Delivery of Ontario's Flood Forecasting and Warning Program

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ABSTRACT:

Flood forecasting and warning is a component of the flood management program in Ontario. The Province of Ontario is responsible for the overall flood forecasting and warning system across the province. Responsibility for local flood warning systems is a delegated role to the local Conservation Authority or Ministry of Natural Resources and Forestry districts where Conservation Authorities don't exist. Flood forecasting and warning guidelines have been developed to aid in the design and assessment of flood warning systems. A provincial flood forecasting and warning committee assists the Ministry of Natural Resources and Forestry with program implementation, and provides input and advice regarding strategic planning. An annual workshop is held to facilitate technology transfer, networking and succession planning. There are several current activities underway to improve documentation of spatial precipitation, spatial snow pack information, soil moisture monitoring, flood documentation, and design of the provincial stream gauge network. This paper describes the flood warning system in Ontario and how it fits into the overall flood management program. It describes the components of the program from the Provincial guidelines and summarizes current ongoing activities to advance the program in Ontario. Both the flood forecasting and warning program, and flood management program, compliment the dam safety program in Ontario. Both programs have common objectives of reducing risk to life and property damage. It is intended that the outcome of the paper increases awareness of the flood forecasting and warning program in Ontario to facilitate a closer working relationship with the dam safety professionals.

RÉSUMÉ:

La prévision et les alertes aux inondations font partie du programme de gestion des inondations en Ontario. La Province de l'Ontario est responsable pour la gestion complète des prévisions et des dangers d'inondation à travers la province. La responsabilité pour la propagation des alertes aux inondations à l'échelle locale est déléguée à l'Autorité de Conservation locale ou au Ministère des Richesses Naturelles et des Forêts lorsqu'une Autorité de Conservation n'existe pas. Les directives pour les prévisions et les alertes aux inondations ont été développées afin d'aider la conception et l'évaluation des systèmes d'alerte aux inondations. Un comité provincial pour les prévisions et les alertes aux inondations assiste le Ministère des Richesses Naturelles et des Forêts avec l'implémentation des programmes, et fournit des contributions et des conseils concernant les planifications stratégiques. Un atelier annuel est organisé afin de faciliter le transfert de nouvelles technologies, d'encourager les interactions collégiales et la planification de succession. Plusieurs activités sont en cours pour améliorer la documentation des données spatiales sur les précipitations, l'information sur l'accumulation de neige, la surveillance de l'humidité du sol, la documentation d'inondation et le plan du réseau de jauge de vapeur provincial. Ce document décrit le système d'alerte aux inondations en Ontario et comment il s'accorde avec le programme global de gestion des inondations. Il décrit les éléments du programme d'après les directives Provinciales et résume les activités qui sont actuellement en cours pour avancer le programme en Ontario. Les programmes de prévision d'inondation et d'alerte, et le programme de gestion d'inondation en général, complètent le programme de sécurité des barrages en Ontario. Les deux programmes partagent les objectifs de réduire les risques mortels et les dommages matériels. Le résultat désiré est que ce document augmente la sensibilisation aux programmes de prévision et d'alerte aux inondations en Ontario, afin de faciliter de bonnes relations de travail avec les professionnels de la sécurité des barrages.

1 INTRODUCTION

Floodplain management in Ontario uses both structural and non-structural approaches to reduce flood damages. This paper focuses on the Flood Forecasting and Warning System in place in Ontario; however, it is important to understand that flood forecasting and warning is one component of the overall flood management approach in Ontario. Both floodplain management and flood forecasting and warning compliment the Dam Safety program in Ontario.

Flood damage reduction started early in the 20th century. From the 1940's through the mid-1990's, dam, dyke, and channelization projects were completed to reduce the potential for flood damages and risk to life. Some notable dam construction projects include Shand Dam in 1942, Fanshawe Dam (1952), Conestogo Dam (1958), and Guelph Dam (1976). Notable dyke projects include London Dykes (1930's), Bridgeport Dykes (1978), Cambridge Dykes (1980-1995), Belleville Ice Control Dams (1978-1990), Brantford Dykes (1985-1995), and most recently the dyking of the lower Don River in Toronto (2012). Structural measures help reduce the potential for flooding of historic development located in floodplains.

The devastating Hurricane Hazel flood in 1954 resulted in several changes and adaptations to flood management in Ontario. The two most notable changes included the need for weather forecasting to provide earlier warning of weather events that could result in flooding, and the need to regulate development in floodplains. Detailed information regarding the hurricane hazel flood can be found at www.hurricanehazel.ca. Following the Hurricane Hazel flood, the Province of Ontario created a hydrometeorlogist position and hired its first hydrometeorologist, with a primary role of forecasting floods. Floodplain regulation began in the 1960's; in some areas of the province the Hurricane Hazel flood is the Regional Storm used to estimate the Regulatory Flood (Hurricane Hazel 2015). Other areas of the province use either Timmins or 100 year storm as the Regional Storm.

In May 1974, a major flood occurred in the Grand River Watershed, causing major flooding through communities of Brantford, Cambridge-Galt, and Kitchener-Bridgeport. The Province commissioned a Provincial Inquiry to investigate the cause of the 1974 flood. This inquiry made 21 recommendations that dealt with flood warnings and the role of reservoirs, as well as recommendations for additional mitigation works to reduce the potential for flooding in the most affected communities. Recommendations from the 1974 flood continue to influence the design of flood warning systems in the Grand River Watershed and other watersheds in the province of Ontario (Ontario Ministry of the Attorney General 1975).

Starting in 1980 and continuing through to 1995, the Federal Flood Damage Reduction Program (FDRP) provided funding to map flood hazards across Canada. Several floodplain mapping studies were completed across Ontario. A requirement of the FDRP funding was that flood hazard mapping be incorporated into municipal planning documents. To aid in completing and implementing floodplain mapping, the Province of Ontario issued Floodplain Technical Guidelines in 1985, and implemented the Provincial Floodplain Policy in 1988. The province updated provincial floodplain mapping technical guidelines in 2002, in the document *Technical Guide- River & Stream Systems: Flooding Hazard Limit*.

Each conservation authority has a provincially-approved 'Development, Interference with Wetlands and Alterations to Shorelines and Watercourses' regulation developed under section 28 of the Conservation Authorities Act. The Conservation Authorities Act regulation authority was expanded through Act amendments in 1998. It was enacted through the 'generic' regulation approved by the province in 2004, and updated individual regulations approved by the Minister in 2006. Ontario Regulation 97/04 allows conservation authorities to prevent or restrict development in areas where the control of flooding, erosion, dynamic beaches, pollution, or the conservation of land may be affected by development, in order to

prevent the creation of new hazards or the aggravation of existing ones. Where Conservation Authorities exist they administer this regulation. In where Conservation Authorities do not exist, the local Ministry of Natural Resources and Forestry (MNRF) district office administers the floodplain regulation.

The above history helps to illustrate how floodplain management has evolved. To reduce the risk of flooding, mitigation measures were implemented where it was deemed practical and cost-beneficial. Floodplain regulation focused on managing floodplains to avoid creating new flood damage potential or risk to life. Both of these outcomes aid in reducing the potential for loss of life and reducing flood damages downstream of dams.

Flood forecasting and warning has evolved over the decades to compliment the structural approaches implemented to reduce the risk of flooding. Floodplain mapping has been adapted to facilitate municipal emergency response to floods. This paper will now discuss the components of the flood forecasting and warning system currently in place in Ontario.

1.1 Responsibility for Flood Forecasting and Warning and Funding of Program

The responsibility for Flood Forecasting and Warning is a delegated responsibility from the Province to the local Conservation Authority (CA) or MNRF district. The Province is ultimately responsible for the Provincial Flood Forecasting and Warning System; the local agency CA or MNRF district is responsible for the local flood forecasting and warning system and for issuance of local flood warning messages (MNRF 1984).

The Province invested $7.41 million dollars in transfer payments to the 36 Conservation Authorities across the province in 2015. These transfer payments fund a portion of the cost for CA's to operate a flood forecasting and warning systems, operate flood control structures, complete minor routine maintenance associated with flood control structures and complete hazard management studies, including subwatershed plans and floodplain mapping. The transfer payments from the Province to CA's are more than matched by Ontario Conservation Authorities. The transfer payment amounts were established in 1995 and have not been updated to reflect true costs of delivering a flood forecasting and warning and hazard management programs. Permit fees are charged to applicants to offset the costs of delivering a floodplain regulation program. While the funding from the Province doesn't fully cover the cost of delivering a program, this operational funding is very important and is very much appreciated by Conservation Authorities.

The province provides $5.0 million dollars annually towards major maintenance of water control infrastructure through the Water and Erosion Control Infrastructure (WECI) program. Conservation Authorities match the provincial contribution to create a $10 million dollar annual budget for capital maintenance. The Province operates 398 dams located in provincial MNRF districts primarily where CA's don't exist. The provincial budget to maintain these structures is approximately $1.8 million dollars annually.

Beyond the above funding, the province contributes approximately $4.3 million dollars annually to the Canada-Ontario Agreement on Hydrometric Monitoring, for the operation of 584 stream gauges by the National Hydrologic Service (Water Survey of Canada). Of the 584 gauges in the Ontario Federal Provincial Cost-Share agreement, 130 are funded by the Federal Government, 332 funded by the Provincial Government, 66 jointly funded (primarily between Ontario and Canada), and 56 funded by other agencies, which include Ontario Power Generation, Public Works and Government Services Canada, Lake of the Woods Control Board, municipalities, or private industry. Funding a specific gauge may be shared or partially funded by one or more agencies. The overall cost break down is 26% Federal, 66% provincial and 14% other. The full cost of the cost-share network is over a $6.5 million dollar range

when funding and overhead from the Federal Government and other agencies are considered. Beyond gauges in the cost-share agreement, additional stream gauges are operated separately by Parks Canada, Conservation Authorities, MNRF districts and Ontario Power Generation that directly support flood forecasting and warning. Operation of the stream gauge network plays a key role in the delivery of a flood forecasting and warning program. Stream gauges can be thought of as public safety devices used to make decisions regarding when to issue flood warnings and contribute to operational decisions related to dams.

A Provincial Surface Water Monitoring Centre located in the Ministry of Natural Resources and Forestry (MNRF) head office in Peterborough provides support to the program partners, including CA's MNRF districts and Water Survey of Canada. The MNRF Aviation, Forest Fire and Emergency Services Branch, located in Sault Ste. Marie, provides detailed weather forecast information customized to support flood operations. Weather forecasts are provided to the Surface Water Monitoring Centre twice per day or more frequently depending on the situation. This custom weather information compliments information available from Environment Canada and other internet sources (MNRF 2014).

1.2 Provincial Flood Forecasting and Warning Committee

The overall flood forecasting and warning program delivery is administered by MNRF with input from program partners through a Provincial Flood Forecasting and Warning Committee (PFFWC). This committee developed Provincial Flood Forecasting and Warning Guidelines in 2008; these guidelines were recently updated in 2014. Provincial guidelines explain the program and establish expectations for the local flood forecasting and warning system, and how the local system integrates to the overall Provincial program.

The committee meets face-to-face twice per annum with several teleconference calls over the course of the year. The committee is chaired by the Surface Water Monitoring Centre Co-ordinator from MNRF. The MNRF provides secretarial and administrative support to the committee. The committee itself has representatives from MNRF policy, engineering, district and surface water centre, five CA's, Ontario Power Generation, Parks Canada Trent Severn and Rideau River systems, Emergency Management Ontario, Ontario Region Meteorological Services of Canada, and Water Survey of Canada (MNRF 2014).

Beyond discussing operational issues and program administration, one of the deliverables of the committee is an autumn Provincial Flood Forecasting and Warning workshop. The two day workshop is typically held in mid-September in the Toronto area; attendance in recent years has reached 150 attendees and continues to grow. The purpose of the workshop is technology transfer and networking. This workshop allows participants to share approaches and ideas, enables participants to meet colleagues, and provides an important succession planning function by helping to train and integrate younger practitioners. The workshop helps maintain a continuity of program delivery in Ontario, particularly as staff retirements occur.

Currently, this type of provincial workshop is unique in Canada. Efforts are made to solicit out-of-province speakers to create linkages to provincial counter parts in other provinces, sharing knowledge and experience across the country.

2 PROVINCIAL FLOOD FORECASTING AND WARNING IMPLEMENTATION GUIDELINES

The Provincial Flood Forecasting and Warning Guidelines provide an explanation of the goals and objectives of the Provincial System. They explain the linkages between the overall Provincial System and the local flood warning systems operated by local CA's or districts. A minimal and generic level of flood

forecasting and warning implementation is identified to help establish a minimum level of consistency and compatibility in program delivery across Ontario. These guidelines also provide information to help assess and design a local flood warning system and monitoring network (MNRF 2014).

The goals of flood forecasting and warning are to:

- Reduce the risk of loss of life, injury, and property damage due to flooding through the issuance of flood messages and information to those that may be at risk, and to those agencies and individuals that respond to the flood event;
- Maintain an understanding of the flood risk at the local watershed and Provincial level, and;
- Provide information for the safe operation of dams

The basic components of a flood forecasting and warning system are described by Figure 1.

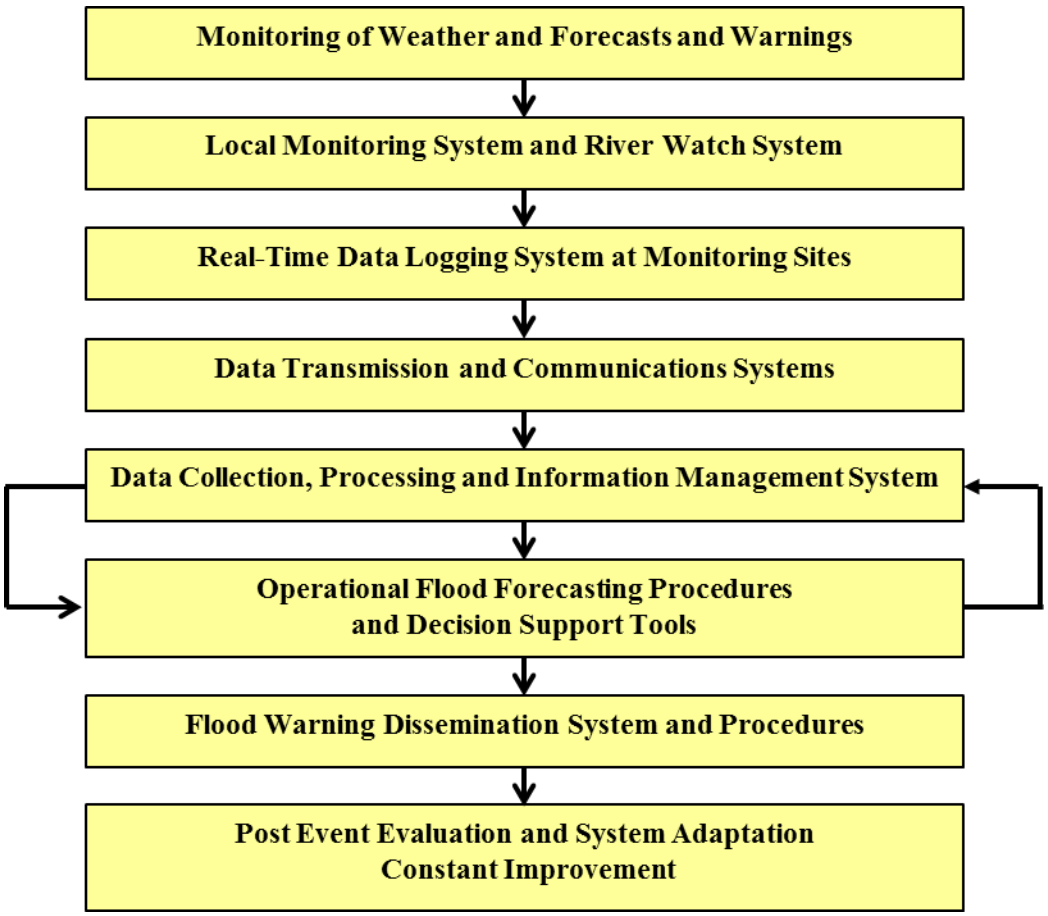

Figure 1: Elements of a Flood Warning System (Adapted from: Nemec 1986)

2.1 Monitoring of Weather Forecasts and Warnings – Provincial Flood Messages

The Provincial MNRF fulfills a key role of monitoring weather forecasts and warnings. While local agencies would also carry out this role, the MNRF employees are trained weather forecasters who collaborate with Environment Canada weather forecasting staff. The MNRF experts focus attention on events that could pose a threat of flooding. Depending on the threat of a weather system, the MNRF will issue Provincial Flood Watch or Watershed Condition Statements messages (MNRF 2014).

2.2 Local Agency Monitoring Networks

The local agency, CA or MNRF district monitors weather conditions and operates a monitoring network to facilitate local forecasting. Weather forecasts do not always turn out as planned. The local monitoring network plays an important role of providing early warning of events that can result in flooding and support local agency forecasting models and techniques. Technology evolves – it is always important to review monitoring network designs to integrate new technologies and to improve efficiency and reliability of monitoring information. The provincial guidelines provide good advice regarding monitoring network design. Automated alerting to precipitation, river level or reservoir level thresholds being exceeded has been implemented in some local monitoring systems. Software such as Kisters™ Wiski-Soda and Win-911 are examples of software with alerting capabilities. Becoming aware of situations early provides additional time to assess and manage events.

Beyond the gauge monitoring network, CA's and MNRF districts often operate a river watch monitoring program. Specific reaches of river are assigned to field staff. Points of interest are identified along the river reach; field staff check and report on conditions at these points of interest. Points of interest may include locations of flooding, staff gauges or stream gauges. Reports from the network of river watch reaches in a watershed help provide an assessment of flooding or potential flooding conditions. River watch reconnaissance is an effective way of monitoring ice conditions heading into and during breakup.

2.3 Data Collection at the Gauge Site

Data loggers collect and store data at individual stream gauges or climate monitoring sites. At Federal Provincial Cost-Share stream gauge sites, the data logger is typically supplied by Water Survey of Canada. At individual agency sites, the agency supplies and operates the data logging and communications equipment. As technology is constantly changing, it is important to carefully review decisions regarding equipment to ensure the equipment will be reliable and the vendor will be available for the long term. Standardizing equipment is desirable from the perspective of staff training and equipment inventory. The flexibility of equipment integration with local agency data collections systems is also a consideration.

2.4 Data Communications

Communication of information from the remote monitoring site to a local dam, local flood forecasting centre, or to the Surface Water Monitoring Centre is transmitted by phone land line, cellular phone, or GOES satellite communications. Some agencies may also use licenced or non-licenced radio telemetry. The vulnerability of the data communications system needs to be constantly reassessed. Cellular-based systems may become overwhelmed during a large disaster. Redundancy of communication from critical sites should be considered in a communications system design. GOES satellite telemetry provides a good alternative to land based communications. Recent upgrades to the GOES system allow data collection to occur on an hourly basis. GOES also has alarm channel capabilities where random unscheduled transmissions can be used to transmit alarms. It is important to assess the points of failure in a communication system and design communication to critical gauge sites to have redundancy, even if that redundancy is simply posting a staff person at the site to radio in manual gauge readings.

Depending on risk, backup voice communications systems may also be a consideration. Wide area low-band radio systems can fulfill this role. However, there needs to be awareness that radio communications are evolving. Public Safety Grade voice radios that include a Public Safety channel are or are becoming more available. The Public Safety Radio standards are converging. The advantage of Public Safety Grade

radios is that the public safety channel allows various response agencies to communicate over a public safety channel. A debrief after the tornado disasters in Oklahoma identified the inabilities of different agencies to communicate over a common radio frequency. This inability to communicate between response agencies created a barrier during the response to the tornado disaster. This further reinforced the importance of public safety grade radios to address this deficiency.

2.5 Data Collection Processing and Data Management

The MNRF operates a data collection and processing system at the Provincial Surface Water Monitoring Centre. This system collects data from the stream gauges in the Federal-Provincial network and a portion of the rain gauge and stream gauge network operated by local agencies or MNRF districts. Manual snow survey measurements collected by local agencies are contributed to the Surface Water Centre, where they are assembled to provide a provincial summary of snow pack conditions. The Ministry of Natural Resources and Forestry and several Conservation Authorities use the Wiski-Soda hydrometric database from Kisters™ to collect, store and manage real-time information required to support flood forecasting and warning, dam management and general water management decisions. CA's and Parks Canada also operate custom data collection and management systems. Collection systems are available from data logger vendors – Forest Technology Services and Sutron are examples. The vendor collection systems facilitate data collections from their brand of data logger over phone line, cellular, wireless, and GOES Satellite communication systems.

2.6 Operational Forecast Procedures and Decision Support Tools

Operational flood forecasting tools and techniques vary across CA's and MNRF districts. Typically, the local flood forecasting systems are adapted to the risk and complexity of the watershed and reservoir system. Simple empirical techniques or lag and route methods are effective in some watersheds. The design of the flood forecasting systems should consider the information needed to provide effective warnings and effective operation of dams and reservoirs. Ideally, a range of techniques, from simple to complex, should be developed with redundancy or fall-back procedures if monitoring data required for the forecasting model or technique is unavailable. A backup plan is a necessity.

Urban flood forecasting and flood forecasting on watersheds with short reaction time is a challenge. Some agencies such as Toronto Region Conservation Authority (TRCA) have integrated weather radar with hydrologic models and hydraulic models to provide real-time flood forecasts on fast reacting urban systems.

2.7 Flood Warning Message Dissemination

Common flood message terminology has been developed by the provincial committee and is documented in the provincial guidelines. Watershed condition statements, flood watches, and flood warnings are the standard flood messages used in Ontario. Common terminology is essential to reduce confusion and to facilitate approaching organizations such as the Weather Network to assist with conveying flood warning messages (MNRF 2014).

Both the CA's and MNRF districts have procedures in place to distribute flood warning messages. Common methods of flood warning message distribution include fax, email, and automated phone call. Manual phone calls always remain an option; if flooding is expected in a local municipality, a manual call is made to the local municipal flood co-ordinator to discuss the flood warning and answer questions.

The flood warning lists maintained by CA's and MNRF districts are typically tested annually and maintained throughout the year. These warning lists can be very useful to dam operators in the event of a dam emergency. Often a portion of contact information in a Dam Emergency Preparedness Plan can be referenced or extracted from CA or MNRF district flood warning lists.

In recent years, automated voice dialler technology has matured and is a main stream technology that allows thousands of phone calls to be made in a matter of minutes. Third party firms such as Aizan^{tm} offer voice dialler services for a reasonable annual fee. The voice dialler service is managed through a web interface. The web interface includes reporting functions; the success of calls can be tracked. Voice dialler technology offers the ability to quickly and efficiently distribute a flood warning message, and can easily be adapted to distribute dam emergency messages (Aizan Technologies 2015).

Several Conservation Authorities are using social media to distribute or advise social media users a flood warning message has been issued. Twitter messages are pushed to users to advise that a flood warning message has been issued, and directs the Twitter user to a web site where more information is available. Facebook is used in a similar manner. Social media is not used for two way conversations; social media users are directed to information available on the web or to emergency contact information.

There is a lot of enthusiasm from social media users to become engaged and contribute information during a flood event. One means of allowing social media followers to contribute information is by creating an event-based hash tag. Social media users can post information to the event-based hash tag; this helps organize information for a given event. Social media users should be reminded not to put themselves in jeopardy when obtaining photos or information. When obtaining information, their personal safety should be their first priority.

The use of a website with information organized to serve the needs of emergency responders and general public should be a component a flood warning system. Information organized on the website can effectively provide information to users and avoid public phone calls. During a larger flood event in December 2008, the Grand River Conservation Authority website saw 18,000 page views of real-time flow and flood message related information in a single day. If those 18,000 page views were single phone calls, the staffing complement would not have been able to service that volume of phone calls.

2.8 Post Flood Event Debriefings

Debriefing after floods is the final important component of a system. Lessons are learned from each flood. Experience gained from each flood event can be used to adapt and improve the system. Information and experience learned from managing smaller floods can be directly transferable to developing Emergency Preparedness Plans for dams; recognizing the potential scale of flooding is different. The Provincial Flood forecasting guidelines can provide a framework to complement the development of Emergency Preparedness Plans for dams.

3 CURRENT FLOOD FORECASTING AND WARNING RELATED ACTIVITIES IN ONTARIO

3.1 Annual Fall Workshop

A two day workshop is held in mid-September each year in the Toronto area. The two day workshop focuses on technology transfer, and provides the opportunity for networking and mentoring of new practitioners to the program. Information about upcoming workshops or agendas and presentation

material from previous workshops may be obtained by contacting MNRF Surface Water Monitoring Centre staff.

3.2 Environment Canada Network of Network Pilot Project

A network of networks pilot project is underway with Environment Canada as part of the PAN AM games. This project is piloting the sharing of real-time climate data with Environment Canada from MNRF, Toronto Region Conservation Authority, and the Grand River Conservation Authority. Real-time climate data is imported into the Environment Canada data management framework (DMF) where it is available to improve Environment Canada weather forecasts and risk management products. The pilot is working through the technical issues associated with sharing data in real-time. Beyond this pilot, the vision is to expand the number of agencies that share data in real-time. Data-sharing agreements and qualifying known quality of data are issues being worked through as part of the pilot project. A similar pilot project is underway in British Columbia.

3.3 Frozen Precipitation and Snowpack Monitoring Enhancements

The MNRF has provided funding for near real-time snow water equivalent sensors and all weather precipitation (weighing) rain gauges. This funding for equipment has been provided to a number of Conservation Authorities and Ontario Power Generation. The purpose of this funding is to improve winter precipitation and snow data collection across the province. The near real-time snow water equivalent sensor was originally developed by Hydro Quebec and commercialized by Campbell Scientific. It is capable of providing daily snow water equivalent estimates.

Conservation authorities in Eastern Ontario formed a collaborative flood forecasting and warning system based on the WISKI/SODA platform. The partnership involves 10 CA's to share expertise and resources in order to develop forecasting tools of mutual benefit. One of these tools is a snow accumulation and melt model that supplements the twice monthly snow course data, by providing daily estimates of snow depth, snow water equivalent, and melt potential. Model estimates of snow information and runoff potential may be produced where there is a good precipitation and temperature dataset. This is particularly important to Eastern Ontario, where the spring rain on snowmelt event is the most common cause of flooding. The modelled data is compared to measurements gathered at the snow courses as well as real-time measurements with the Campbell Scientific sensors. Data from the models are shared with MNRF and is available to all agencies.

MNRF Surface Water Monitoring Centre staff are working with National Oceanic and Atmospheric Administration (NOAA) to collaborate and improve the Snow Data Assimilation System (SNODAS) products covering portions of Ontario. Products from SNODAS are daily gridded 4 km spatial products that provide estimates of a range of modelled snow pack parameters. These parameters include snow depth and snow water equivalent. Surface Water Monitoring Centre staff are working with NOAA to share snow pack information collected in Ontario; this is to help improve the accuracy and reliability of the SNODAS product covering southern Ontario, to aid the flood forecasting and warning program (National Snow and Ice Data Centre 2015).

3.4 Integration of Provincial Groundwater Monitoring Site with Precipitation Monitoring

Data logging infrastructure at Provincial groundwater monitoring sites is being upgraded. As part of this upgrade, most sites are being equipped with GOES satellite communication capabilities. Groundwater monitoring sites equipped with GOES offers the opportunity to enhance the real-time rain gauge collection network by adding tipping bucket rain gauges at these sites. The addition of tipping bucket rain

gauge also enhances the analysis from a groundwater perspective that can be completed at these sites. Information from provincial groundwater monitoring sites will be collected, stored and disseminated in near real-time by the MNRF via their Wiski system. At sites where precipitation gauges have been implemented, information collected will be shared through the Network of Networks project with Environment Canada.

3.5 Community Collaborative Rain, Hail and Snow Network (CoCoRaHS)

Through encouragement of provincial Surface Water Monitoring Centre staff, the Ontario Ministry of Agriculture Food and Rural Affairs (OMAFRA) assumed the role of provincial co-ordinator for the Community Collaborative Rain, Hail and Snow Network (CoCoRaHS). This volunteer network contributes rain, snow, and hail observations and provides potential for a broader coverage of manual ground-based precipitation observations. These observations help document events, particularly with larger events that can result in flooding. In the future, Environment Canada intends to integrate these observations into the Environment Canada data management framework. This will make them available to Environment Canada weather forecasters and to risk management products produced by Environment Canada. Local CA's and MNRF districts have been encouraging volunteers to get involved in an effort to expand the ground-based observation network.

3.6 Canadian Precipitation Analysis (CaPA) Implementation

Environment Canada has been developing a new spatial quantitative precipitation product called Canadian Precipitation Analysis (CaPA). The CaPA product provides quantitative precipitation estimates on a 10 km grid, on a 6 hour and 24 hour basis. Work is underway to develop a 2.5 km grid product over the next two years. The CaPA product uses weather generation model input, weather radar, satellite information, lightening information, and ground-based precipitation information using real-time and manual observations. All of these information sources are combined to provide the best estimate of precipitation in 6 hour blocks over a 24 hour basis. The CaPA product is important to aid in documenting events that have generated floods and to advance risk management products such as Intensity Duration Frequency curves (IDF) and probable maximum precipitation estimates (PMP). The implementation of the Network of Networks, increased precipitation and snow monitoring by CA's and MNRF districts, and volunteer climate monitoring are important initiatives to provide a denser ground-based precipitation network to improve the accuracy of estimates from CaPA. Better estimates from CaPA will improve risk management products used by the flood forecasting and warning system and dam safety programs (MNRF 2014).

3.7 Ontario Climate Advisory Committee (OCAC)

A provincial climate advisory committee is active in Ontario. The Ontario Climate Advisory Committee (OCAC) acts as an advisory committee to Environment Canada. The committee is composed of practitioners who rely on climate data. It is the last active climate advisory committee in Canada; at one time there were climate advisory committees in most provinces. The climate advisory committee has participation from CA's, MNRF Surface Monitoring Centre, Ontario Ministry of Transportation, Ontario Power Generation, academic representatives from universities, and Environment Canada Ontario Region staff. This committee is an avenue to provide advice to Environment Canada from a practitioner's perspective. The perspective provided by this committee helps adapt EC climate-related programs or products to local needs in Ontario. It has been effective at realizing the implementation of initiatives like the Network of Networks, CaPA, and investigations into severe precipitation events in 2000, 2004, 2006 and 2013.

3.8 Flood Documentation Database

A Greater Toronto Area (GTA) group of CA's has developed a flood documentation database. Although initially designed for use by the GTA group of CA's, the MNRF provided funding to develop the database for province-wide implementation. The initial version of this database will be available later this summer. This database is designed to allow users to organize information related to a flood. This application has three main modules or functions: pre-flood information, during flood information, and post flood information. It is expected the database will be adapted as users gain experience with the database and as technology evolves.

3.9 Large Scale Soil Moisture Monitoring

The Ministry of the Environment and Climate Change (MOECC), the Ministry of Natural Resources and Forestry, and the University of Guelph are in discussions regarding a soil moisture monitoring network. The soil moisture monitoring network is being designed to use ground-based soil moisture probes to help calibrate remotely-sensed satellite soil moisture estimates. The outcome of this work is to monitor antecedent soil moisture. This information is useful to inform the potential for flooding and the severity and extent of droughts.

3.10 Alert Ready

The Provincial Flood Forecasting Committee is investigating how the new Alert Ready warning system could be used to communicate flood warning messages to the general public. This system was first introduced in March of 2015. The system includes provision for urban flash flooding, storm surge and dam overflow floods. The intent of Alert Ready to deal with riverine flooding is being explored.

3.11 Ontario Hydrometric Co-ordinating Committee (OHPCC)

The MNRF and EC – Water Survey of Canada administers the Canada/Ontario Bilateral Agreement for Water Quantity Surveys – essentially the operation of surface water stream flow stations. This agreement is administered through the Ontario Hydrometric Program Co-ordinating Committee (OHPCC). The OHPCC meets approximately four times per year. It has representatives from the Province of Ontario, Federal Water Survey of Canada, and Conservation Authority representatives. Beyond administration of the agreement, this committee helps to ensure effective program and information delivery. Stream flow information is very important to the Flood Forecasting and Warning, and Dam Safety programs. Stream gauges should be thought of as public safety devices; information from these gauges is used to make decisions regarding issuance of flood warnings and dam operations. A user survey of the stream gauge network in Ontario is being conducted by the MNRF. This survey is intended to capture the use of information from individual stream gauges and the value of individual stream gauges to the various programs including flood forecasting and warning. The outcome of the survey is to highlight or rank the importance of individual stream gauges. As an example, high ranked stream gauges associated with flood forecasting and warning will help inform decisions to add backup communication at these gauges, and to improve the accuracy of the extreme portion of the rating curve by implementing calibrated hydraulic models at these sites. This survey is being completed over the summer of 2015. Fall hydrometric work days are being planned with the vision of creating a networking opportunity for EC - Water Survey Technicians to meet with local CA and MNRF district staff. It is an opportunity to highlight the purpose of the stream gauge network, its importance to public safety, and to explore means of improving service delivery.

3.12 Ministry of Natural Resources and Forestry Floodplain Mapping Pilot Projects

The MNRF is funding pilot projects with the Grand River and Ganaraska Conservation Authorities to investigate new technologies and approaches to update floodplain mapping. These pilot projects were initiated in late 2014 prior to the announcement of the Public Safety Canada National Disaster Mitigation Program announced in January 2015. The pilot projects being completed for MNRF were in anticipation of the NDMP, and are meant to inform MNRF and CA's of modern technology and approaches that could be used to update floodplain mapping. Case studies investigate new approaches to base mapping creation; leveraging the investment in the Provincial imagery information basis; methods of field hydraulic data collection; lessons learned from recent applications of 2-D hydraulic modeling software; potential application of HEC-HMS as a real-time flood forecasting model; and application of the Life Safety Model to floodplain management.

4 CONCLUSIONS

The above is sample of some of the key activities that are ongoing in Ontario regarding flood management. The flood forecasting and warning program will continue to evolve. Opportunities to create better linkage between Flood Forecasting and Warning and the Dam Safety Program are always welcome and encouraged.

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