain setting or for certain purposes and ensure there is a proper understating of the uncertainty associated with these products.

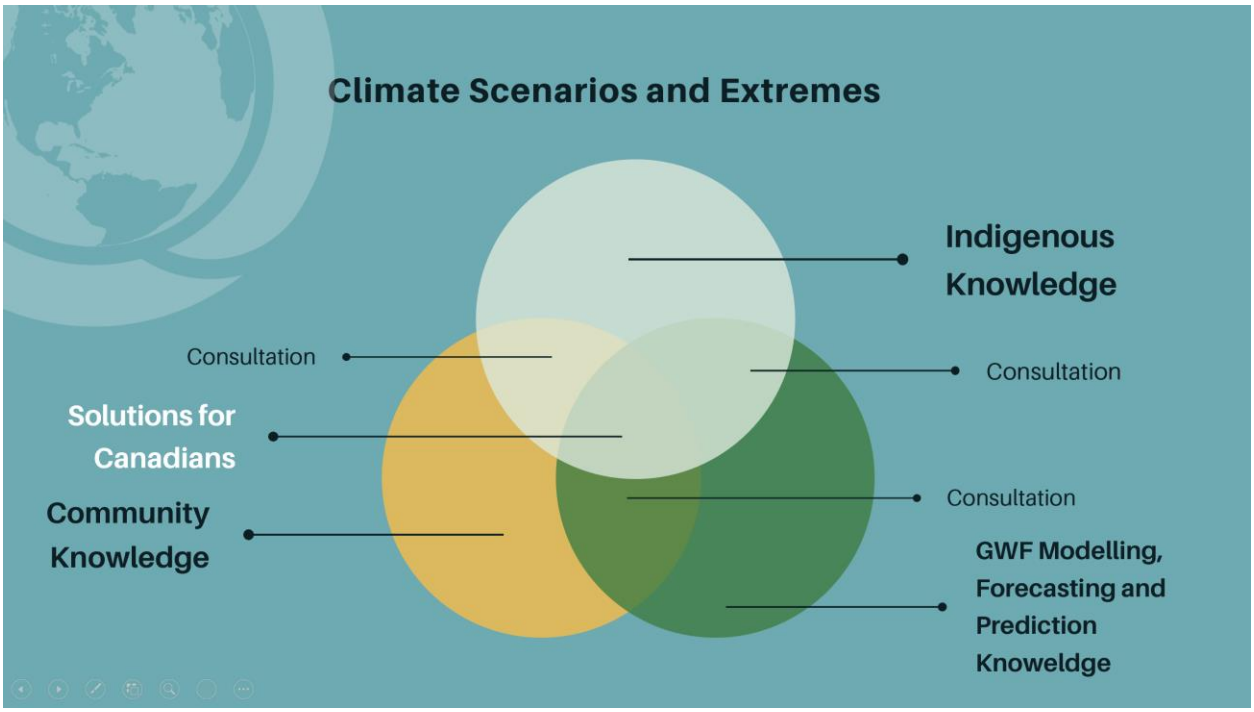
How is Indigenous knowledge supporting these efforts and how do we fully engage Indigenous knowledge and communities?

Roland initiated the conversation pointing out Science offsets a way of communicating the fluctuation of climate and the environment. It really comes down to the understanding what breaks down and the human element of the indigenous peoples. There is a breakdown of the oxygen of indigenous peoples and the non-indigenous society historically wants Indigneous peoples to go with the flow. There is a reality that indigenous people don't count. How do you break down the elements of that lack of humanness.

Al and other recognized that we rarely listen to the knowledge keepers and elders, yet they know the land, the history and can help in a shared effort with our collective understanding of the climate and recent impacts. The group agreed that although it seem a big leap from traditional understanding of elders and knowledge keepers to downscaling techniques that we explore as scientist, maybe the leap is not that large. It is clear the indigenous communities know the impact of climate change, whether it be permafrost degradation, changes in flow regimes, changes in wildlife or landscapes, we need to have a better relations hip with the leader and knowledge keepers and collectively address the issue they see ate the community level.

Action:

There is overlap between what we do in climate science and what the elders and knowledge keepers know about the climate system. Perhaps that needs to be explored more carefully.



<u>Water quality stressors</u>

Projects represented at the Water Quality break-out

- Sub-Arctic Metal Mobility Study (SAMMS)
- Evaluation of Ice Models in Large Lakes
- Winter Soil Processes in Transition
- Sensors and Sensing Systems for Water Quality Monitoring
- Geogenic Contamination of Groundwater Subarctic Regions
- Managing Urban Eutrophication Risks under Climate Change
- FORMBLOOM
- Agricultural Water Futures
- Prairie Water
- Lake Futures

- Co-Creation of Indigenous Water Quality Tools

Available water quality data

- Syntheses of existing data:
    - Agricultural nutrient loads (edge-of-field, seasonal, snowmelt vs. rain, …)
    - Nutrient data reanalysis with ML across Great Lakes basin and open access data base
    - Lake nutrients (mainly N&P), metals and ancillary data: L. Erie, L. Wilcox, Experimental Lakes
    - Algal growth windows and rates in cold and cold-temperate lakes: open access data base
    - Synthesis water quality data time series from Yukon Government
    - Increased collaboration with data repositories (e.g., DataStream)
- New data series (1-3 years) produced by the projects
    - Data on winter processes in cold regions (soils, lakes, reservoirs)
    - Groundwater contaminants (e.g., As and U in Yukon)
    - Data surveys for ~150 wetlands in prairies (nutrients, physical-chemical parameters including salinity)
    - Urban watersheds in GTA: nutrients and geochemical parameters (focus on large rain events)
    - Deployment of existing and new sensors and sensor nodes (e.g., Buffalo Pound, Six Nations)
- Human-water systems
    - Six Nations: surveys of mental & physical health impacts of water insecurity

Modeling results and conceptual understanding

- Modeling:
    - Tile drainage module in CHRM
    - Nutrient legacies in agricultural landscapes and effects on river loads (e.g., Grand River)
    - AI and ML applications to data series (e.g., nutrients Great Lakes basin, L. Erie ice phenology, winter soil processes)
    - L. Erie P model: role of littoral zone and internal loading
    - Upscaling urban hydrology and associated contaminant loads
- New concepts, frameworks, syntheses
    - Nutrient dynamics:
        - hydrological connections (field → catchment)
        - biogeochemical legacies (watersheds → regional)
        - internal loading processes (lakes and reservoirs)
    - Climate change impacts on cold region critical zone processes:
        - freeze-thaw and atmosphere-soil-groundwater interactions
        - Permafrost thaw and groundwater flow dynamics: impacts on metal contaminant transport
    - Wetland typology for the Prairies

Water quality: advancing sensing capabilities

- New sensors/sensor systems:
    - Chloride, selenium, metals (Pb, Cu, Ag, …), phosphate, cyanobacteria
    - Long-range data transfer capabilities, controlling fouling/scaling sensors
    - Commercialization efforts are underway

Engaging Indigenous knowledge and communities

- Re-inventing water quality monitoring and research:
    - Six Nations: strong focus on training and capacity building: deployment of sensors and water sampling with and by community youth (hands-on experiential learning, trust-building, team-work)
    - Connecting water quality data acquisition to securing a sustainable water future for the community
    - Snowball effect: from water to other environmental research questions and issues
    - Ohneganos Project: multi-media products, digital story-telling, indigenous mapping
- Water quality stressors:
    - Main stressor: access to (clean) water: perception, information, trust, mental health impacts

Pulling it together (Day 2)

- Accelerating exchanges of data, methods, experiences
    - Create a water quality "slack" (chatroom)
    - Integrate western and Indigenous knowledge in mapping tools (multilevel, multi-functions, continuous updating, history, stories, health data, wq indicators, climate change, …) for knowledge translation
    - Dissemination and curation of knowledge gained through GWF
- Integration: within and among projects
    - Watershed-lake modeling
    - basin scale water quality data visualization
    - Rural-urban landscapes
    - Climate scenarios
- Pan-Canadian and international impact
    - Focus on meaningful communication and raising awareness
    - Virtual media; virtual reality (water stories, art, language, culture, …)
    - Mapping; visualization for water quality
- Water quality stressors and Indigenous communities
    - Formalizing training; open access curriculum; credits through universities
    - Internships for community trainees; leverage GWF to secure funding at federal/provincial level
    - Long-term relationships – mechanisms to maintain them

<u>Ecosystem change</u>

Ecosystem Groups' Reflections on Reports:

- The group thought that the emphasis of the summary document was on measuring hydrology and understanding hydrology. Determining the factors that are impacting hydrology, and the implications of hydrology for change of ecosystems in ways that impact hydrological processes.

- We discussed that one of the challenges in GWF continues to be, how do we relate those findings to ecosystem functioning? As well, we noted that there has been surprisingly little focus on how ecology drives the hydrology.
- Also, we talked about the terms ecosystem function vs ecosystem services – What was available in the project reports indicates a focus of GWF on hydrology variables important to ecological services. There seems to be confusion among hydrologists of what the terms mean and how far to take hydrological research so ensure it is useful for understanding ecosystem form, function and change.
- Leaning into Indigenous knowledge and perspectives could help overcome many of the outstanding challenges. The dominant western view is that hydrology drives much of ecosystem functions but there might not always be a clear link between hydrology and ecosystems. The Indigenous world view is that interactions are much more holistic. Elder Blair Johnston described the ancient relationship of land-water-sky of his people, and how this might be useful lens to understand how ecosystems are functioning. Our discussions circled around the bridges that would be needed in GWF to employ this land-water-sky-people framework in a meaningful way so that there is impact on Canadian policies and practice.
- Learning must be two-way, that we must braid western and Indigenous knowledges, and that the focus should be on educating youth – both Indigenous and non-Indigenous to see real paradigm change in the future. The group noted that the GWF structure is only in its infancy in being posited to accommodate this.
- We noted that there are more data available beyond that described in summary document which relate to ecosystems and ecology.
- key term “ecosystem” was perhaps not the best summary search term as those with an ecology focus are more likely to use more specific terms in describing their research
- Although there are lots of relevant observational data available, the group saw them as largely disjointed across space and even areas of observations and discussed potential solutions which I will get to in a minute.
- We also wanted to congratulate a few nimble GWF researchers. They were able to quickly shift their work on emerging methods to determine environmental change (eDNA) to provide direct support of human health via developing methods for detection of covid in wastewater.

The group also discussed a range of ideas to advance synthetic and integrative work across GWF in ways that would be meaningful to ecosystems:

- Everything GWF does is place-based. Thus data are quite individual or regional. First, it would be very useful to collate all of the info (the science and the Indigenous knowledges and stories) across GWF in a high level, spatially explicit tool that it can be used to identify opportunities to synthesize and integrate that would be best led by the data management team. Plus, it would provide opportunity to connect with other research being done in Canada, as GWF is a small portion of the research being done.
- GWF has brought people together with different expertise and methodologies. Has that materialized into new types of approaches to some of the water problems being tackled? Our group thought there would be opportunity near the end of GWF for this type of introspection and a synthetic piece.

- A synthesis idea to cover all of GWF is to put all the sites into a climate space, a people space – who (eg. urban centres underrepresented in GWF) and a problem space – what types of societal challenges has GWF address, who are the communities represented. Then do a gap analysis.
- Another synthesis approach would be to pick one variable, like ET or sap flow, and carry out a quantitative analysis across geographies. Models could be brought in to assist with spatial representation. Or, focus across geographies at the scale of one ecosystem type, for example, wetlands, in which a synthesis is underway (Westbrook, Waddington, Strack). We also thought a little about quantitative synthesis. For example, there was an excellent paper on ET across the entire boreal. A group could scale this type of quantitative, synthetic work to the scale of GWF.
- More specific to ecology and ecosystems, the group saw value in trying to pull out information on hydrologic change related to land use / climate warming and consider what can be useful and what is likely not useful for describing ecosystem functions? Could be a good synthesis type paper.
- It is important in any of the perspectives to keep in mind: How will all this work impact government policy and focus???? Because if all of this work has no uptake in practice, then what value have we added?

<u>Hydrological change</u>

What observational data and model results are/will be available?

- Spatial datasets for North America; 30,000 stations across the continent; ensemble datasets, etc.
- WRF high-resolution simulation atmospheric model; historical and future projections
- Next generation modelling – geospatial intelligence; incorporate more science queries, etc.
- Improved models – apply across the Canadian basins
- Some communities are planning to establish knowledge centers
- Visualization team also needs to be engaged more, nice progress, to see them engaged.
- Virtual gallery has been a very nice mechanism to illustrate outcomes, bridging results to people.

What future projections can be made and how confident are these?

- Uncertainty is about unravelling the sources of uncertainties
- Are we better at capturing and communicating uncertainties in the projections being made? For instance, do not use the uncertainty word in public communication. We are unravelling the uncertainties (complex feedbacks, for instance), though.

How is Indigenous knowledge supporting these efforts and how do we fully engage Indigenous knowledge and communities?

- First Nations communities are interested in data, scientific information, and information on water quality. They are very interested to know if "water is good to drink and is fish healthy to eat".
- When Water is Braided interlaced arts, science, and perspectives for explorations in indigenous water management. Through participation in the Virtual Gallery, individual projects (including co-development of research priorities,
- It's critical to make sure we remain interactive with people/stakeholders. How is hydrological change influence things people really care about (icings, landscape stability, water quality, transportation, ice roads)?

What do we have across projects and how can we pull this together?

- Think about the 'next user' versus the 'end user'.

- Gary suggested that university courses are needed. Encourage the kids to go to school. So that people are trained properly for dealing these problems. Gary also suggested to start this kind of education at a young age. This will let people be better stewards than we have been.
- Engage with users who have decided that they have specific needs for models.
- As an example, Bryan noted an intercomparison project in the Great Lake – built an internal website to distribute results of 13 models; look at results, visualize results and download.

Can we pull these together in a more synthetic way to make broader statements?

- Can we predict the next big issue is for Canada? Flooding is perhaps been front of mind, but what about agriculture. No shortage of issues, mind you.
- We need some specific statements as well - solutions and mitigations.
- We need to pitch at the right level of government.

What are the expected impacts on Indigenous communities?

- Changes to river morphology such that the environmental system, including the wildlife, does not behave like it used to. Gary compared it to arteries through the landscape. The loss of environmental quality will affect everyone so it should be prioritized to reduce everyone's risk.
- Maps and conceptual models (could these also show impacts (good and bad of choices) are good products. Producing these for extreme conditions might be a valuable synthesis product.

<u>Human and health dimensions</u>

Several GWF projects (including Is Our Water Good to Drink, Northern Water Futures, FishNet, PrairieWaters, IMPC, among others). These included FWF projects that are co-led with Indigenous partners, affiliated projects, and projects that include Indigenous community as well as broader user engagement.

The projects working directly with Indigenous community partners on community-relevant questions highlighted that the projects have come about as a result of conversations with Indigenous community partners and the research in these projects are community-driven, with the emphasis that community-based, citizen science, and participatory action research is meaningful when they're rooted in mutual trust where the projects have taken the time to build those relationships.

Two important observations that are important to note:

a. First, there was wide recognition of the negative impacts COVID has had on social science research efforts. For example, efforts that depend on face-to-face relationship-building, community visits, in-person and ongoing dialogue, students' data collection, etc. have all been disrupted or put on pause to a large extent.
b. Second, it was noted that a lot of human dimensions related research happen in relation to affiliated projects in association with GWF work (or in the same research regions) that are in some cases not being captured fully under the GWF umbrella – so perhaps there is a need for recognizing and acknowledging the work being done under the affiliated projects within the larger Global Water Futures program in a better way. For example, by revisiting some of those affiliated project proposals to put an effort into bringing these projects into the GWF circle.

The group had in-depth discussions around opportunities that arise out of the synthesis that can hopefully be explored further in future GWF discussions:

1. First, there is a synthesis opportunity that emerged out of discussions around human data, data-sharing protocols, and agreements that can perhaps lead to a joint publication focusing on **best practices for human data management**. A few highlighted practices include drawing initial research agreements with collaborators (e.g. communities) where data ownership, sharing protocols, and expectations are discussed. GWFNET is often talked about in the context of modelling but could become an important tool for data management in social science research aspects for GWF too. A need for recognition of internal use vs external use of data was also brought up (that is, contextualization of data and knowledge was emphasized).
2. Another synthesis opportunity at the GWF level is to **engage with people and places to inform models.** As an example, Traditional knowledge and Indigenous knowledge often are relayed through the narration of experiences and oral histories – models and modellers, on the other hand, are often by definition quantitative. Connecting the two often takes rigorous negotiation between modellers and Indigenous stewards, coordinators, or community leaders through ongoing engagement and dialogue.
3. Use of online visual tools (e.g. a mapping initiative) is another opportunity to capture Indigenous languages and histories and in the process, and support their integration with the modelling efforts as well. This will help with **scoping capturing or defining metrics, indicators, and predictors from a Traditional Knowledge and Indigenous Knowledge perspective.**
    a. Often research questions are centered around specific objectives or indicators, e.g. the projects specifically centered around health and contaminants in the water might not specifically ask research questions about climate change, but for communities, they're experiencing the cumulative effects all the same. So there was an emphasis on **holistic understanding** in this group as well (it ties to some of the points made by Cherie and Chris earlier).
    b. In circumstances like COVID, knowledge brokers (either community stewards or researchers and youth, or university researchers and HQP who have knowledge of context) play an even more valuable role in sustaining representation of community voices in the research.
4. Another emerging opportunity based on learned experience across the GWF program is **being proactive rather than reactive** in acknowledging the need for collaboration and partnerships with the end-user community (including Indigenous communities) in order to get their input in research efforts. The notion of reciprocity was highly emphasized as the core of knowledge mobilization, and for end-user-researcher relationships, and this is considered essential for Indigenous engagement.
5. Synthesizing minimum expectations of research practices by establishing core competencies of engaging in social science aspects of research (in terms of expectations around KM, EDI practices, social capital, background knowledge of histories of community and their practices, in particular, knowledge of governance rights of Indigenous communities and what they mean). These were underlined as a necessity for **establishing a set of research protocols as a starting point across the program**.
6. **Meeting people where they are at** emerged as a theme as well in discussion – that is, recognizing that it might not always be publications or academic outputs that are deemed as research outputs

of priority or utility in the end-user community (including Indigenous communities), but that user-specific research output could include news features, art, podcasts etc.

7. We found that there are in fact **a lot of success stories across the project**, so having more science features on stories around engagement processes as well rather than model outcomes alone, would be a great way for projects to learn from each other and stay up to date with projects across the program.