International Souris River Study Board

WORK PLAN FOR THE SOURIS RIVER BASIN

Photos of the 2011 floods and Boundary Reservoir in the Souris River Basin

Submitted by the International Souris River Study Board to the International Joint Commission

November 5, 2017 (Revised October 10, 2018)

10/10/2018

Executive summary

Introduction and Organization

The sharing and management of water across the International Boundary between Canada and the United States, including the Souris River Basin, has its origin in the Boundary Waters Treaty of 1909 between the two countries. The Treaty also established an International Joint Commission (IJC) to have jurisdiction over the use, obstruction, or diversion of the waters. Over the decades various binational boards have been established by the IJC to address the management of transboundary waters of the Souris River Basin and its major tributaries.

In May 1959, the International Joint Commission (IJC) was directed by the U.S. and Canadian Governments that interim measures recommended by the IJC in a report dated 1940 were accepted by Governments. The IJC subsequently issued a directive creating the International Souris River Board of Control, which specified flow apportionment between the states and provinces and empowered the Board of Control to advise on flow apportionment in the case of severe droughts.

An agreement between the Government of Canada and the United States for Water Supply and Flood Control in the Souris River Basin was signed in October 1989. Pursuant to that agreement, and a subsequent request from Governments in April 1992 and December 2000, the 1959 interim measures were modified.

In 2000, the IJC directed the International Souris-Red Rivers Engineering Board to transfer its responsibilities related to the Souris River to the International Souris River Board of Control. The IJC also changed the International Souris River Board of Control's name to the International Souris River Board (ISRB). The ISRB operated under an April 11, 2002 Directive until 2006 when the IJC changed the mandate to move to a more encompassing watershed approach. The new Directive dated January 18, 2007 sets out the duties of the ISRB as it moves toward a watershed approach. The ISRB is responsible for ensuring compliance for flow apportionment and low-flow measures. Also, the ISRB ensures the terms of the 1989 International Agreement for Water Supply and Flood Control in the Souris River Basin are met, including the terms of Annexes A and B of the Agreement and subsequent Amendments to Annexes A and B in 2000.

Unprecedented flooding in the Souris River Basin in 2011 focused attention on review of the Operating Plan contained in Annex A to the 1989 International Agreement. Interests in the basin, particularly in North Dakota, asked that additional flood protection measures be evaluated, above and beyond what is currently provided under the International Agreement, and that the Operating Plan contained in Annex A of the Agreement be reviewed. In addition, the Agreement requires that the Operating Plan be reviewed periodically to maximize the provision of flood control and water supply benefits that can be provided consistent with the terms of the Agreement. In light of

these facts, the IJC's ISRB established the 2012 Souris River Basin Task Force at its February 22, 2012 meeting in Bismarck, North Dakota to conduct a review of the Operating Plan contained in Annex A for presentation to the Governments of Canada and the United States. The Task Force held its organizational conference call under its Terms of Reference (TOR) from the ISRB on April 20, 2012. The ISRB reported to the IJC and the IJC reported to the Governments on the status of Task Force activities at the IJC Semi-Annual Meeting in October of 2012.

The first requirement of the Task Force TOR was to development a Plan of Study in 2013 (2013 POS) to conduct the review. The 2013 POS document describes the detailed POS and studies that are needed to review the existing Annex A Operating Plan for the reservoirs comprising the Souris Basin Project described in the 1989 Agreement in Saskatchewan and North Dakota and to evaluate alternatives to maximize flood control and water supply benefits. The ISRB submitted the 2013 POS to the IJC in April 2013. The IJC submitted to governments a "Plan of Study: For the Review of the Operating Plan Contained in Annex A of the 1989 International Agreement Between the Government of Canada and the Government of the United States of America" on June 7, 2013.

On July 5, 2017, the governments of Canada and the United States issued a reference for the IJC to undertake the Plan of Study. In accordance with Article IX of the Boundary Waters Treaty of 1909, the governments of Canada and the United States request that the IJC examine and report on flooding and water supply in the Souris River Basin, and coordinate the completion of the full scope of the 2013 "Plan of Study: For Review of the Operating Plan Contained in Annex A of the 1989 International Agreement Between the Government of Canada and the Government of the United States of America."

On September 5, 2017, the IJC issued a directive to establish and direct the International Souris River Study Board (ISRSB, or Study Board) to examine and report to the IJC on matters raised by the Governments of Canada and the United States in the reference dated July 5, 2017 directing the Study Board to aid the IJC in fulfilling the terms of the reference. Under item (1) of the Directive, the IJC directed the Study Board to develop a Work Plan by November 5, 2017. The Work Plan needed to include a detailed schedule and budget for the studies and tasks to be conducted. This document is the Work Plan.

The purpose of this Work Plan is to describe all studies needed to assist the IJC in fulfilling the terms of the July 5, 2017 reference. The Work Plan also documents the actions taken to guide and direct the activities of the Study Board.

The Study Board is responsible for providing oversight to study activities and ensuring that study activities will meet the goals of the references and directives of the IJC's International Souris River Board Study. The IJC has appointed an equal number of members from Canada and the United States to the Study Board and named a member from both Canada and the United States to be the Co-chairs of the Study Board. The Co-chairs are jointly taking a leadership role in

planning and implementing the Study Board's mandate. Two study managers, one from Canada and one from the United States, are responsible for assisting the Study Board on delivering its mandate. The Study Managers will work under the joint direction of the co-chairs of the Study Board and shall not be members of the Study Board. The Study Managers will keep fully abreast of the work of the different groups and function as liaisons between the Study Board and those groups. The Study Managers will be responsible for the effective management of the Study Board's Work Plan. Study Managers are responsible for communicating to the different groups the direction of the Study Board and assisting in general administrative and financial/contractual tasks.

Study Objectives

Each element of the Governments joint reference will be addressed by the plan described in this document, which contains a number of tasks that are grouped under four broad activities:

a. Operating Rules Review
b. Data Collection and Management
c. Hydrology and Hydraulics
d. Plan Formulation

The operating rules review (table1-OR1) will identify areas where the language and text in Annex A of the 1989 Agreement can be improved for ease of understanding and clarity of interpretation. This study activity directly addresses the Governments' Reference item 5: *A detailed review of the Operating Plan contained in Annex A of the 1989 Agreement.*

The data collection and management activities (table1-DW1-DW4) will collect and harmonize the data necessary to support hydraulic and hydrologic modelling and associated studies. This study objective directly addresses the governments' Reference item 1: *The collection and harmonization of data necessary to support hydraulic and hydrologic modelling and associated studies.* These efforts are considered necessary in order to carry out the analysis phase of the study formulated in the Hydrology/Hydraulic activities (HH1-HH10). It is important to note that many elements of the analysis phase can be carried out in parallel to the review and data collection phases of the Work Plan.

The hydrology and hydraulics activities (table 1-HH1-HH10) will setup the stochastic, hydrologic, hydraulic and reservoir modelling platforms to be used for testing and evaluating alternative operating scenarios. This study activity directly addresses the Governments' Reference items 2, 3, and 4. Reference item 2: *The development of hydrological watershed runoff and inflow sequences to allow for the simulation of various water supply conditions including historical conditions, extreme conditions, and conditions influenced by the effects of climate change.* Item 3: *The development of hydraulic, hydrologic and optimization modelling tools that will allow for the accurate simulation of flows within the Souris River so that operational scenarios may be evaluated.* Item 4: *Studies evaluating the physical processes occurring in the Souris Basin which are thought to have contributed to recent flooding events.*

The Plan Formulation (PF1-PF4) study activities will lead to formulating alternative plans and evaluating the plans regarding improvements in the Operating Plan outlined in Annex A of the 1989 agreement. Also, study activities will evaluate various flood protection and water supply measures beyond what is provided under the 1989 agreement. This study objective directly addresses the governments' Reference items 6 through 10. Reference item 6: *Identifying and, as appropriate, making recommendations regarding improvements to the Operating Plan contained in Annex A of the 1989 Agreement to reduce the flooding and water supply risks in the Souris River basin with consideration to low flow, apportionment, water quality and aquatic ecosystem health.* Item 7: *The evaluation, on a qualitative and quantitative basis, of the costs and benefits of a range of possible infrastructure and operational plans regarding flooding and water supply in the Souris River basin.* Item 8: *The evaluation of additional flood protection measures, beyond what is currently provided under the 1989 Agreement, which may include feasibility evaluations of increasing storage at existing dams, more efficient channel alignment and capacity, and the provision of flood control measures in and around communities within the basin.* Item 9: *Assessing possible adaptation strategies to address the potential future variability in water supplies associated with climate change.* Item 10: *Facilitating collaboration among various Federal, State, Provincial, local agencies, the public, as well as Native American Tribes, First Nations, and Métis located within the basin to share their views and provide input during the study process.*

Throughout the study, public opinions, Government agencies and stakeholder perspectives will be sought to foster communication and participation at all levels on both sides of the border. The IJC is committed to providing all interested parties with convenient opportunity to be heard, as required in the Boundary Waters Treaty. The IJC emphasizes the importance of public outreach, consultation and participation, and promotes policies and programs that enable community input in the decision-making process.

A Public Advisor Group (PAG) will be established to help engage the public during the study on an ongoing basis. PAG members will represent multiple areas of interest and various geographic locations across the Souris River basin and include an equal number of people from Canada and the US. PAG members will have the opportunity to provide advice on the Study Board's public participation activities laid out in its Directive.

Four general levels of study review will be used to assure technical quality of the activities: Sufficiency Review (by ISRSB) (SR) Agency Quality Control (AQC), Agency Technical Review (ATR), and Independent external review conducted by an Independent Review Group (IRG). The IRG will be contracted by the IJC; however, the IRG will operate independently outside the control of the IJC and the ISRSB.

The Study review process is based on a few simple but fundamental principles:

- Peer review is key to improving the quality of work in studies and so interim reviews as well as the final reviews are beneficial for checking methods and assumptions early when corrections are still feasible;
- Reviews will be scalable to the content of each component of the study, deliberately included as part of the study process throughout the life cycle of the study (scoping, interim products, and final products), and concurrent with recommendations to include previous work in the study and completion of new study phases/ products from each contributing agency/contractor and the study board;
- Since previously completed work products may have already undergone sufficient peer and independent reviews, products will be screened for level and need for review for the purposes of this study.
- An IRG level review will be completed on all recommendation and implementation documents and specific study products identified as fundamental to making those recommendations. For other products, the Study board will provide documentation of existing reviews and recommendations to the IRG for level(s) of review, and the IRG will provide their decisions on whether to perform additional review.

Cost and Timeline

The total cost for each group of tasks planned by the ISRSB is shown in table 1a. The Work Plan is considered a living document and will be revised as the Study progresses, scope of work is modified, funding levels change, results become available, and stakeholders and public inputs are provided. Detailed cost estimates are provided in the workplan. The broad timeline is shown in table 1b.

Old No.	New No.	Name	Group	Canada Costs (CND)	USA Costs (USD)
1a, 1b, 2	OR1	1989 Agreement Language Review	Operating Rules Review	6	0
				6	0
3	DW1	Summarize POS Projects and Report Progress since 2013	Data Collection and Management	3	0
4	DW2	Lidar and Bathymetry for Reservoirs		75	0
5	DW3	Review of Hydrometerological Network Report		15	0
6	DW4	Data Collection for PRM		0	85
				93	85
7	HH1	Regional Hydrology	Hydrology & Hydraulics	44	25
8	HH2	Stochastic Water Supplies		6	185
9	HH3	Artificial Drainage Impacts Review		43	0
10	HH4	Flow Simulation Tools Development (MESH)		76	0
11, A4	HH5	ECCC Climate Change Supplies		47	5
12	HH6	Reservoir Flow Release Planning (RES-SIM)		64	65
13	HH7	Reservoir Flow Release Planning (HEC-RAS)		3	16
new	HH8	Develop PRM Model		4	72
new	HH9	Model System Integration		28	0
new	HH10	Forecasting Assessment		175	0
				490	368
14, A1, A3, A5, A(	PF1	Workshops and Engagment	Plan Forumlation	209	175
15, 16, 17	PF2	Run and Evaluate Alternatives		173	238
new	PF3	Dam Safety		3	75
new	PF4	Roadmap for apport., water quality, and aquatic eco. health		0	0
				385	488
	A1	Administration - Independent Review Group		47	33
	A2	Administration - Study Manager (Canada)		165	0
	A3	Administration - Study Manager (U.S.)		0	106
				212	139
			Total	1186	1080

Table 1a. Canadian and U.S. costs, activities required to meet the IJC September 5, 2017 Directive to the International Souris River Study Board

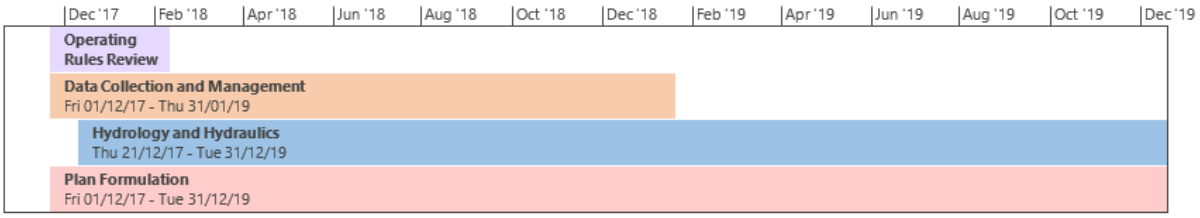

Table 1b. Broad Study Timeline. Detailed timelines are provided in the workplan.

Table of contents

List of Tables

List of Figures

1 Preamble

The International Souris River Study Board (ISRSB, or Study Board) Draft Work Plan, dated November 5, 2017 (revised October 10, 2018), is respectfully submitted by the ISRSB to the International Joint Commission (IJC). The ISRSB will use the Work Plan to complete the scope of work outlined in the July 5, 2017 reference letter to the ISRSB. In the reference the IJC directed the ISRSB to undertake the "Plan of Study: For the Review of the Operating Plan Contained in Annex A of the 1989 International Agreement Between the Government of Canada and the Government of the United States of America" for the Souris River Basin that was submitted to the IJC in April 2013.

2 Acknowledgements

This Work Plan could not have been developed without the assistance of the current members of the ISRSB, the past Task Force, and Core Committee; both established by the International Souris River Board (ISRB). We would also like to thank the ISRB for their support and assistance in formulating this plan.

The previous Task Force was instrumental in developing the "Plan of Study: For the Review of the Operating Plan Contained in Annex A of the 1989 International Agreement Between the Government of Canada and the Government of the United States of America" for the Souris River Basin in 2013.

The Core Committee was charged with reviewing and updating the language and data in the International Agreement. The Core Committee reviewed the Agreement, identified sections of the Agreement which are no longer relevant, updated and re-plotted a number of tables and graphics pertaining to reservoir properties, and compiled these recommendations for presentation to the ISRB.

The members of the Study Board were appointed by the IJC to provide expertise needed to develop and guide the scientific activities and tasks required to complete the Work Plan. Although most Study Board members are employed by government agencies in both Canada and the United States, all members serve in their personal and professional capacities and not as representatives of their agencies, countries, or organizations. The proposals presented in this Work Plan were developed by ISRSB members and staff from government agencies they are employed by. The proposals adopted by the Study Board should not be considered as official opinions, positions, or commitments of any organizations, agencies, or departments named in this Work Plan.

3 Introduction to the International Souris River Study

The Souris River Basin is a 61,770 square kilometer (23,850 square mile) basin in the Provinces of Saskatchewan and Manitoba in Canada and the State of North Dakota in the United States (fig. 1). The Souris River originates in Saskatchewan, crosses the International Boundary into the United States and passes through the North Dakota, and then again crosses the International Boundary into Manitoba before joining the Assiniboine River. The Souris River is known locally in North Dakota as the Mouse River. The river valley is flat and shallow, and the basin's semi-arid prairie landscape has been extensively cultivated. Major reservoirs have been constructed in both Canada and the United States, including Boundary, Rafferty and Grant Devine (formerly Alameda) Reservoirs in Saskatchewan, and Lake Darling in North Dakota (fig. 1). The basin also includes a number of wildlife refuges and small impoundments along the North Dakota portion of the river.

The sharing and management of water across the International Boundary between Canada and the United States, including the Souris River Basin, has its origin in the Boundary Waters Treaty of 1909 between the two countries. The Treaty also established an International Joint Commission (IJC) to have jurisdiction over the use, obstruction, or diversion of the waters. Over the decades various binational boards have been established by the IJC to address the management of transboundary waters of the Souris River Basin and its major tributaries.

In May 1959, the International Joint Commission (IJC) officially approved and signed a directive that created the International Souris River Board of Control. In 2000, the IJC directed the International Souris-Red Rivers Engineering Board (1948 Reference) to transfer its responsibilities related to the Souris River to the International Souris River Board of Control. The IJC also changed the International Souris River Board of Control's name to the International Souris River Board (ISRB). The ISRB operated under an April 11, 2002 Directive until 2006 when the IJC changed the mandate to move to a more encompassing watershed approach. The new directive, dated January 18, 2007, sets out the duties of the ISRB as it moves toward a watershed approach. The ISRB operates under the 2007 Directive from the IJC and reports to the IJC annually. The ISRB is responsible to:

1. Oversee the implementation of compliance with the 2000 Interim Measures as Modified;
2. Assist the Commission with the Joint Water Quality Monitoring Program;
3. Perform an oversight function for flood operation;
4. Maintain an awareness of existing and proposed developments;
5. Report on aquatic ecosystem health issues in the watershed; and
6. Carry out other studies or activities the Commission may request.

Unprecedented flooding in the Souris River basin in 2011 focused attention on review of the Operating Plan contained in Annex A to the 1989 International Agreement. Interests in the basin asked that additional flood protection measures be evaluated, above and beyond what is currently provided under the International Agreement, and that the Operating Plan contained in Annex A

of the Agreement is reviewed. In addition, Article V of the Agreement requires that the Operating Plan be reviewed periodically to maximize the provision of flood control and water supply benefits that can be provided consistent with the terms of the Agreement. In light of both of these realities, the IJC's ISRB established the 2012 Souris River Basin Task Force at its February 22, 2012 meeting in Bismarck, North Dakota to conduct a review of the Annex A Operating Plan for presentation to the Governments of Canada and the United States. Subsequently, members from Federal, State, Provincial, and local agencies were appointed by the ISRB. The Task Force held its organizational conference call under its Terms of Reference from the ISRB on April 20, 2012. The ISRB reported to the IJC and the IJC reported to the Governments on the status of Task Force activities at the IJC Semi-Annual Meeting in October of 2012.

The first requirement of the Task Force (TOR) was to develop a Plan of Study (2013 POS) to conduct the review. The 2013 Plan of Study describes the detailed POS and studies that are needed to review the existing Annex A Operating Plan for the reservoirs comprising the Souris Basin Project described in the 1989 Agreement in Saskatchewan and North Dakota and to evaluate alternatives to maximize flood control and water supply benefits. The ISRB submitted the 2013 POS to the IJC in April 2013. The IJC submitted to governments a "Plan of Study: For the Review of the Operating Plan Contained in Annex A of the 1989 International Agreement Between the Government of Canada and the Government of the United States of America" on June 7, 2013. On July 5, 2017, the governments of Canada and the United States issued a reference for the IJC to undertake the Plan of Study. In accordance with Article IX of the Boundary Waters Treaty of 1909, the governments of Canada and the United States request that the IJC examine and report on flooding and water supply in the Souris River Basin, and coordinate the completion of the full scope of the 2013 "Plan of Study: For Review of the Operating Plan Contained in Annex A of the 1989 International Agreement Between the Government of Canada and the Government of the United States of America."

On September 5, 2017, the IJC issued a directive to establish and direct the International Souris River Study Board (Study Board) to examine and report to the IJC on matters raised by the Governments of Canada and the United States in the reference dated July 5, 2017. Accordingly, the IJC established the Study Board to aid the IJC in fulfilling the terms of the reference. Under item (1) of the Directive, the IJC directed the Study Board to develop a Work Plan by November 5, 2017. The Work Plan needed to include a detailed schedule and budget for the studies and tasks to be conducted. In the Work Plan, reference is made to links that contain supplemental information providing comprehensive information on membership of various Groups assisting the Study Board.

Considerable POS Project work was done by various agencies since 2013. The cost and time estimates provided in the Work Plan are based on assumptions that the work from the 2013 POS scope that has been completed in the interim, will be sufficient to meet the needs of the study and approved for use by the Study Board. In advance preparation for the reference, the International Souris River Board with IJC Liaisons recommended that the schedule for completing the entire study be increased from the two years proposed in the 2013 POS to three years in the 2017 reference. The additional year included time necessary for the IJC to form the Study Board on

the front end, and preparation time for submittal to the Governments at the back end and allowing some additional time for Task work in the Work Plan.

From October 11 to 13, 2017, the Study Board met at the United States Army Corps of Engineers Office in St. Paul, Minnesota, to discuss each item of the 2013 POS, the progress on each item outlined in the 2013 POS, and how the Work Plan should be formed in light of the work done to date. The current Work Plan was developed from the discussions at the St. Paul meeting as well as through subsequent discussions.

The purpose of this Work Plan is to describe all studies needed to assist the IJC in fulfilling the terms of the July 5, 2017 reference. The Work Plan also documents the actions taken to guide and direct the activities of the Study Board.

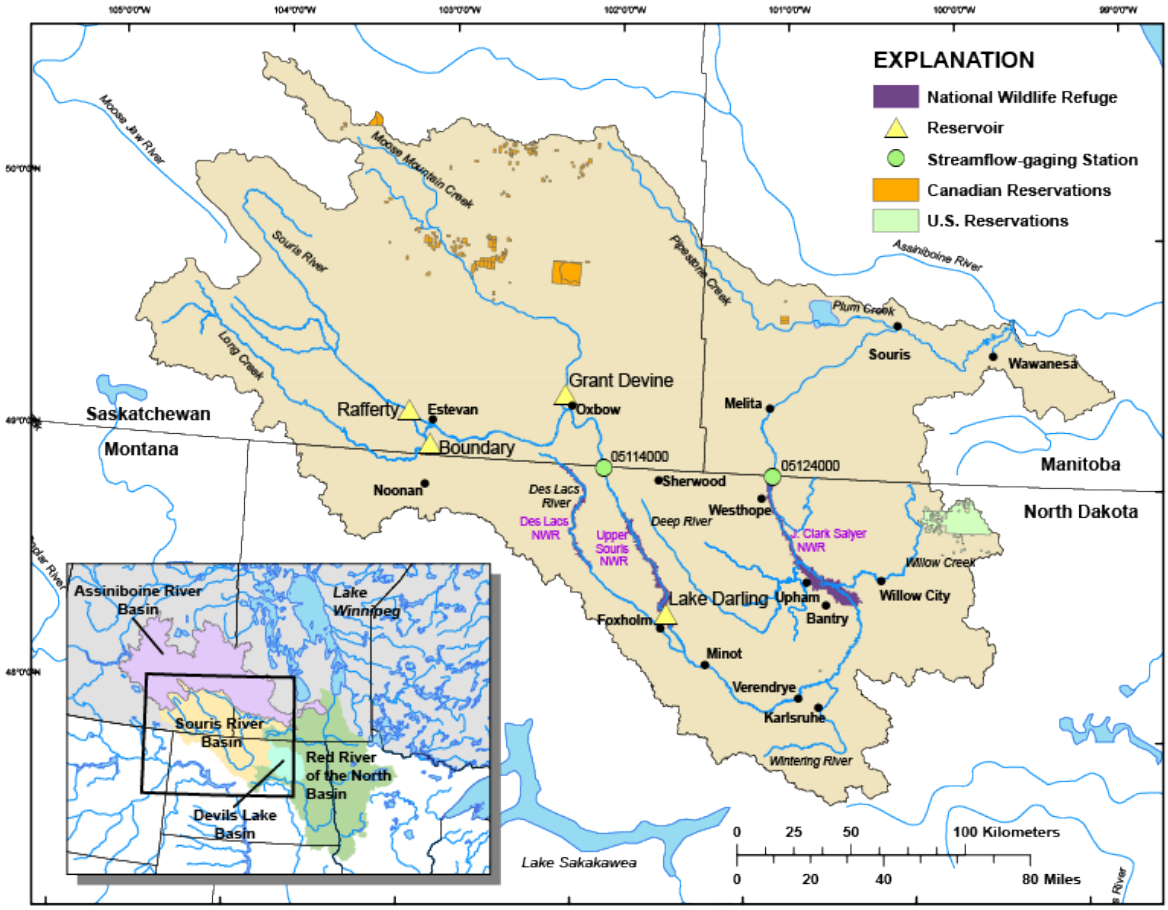

Figure 1. Souris River Basin showing locations of major reservoirs and National Wildlife Refuges and general direction of flow (From Kolars and others, 2015).

4 Organization of the study and governance structure

The detailed description of the study's governance structure is summarized below. Please refer to the cited organizations and program acronyms as needed.

- **Study Board**: The International Souris River Study Board is responsible for providing oversight to study activities and ensuring that study activities will meet the goals of the references and directives of the IJC's International Souris River Board Study. The Study Board and its advisory bodies will conduct their work by consensus. The IJC has appointed an equal number of members from Canada and the United States to the Study Board and named a member from both Canada and the United States to be the Co-chairs of the Study Board. The Co-chairs are jointly taking a leadership role in planning and implementing the Study Board's mandate. On behalf of the Board, the Co-chairs have authority and responsibility for the study.
- **Study Managers**: Two study managers, one from Canada and one from the United States, are responsible for assisting the Study Board on delivering its mandate. The Study Managers will work under the joint direction of the co-chairs of the Study Board and shall not be members of the Study Board but will participate in every Study Board meeting. The Study Managers will keep fully abreast of the work of the different groups and function as liaisons between the Study Board and those groups. The Study Managers will be responsible for the effective management of the Study Board's Work Plan. Study Managers are responsible for communicating to the different groups the direction of the Study Board and assisting in general administrative and financial/contractual tasks, including providing briefings to the Study Board on tasks identified by the Co-chairs.
- **Public Advisory Group (PAG):** The IJC, with advice from the Study Board, will establish a binational PAG by December 5, 2017. Members of the PAG will be appointed by the United States and Canadian IJC secretaries in consultation the IJC Liaisons and the Study Board. The PAG will include an equal number of members from each country representing key interests and geographic regions within the Souris River Basin. The PAG will help involve the public by bringing information from the Study Board to their various networks throughout the community, as well as bringing back views from the community for consideration by the Study Board. The PAG will assist the Study Board in the development of a Stakeholder Engagement Plan to be delivered by the Study Board to the IJC by December 5, 2017. This engagement plan is included as section 6 in this workplan.
  Co-Chairs, one from Canada and one from the United States, will direct the PAG as well as serve on the Study Board. The PAG is an advisory group and an important means of engaging the public in the study on an ongoing basis.
- **Climate Advisory Group (CAG):** The Study Board will establish a CAG once the Board is satisfied that the integrated modelling system, which will be used for plan formulation, is mature enough to accept climate change inputs.
- **Resource and Agency Advisory Group (RAAG):** The study board will establish the RAAG consisting of about 20 core members from Saskatchewan, Manitoba, and North Dakota, as well as federal agencies from Canada and the U.S. Members will serve as a conduit for agency and industry input on interests to the study process and for dissemination of study outcomes to the same groups. Members will represent agencies or industries, which:

    1. Have authority to alter flows;

2. Own infrastructure that control flows;
3. Have regulatory responsibilities for flows;
4. Administer water use permits;
5. Oversee floodplain development policies;
6. Or have a public service interest in how water is managed.

Co-Chairs, one from Canada and one from the United States, will direct the RAAG. The RAAG is an advisory group and an important means of engaging the public in the study on an ongoing basis.

- **First Nations, Metis and Tribes:** The Study Board is working with the PAG and IJC to contact potential First Nation and Tribes who may be interested in various aspects of the Work Plan. A work shop focused on Aboriginal Consultation with First Nations in Saskatchewan and Manitoba will be held in June 2018. The goal for the meeting is to establish engagement meetings to have meaningful dialogue with the Nations regarding the impact of flooding and water supply. In the United States, Study Board committee members have met with Scott Davis, Executive Director of the North Dakota Indian Affairs Commission to seek guidance on Tribal interest and the consultation process. In September 2018 the Study Board will send out a letter to all Tribal contacts Mr. Davis will provide to establish the Tribes interest in the Work Plan.
- **Independent Review Group (IRG)**: The IRG has been established by the IJC to ensure that independent technical reviews are carried out as required during the Study process.

The resulting Souris River Study Board governance structure is shown on figure 2.

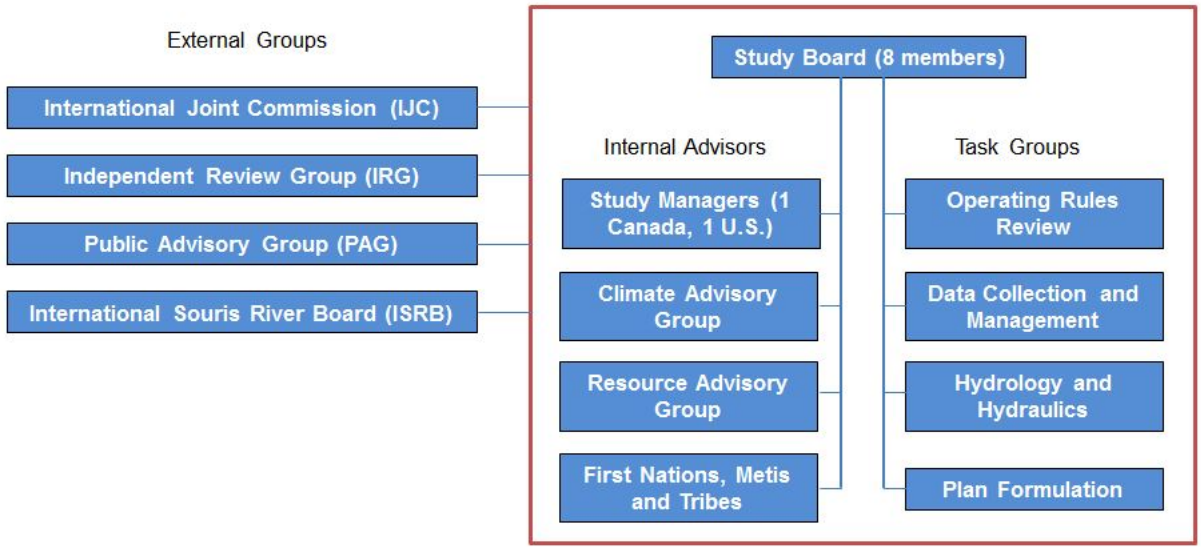

Figure 2 ISRSB Governance Structure. The ISRB, Study Board, PAG and IRG are creatures of the IJC. The red boundary illustrates the makeup and task groups of the ISRSB.

5 Plan to achieve the objectives of the study

Each element of the governments' joint reference will be addressed by the plan described in this document, which contains a number of tasks that are grouped under four broad activities:

a. Operating Rules Review
b. Data Collection and Management
c. Hydrology and Hydraulics
d. Plan Formulation

The operating rules review will identify areas where the language and text in Annex A of the 1989 Agreement can be improved for ease of understanding and clarity of interpretation. The data collection and management activities will include tasks to collect and harmonize the data necessary to support several hydraulic and hydrologic modelling tasks. Both of these efforts (Operating Rules Review and Data Collection and Management) are considered necessary in order to carry out the analysis tasks of the study formulated in the Hydrology and Hydraulics and Plan Formulation tasks. It is important to note that many of the analysis tasks in the Hydrology and Hydraulics and Plan Formulation activities can be carried out in parallel with the Operating Rules Review and Data Collection and Management activities of the Work Plan. The hydrology and hydraulics activities will setup the stochastic, hydrologic, hydraulic and reservoir modelling platforms to be used for testing and evaluating alternative operating scenarios. Throughout the study, public opinions, Government agencies and stakeholder perspectives will be sought to foster communication and participation at all levels on both sides of the border. The Study Board will monitor flood control and water-supply activities and studies being conducted by Federal, State, and Provincial agencies to avoid any duplication of effort. An overall schematic representation of the modeling process is outlined in Figure 3.

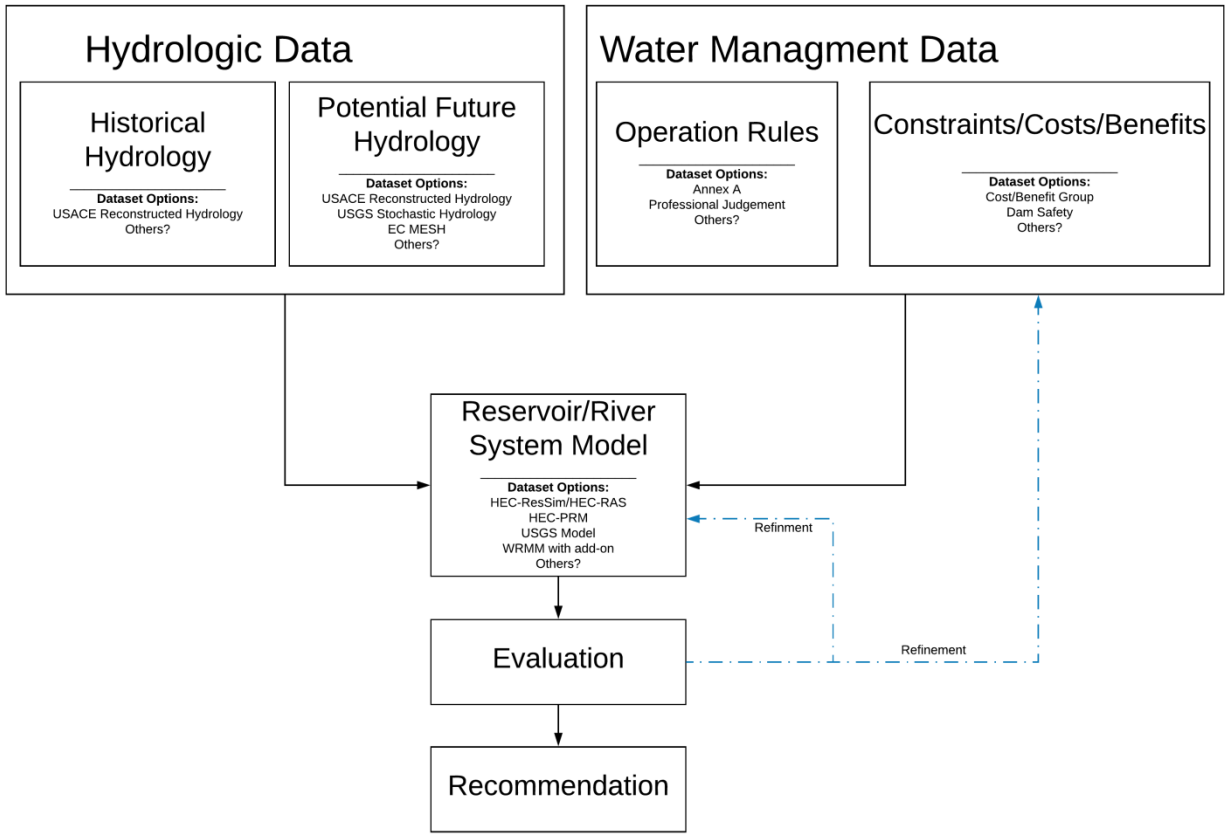

Figure 3. Connections between the various modelling components in the Work Plan.

The public is and will remain involved at strategic milestones of this study, notably through the efforts of the PAG, to obtain input and to register concerns regarding flooding and potential management and mitigation measures. The Study Board will engage the stakeholders through periodic public meetings during the duration of the study. At a minimum, the Study Board will hold public meetings at the same time as the ISRSB meetings held in February and June of each year through February 2020. Certainly, the Study Board will report out on how the comments and input received were used to arrive at final alternatives.

Our vision is to engage the public for input to the Study at the following times:

1. June 2018 ---Impacts and Benefits of River Stages and Flows
2. January 2019 --- Creating Alternatives, Balancing Impacts, and Perspectives on Modeling Results
3. September 2019 --- Perspectives on Detailed Study Results

The study Work Plan has been submitted to the IJC, and the Study Board has modified the Work Plan based on comments from the IJC. The Work Plan will be submitted to an IRG for third party review. The IRG will also be called upon to assess the quality of key developments and

publications throughout the study and to ensure scientific soundness. At about the same time the Work Plan is submitted to the IRG, the Work Plan will be submitted to the PAG for their input. Major comments from the IRG and PAG and responses will be provided at IJC website in the near future.

The following sections provide information on each of the study objectives. Each objective will state which Reference item it addresses, provide a description of the study objective, identify the lead and responsible individuals, and describe the scope of work under the objective. The scope of work entails a description of work tasks, which individuals will be performing that task, an estimated budget and timeline for completion. Each task is numbered and can be cross referenced in the summary table for that objective.

It is important to note that while some work has occurred during the intervening years of proposing the initial POS in 2013, and that those efforts may help reduce the amount of funds needed to address the remaining Tasks, that until those work elements are integrated with the other tasks to be developed it will not be known if they are sufficient as they stand or if additional work will be needed. This has potential implications for both cost and schedule for the study which are already reduced from the 2013 estimate. The cost and schedule presented in this Work Plan currently assumes that the work done since 2013 will be sufficient to meet the requirements of the succeeding tasks.

5.1 Operating Rules Review

This study objective directly addresses the Governments' Reference item 5: *A detailed review of the Operating Plan contained in Annex A of the 1989 Agreement.*

This objective consists of identifying areas where the language and text in Annex A of the 1989 Agreement can be improved for ease of understanding and interpretation. An ISRB Core Committee has submitted proposed modifications to Annex A to the ISRB. The operating plans for both flood control and water management ("normal operations") are given in "Annex A" and "Annex B" of the International Agreement. There is some cross-referencing in the Annexes.

Most of the preliminary work completed by the Core Committee, having been motivated by the experience of the 2011 flood were focused on "Annex A". The issue of water management (largely Annex B) will be addressed in the work of the Study Board.

The historical record and stochastic study indicate that the Basin is highly variable and cyclical. This means that both flood and drought conditions are important but that the transitions between wet and dry periods are also critical. The Study Board intends to use long period historical and stochastic data sets to identify optimal practices under all these conditions.

Although there is zero cost to the ISRSB for this task, it is included in the Work Plan because it directly relates to the mandate of the ISRSB.

Scope of Work:

Task OR1: 1989 Agreement Language Review

ISRSB leads: Rebecca Seal-Soileau (USACE), John Fahlman (WSA)

Technical lead: Elizabeth Nelsen (USACE)

Technical team: Jeff Woodward (WSA), Tim Fay (retired NDSWC), Scott Jutila (IJC), Ken Bottle (USFWS)

This task involves completing a draft document for the ISRSB and ISRB to review.

Subtasks:

	Task	Assigned to	Due Date/Timeline
1	Complete draft document	Tech. Team	December 31, 2017.
2	The ISRSB to review the draft document	ISRSB	January 31, 2018.
3	Present the document to the ISRB	ISRSB	February 21, 2018.

Timeline: December 2017-Febuary 2018

Est. Cost: $6K CAN, $0 US

Nominal cost to the Study Board budget. Work on this task has been almost completed and funded by Agencies who have members on the ISRB Core Committee. Some funding is required due to review needed by agencies participating in the study.

Resources: ISRB Core Committee

Predecessor: n/a

Successor: n/a

Review: ISRSB and ISRB to review.

5.2 Data Collection and Management

This study objective directly addresses the governments' Reference item 1: *The collection and harmonization of data necessary to support hydraulic and hydrologic modelling and associated studies.*

Within the topic of data collection and management, four broad classes of data are to be harmonized and made available to water-resource scientists and engineers working on various Work Plan tasks. In addition, the data will be available for use by anyone interested in the hydrological information. These are the physical data of the Souris River basin, reservoir elevation-storage-volume-outflow information, hydro-climatic and hydrometric network information, and bathymetric information of the river system. The study board has determined that much of this data has already been collected and, with the exception of a few gaps, mainly needs to be summarized for publication. As a result, the Data Collection and Management tasks are as follows. DW1 is to Summarize POS projects and report progress since 2013, DW2 is the collation and collection of bathymetry and LiDAR data for Rafferty and Grant Devine

Reservoirs, DW3 is a review of a Hydrometeorological Data Network Improvement Report, and DW4 is data collection for the Prescriptive Modelling System.

Scope of Work:

Task DW1: Summarize POS Projects and Report Progress since 2013

ISRSB lead: Gregg Wiche (retired USGS)

Technical lead: Gregg Wiche (retired USGS)

Technical team: Rebecca Seal-Soileau (USACE), Jeff Woodward (WSA), Bruce Davison (ECCC)

This task involves summarizing the available studies, datasets, and modelling setups that pertain to the POS as it stands today, and in relation to the 2013 POS optimal scope option. It will also strive to make any of these studies, datasets and modelling setups available to the ISRSB along with information to the public about what is available.

Subtasks:

	Task	Assigned to	Due Date/Timeline
1	Complete draft document	Gregg	May 1 - Jun 15, 2018
2	The ISRSB to review the draft document	ISRSB	Jun 15 – Sep 15, 2018
3	Document completion	Gregg	Sep 15 – 30, 2018
4	All information to be made available to the ISRSB	Gregg	Sep 30, 2018
5	ISRSB website to be updated with information about what is available	IJC Com. Staff	Oct 15, 2018

Timeline: May 2018 – October 2018

Est. Cost: $3K CAN, $0 US

The expectation is that the study managers will complete this task with the support of the ISRB and the ISRSB. Some funding is required due to review needed by agencies participating in the study.

Resources: POS Board

Predecessor: n/a

Successor: n/a

Review: Internal review by ISRSB.

Task DW2: Collation and collection of bathymetry and LiDAR data for Rafferty and Grant Devine Reservoirs

ISRSB leads: Jeff Woodward (WSA)

Technical lead: Cesar Perez-Valdivia (WSA)

Technical team: Chris Korkowski (NDSWC), ND Data Hub (Rob Baisler), USGS (Steve Shivers)

This task involves reviewing what bathymetry and LiDAR is available for Rafferty and Grant Devine reservoirs and collecting the data that is needed to complete the dataset as required for the plan formulation group. The plan formulation group will use existing bathymetry data sets to begin its model testing and will adjust as data is made available.

Subtasks:

	Task	Assigned to	Due Date/Timeline
1	**Data Gap Analysis**		
a)	Verify what data already exists (Include data needed for both RESSIM and RAS model in Saskatchewan)	SWSA staff	Nov 1 - Dec 31, 2017
b)	Collate existing data	SWSA staff	Nov 1 - Dec 31, 2017
c)	Buy-in from POS Board that existing data is sufficient.	SWSA staff	Feb 9, 2018
2	**Initiate Contracting**		
a)	Start the contracting process for remaining data needs	SWSA staff	Feb 15, 2018
3	**Executing the Contract**		
a)	Collecting LiDAR field data in the spring of 2018 before leaf-up	Contractor	May 1 – May 31, 2018
b)	Process Lidar and Bathymetry Data to produce capacity curves (part of contract)	SWSA staff	Jun 1 – Jun 30, 2018
c)	Final products received from contractor		Jun 30, 2018
4	**Receipt and Review of the Data**		
a)	Data and report to IJC and Study Managers.	Jeff Woodward	Aug 31, 2018

Timeline: November 2017- August 2018

Est. Cost: $75K CAN, $0 US

Canadian costs include $60,000 for LiDAR imagery and $15K for WSA staff time to manage the collection of the LiDAR imagery along with its analysis and reporting.

Resources: POS Board

Predecessor: n/a

Successor: HH6, and HH7

Review: USGS and/or the USACE to review contractor's work.

Task DW3: Review and Update of Hydrometeorological Data Network Improvement Report

ISRSB Contact: Al Pietroniro (ECCC)

Technical Lead: Rachel Weller (ECCC)

Technical Team: Holly Reckel (NWS), Cesar Perez-Valdivia (WSA), Bruce Davison (ECCC), Chris Korkowski (NDSWC)

, USACE (TBD), Jeff Woodward (WSA)

This task involves reviewing network upgrades since the *Souris River Basin Hydrometeorological Data Network Improvement Workshop Report* was published in 2013. The report evaluates the atmospheric and streamflow monitoring networks for water supply and flood forecasting. The recommendations in the 2013 report will be evaluated to determine if the identified network gaps have been covered by upgrades since the reports publication or if the gaps are still present. Many of the identified network gaps have data but it is not usable for flood forecasting.

Recommendations will be set forth for improvements to the hydrological and meteorological networks based on the 2013 report and work done since then. A presentation and report will be created outlining the recommendations.

Sub-tasks

	Task	Assigned to	Due Date/Timeline
1	Review existing report	Tech Team	Aug 1 – Sep 6, 2018
2	Identify upgrades to the Hydrometeorological Data Network since the 2013 report	Holly	Sep 6 – 7, 2018
3	Determine what is actually usable for flood forecasting	Holly	Sep 6 – 7, 2018
4	Identify Current Gaps in the observational Network	Holly	Sep 6 – 7, 2018
5	Catalogue alternative sources of data (Water Extent, SWE, Soil Moisture)	Rachel	Sep 6 – 7, 2018

6	Provide a report and presentation to the ISRSB on recommendations to improve the Hydrometeorological Data Network for the purposes of improving forecasting	Rachel	September 14th, 2018
7	Summarize existing datasets (CaPA, CaLDAS, evaporation, and transpiration) that are not included in the report.	Rachel	September 30th, 2018

Timeline: August 2018- September 2018

Est. Cost: $15K Can, $0 US.

Resources: ECCC and NCRFC

Predecessor: n/a

Successor: n/a

Review: IRG to review initial draft of report.

Task DW4: Data Collection for the Prescriptive Modelling System

ISRSB leads: Tim Fay (retired NDSWC)

Technical lead: Nate Anderson (USACE)

Technical team: Chris Korkowski (NDSWC), Rachel Weller (ECCC), Cesar Perez-Validivia (WSA), Mark Lee (MSD), Kacie Opat (USACE), Frank Durbian (USFWS)

This task involves collecting input data for the PRM model. HEC-ResPRM uses a modified form of network-flow programming to perform reservoir operations optimization. HEC-ResPRM "prescribes" optimal values of flow and storage over time by minimizing user-defined Performance Indicators at selected locations in the water resource network. Performance Indicators associate an impact or benefit with designated levels of flow or storage. HEC-ResPRM then optimizes the system using the Performance Indicators and the hydrology inputs.

Determining model simulation performance indicators will be a complex and iterative task. This effort will involve coordination between all agencies and using input from the RAAG, PAG, and official government agencies and other stakeholders. The goal is for Saskatchewan, North Dakota and Manitoba to independently develop performance indicator curves through a collaborative process using a uniform methodology.

These performance indicators will be used to evaluate how newly developed regulation options could impact all interests throughout the basin.

Sub-tasks:

	Task	**Assigned to**	**Due Date/Timeline**

1	**Data Gap Analysis**		
a	Verify what data already exists	Chris	Jun 1 – Jul 16, 2018
b	PAG, RAAG input scheduled to be received for use in Performance Indicator's	Rachel	RAAG Sept 30, 2018 PAG Nov 12, 2018
2	**Build Performance Indicators**		
a	Draft Performance Indicators	Tech Team	Jul 16 – Sep 30, 2018
b	Additional & Revised Performance Indicators	Tech Team	Oct 1, 2018 – Feb 28, 2019
i	Engaging PAG Input	Rachel	Oct 1, 2018 – Dec 31, 2018
ii	Webinars and workshops. (PF1)	PF1 Team	See PF1 Task
iii	Talking through the Performance Indicators in the January 2019 F2F	Nate	Jan 2019
iv	Follow-up discussions	TBD	TBD

Timeline: June 1, 2018 – January 2019

Est. Cost: $0 CAN, $85K US.

$85K for USACE.

Resources: ISRSB, PAG, RAAG

Predecessor: PF1

Successor: PF1, PF2, and HH8

Review: IRG

Notes:

5.3 Hydrology and Hydraulics

This study objective directly addresses the governments' Reference items 2, 3, and 4. Reference item 2: *The development of hydrological watershed runoff and inflow sequences to allow for the simulation of various water supply conditions including historical conditions, extreme conditions, and conditions influenced by the effects of climate change.* Item 3: *The development of hydraulic, hydrologic and optimization modelling tools that will allow for the accurate simulation of flows within the Souris River so that operational scenarios may be evaluated.* Item

4: *Studies evaluating the physical processes occurring in the Souris Basin which are thought to have contributed to recent flooding events.*

This section describes the work needed to setup the stochastic, hydrologic, hydraulic, and reservoir modelling platforms to use for the plan formulation piece. Task HH1 involves reconstructing the hydrology of the basin in order to have a frame of reference when considering supply sequences for operational review. Task HH2 involves providing a stochastic analysis and simulated data required for plan formulation. Task HH3 involves summarizing known information about artificial drainage in the Souris River Basin. Task HH4 involves developing additional tools and evaluating existing tools for flow forecasting. Task HH5 involves developing climate change scenarios using atmospheric General Circulation Model (GCM) and/or Regional Climate Model (RCM) climate change predictions as inputs to hydrologic models under various climate-change-induced land-change scenarios. Task HH6 involves updating the RES-SIM model with the Canadian reservoir data, along with calibrating the model for floods and droughts. Task HH7 involves updating the RAS model (including SK and ND) with any data SK finds and re-calibrating the model. Task HH8 involves developing a HEC-ResPRM model to be used in optimizing flow schemes in the basin. Task HH9 involves coupling the various models together to form integrated modelling systems.

Figure 4 illustrates how some of the models will fit together into an integrated modelling system. The hydrologic models will be used throughout the basin to predict how water moves from the land-surface to the rivers, and in the waterways not modelled by reservoir or hydraulic models. A hydraulic model will be used to more accurately predict the water flowing in the main stem of the Souris River, and the reservoir models will be used to predict the water fluxes in the four reservoirs indicated on the map (Rafferty, Boundary, Grant Devine and Lake Darling). These integrated models will be driven by inputs from the stochastic and climate models.

Figure 4 A map showing how the hydrologic, hydraulic and reservoir models fit together in their representation of the hydrology on the landscape**.**

Task HH1: Regional and Reconstructed Hydrology

ISRSB leads: Rebecca Seal-Soileau (USACE), Jeff Woodward (WSA)

Technical lead: Cesar Perez-Valdivia (WSA), Chanel Mueller (USACE)

Technical team: Dan Mielke (USACE), Rachel Weller (ECCC), Moges Mamo (ECCC), Mark Lee (MSD), Brett Hultgren (USACE), Garrett Blomstrand (USACE)

This task builds off of the analysis conducted in 2013 by the U.S. Army Corps of Engineers as part of the Regional and Reconstructed Hydrology of the Souris River. The daily flow datasets generated at critical locations in the basin as part of the 2013 analysis will be extended backward and forward to cover the period of record 1930-2016. Currently the data sets cover the period of record 1946-2011. These locations stretch from the reservoirs in the headwaters of the Souris River (Rafferty, Boundary, and Grant Devine Reservoirs) to the confluence of the Assiniboine River at Wawanesa, Manitoba.

This task updates datasets at the main stem and calculates local flows that are required to calibrate (i.e. 2001-2011) and validate (i.e. 2012-2016) the HEC-RESSIM for the Souris River. Once the model had been calibrated and validated the entire data set will be use to run the model and evaluate alternatives.

Sub-tasks:

	Task	Assigned to	Due Date/Timeline
1	Collate ISRB natural flow calculations	Rachel	Jun 1 – Aug 31, 2018
2	Compare and summarize the two approaches (ISRB natural flow and RRH)	Rachel	Sep 1 – Sep 30, 2018
3	Review and approve the reconstructed hydrology work from 1945 to 2011	ISRSB	Dec 1, 2017 – Feb 9, 2018
4	Extend reconstructed hydrology for the 1930-1945 period from the Canadian Reservoirs to Sherwood (Cesar)	Cesar	May 1 – Aug 31, 2018
5	Extend reconstructed hydrology for the 1930-1945 period from Sherwood to Westhope	Moges	Sep 1 – Dec 31, 2018
6	Extend reconstructed hydrology for the 1930-1945 period from Westhope to Wawanesa	Moges	Sep 1 – Dec 31, 2018
7	Extend reconstructed for the 2012-2017 period from the Canadian Reservoirs to Westhope	USACE	Aug 1 – Sep 30, 2018
8	Extend reconstructed hydrology for the 2010-2017 period from Westhope to Wawanesa	Moges	Sep 1 – Dec 31, 2018

9	Using the updated HEC-ResSim model update HH1 for 1930-2016 from reservoirs to Westhope	USACE	Feb 1, 2019 – Mar 31, 2019.

Timeline:

December 21, 2017 – February 28, 2019

Est. Cost: $44K CAN, $25K US.

Resources: USACE

Predecessor: N/A

Successor: PF2, and HH10

Review: USACE, ISRSB

Notes: USACE work will be reviewed using internal processes and compared to ECCC natural flow calculations. If appropriate, the ISRSB will sign-off on the work as being suitable for the POS.

Task HH2: Stochastic Hydrology Dataset

ISRSB leads: Gregg Wiche (USGS)

Technical lead: Angela Gregory (USGS)

Technical team: Skip Vecchia (USGS), Jeff Woodward (WSA), Tim Fay (retired NDSWC), Bruce Davison (ECCC), USACE (TBD)

This task builds off previous work that investigated possible future floods and droughts in the Souris River Basin. The work described in this task follows the stochastic model described in Kolars and others (2016; in review) by investigating the impacts of climate change on unregulated and regulated flows and investigating the impact of reservoir operations changes on floods and droughts. The USGS currently has a Joint Funding Agreement with the ND State Water Commission to complete the stochastic hydrology tasks for the International Joint Commission's Souris River Plan of Study. This project will provide the stochastic analysis and simulated data required for completing HH 9 and PF2 of the draft Souris River Plan of Study (SRPOS). Specific tasks to be completed are described below:

Sub-tasks:

	Task	**Assigned to**	**Due Date/Timeline**
1	Generate stochastic traces of future climatic inputs and natural (unregulated) runoff and generate a published data release.	Angela	October-December 2018

2	Evaluate the effects of climate change including coordination with Climate Advisory Group and U.S. Army Corps of Engineers on climate change criteria, generating traces with climate change effects, and scenario selection for other models.	Angela	September-April 2019
3	Provide stochastic inputs for other tasks including scenario selection in coordination with other groups, data disaggregation to daily time steps for other models, and extending the regulated model from Minot to Westhope to evaluate input scenarios.	Angela	September, 2018 – April 2019
4	Evaluate the effects of reservoir operation changes on severe floods, droughts, and climate change effects. This task includes the modification of regulated stochastic model to include optimized reservoir operations, evaluation of scenarios and future runoff, and statistical evaluation for comparisons of unregulated flow, current operations, operational alternatives, and scenarios.	Angela	March-October 2019
5	Analysis and generation of a report documenting the model methodology, stochastic datasets, and results.	Angela	January-December 2019

Timeline:

October 2018-December 2019

Est. Cost: $6K CAN, $185K US.

Canadian costs are for review of the work and US costs are broken down as follows:

Task 1: $30,000 Task 2: $30,000

Task 3: $45,000 Task 4: $50,000 Review of approach: November-December 2019

Task 5: $30,000

Resources: None.

Predecessor: N/A

Successor: HH5, HH6, HH8, and HH9

Review: USGS (internal), USACE, ECCC, SWSA, IRG

Notes:

References:

Kolars, K.A., Vecchia, A.V., and Ryberg, K.R., 2016, Stochastic model for simulating Souris River Basin precipitation, evapotranspiration, and natural streamflow: U.S. Geological Survey Scientific Investigations Report 2015–5185, 55 p., http://dx.doi.org/10.3133/sir20155185.

Kolars, K.A. and Vecchia, A.V., (In Review), Stochastic Model for Simulating Souris River Basin Regulated Streamflow Upstream from Minot, North Dakota: U.S. Geological Survey Scientific Investigations Report.

Task HH3: Artificial Drainage Impacts Review

ISRSB leads: Mark Lee (MSD)

Technical lead: Mark Lee (MSD)

Technical team: Doug Johnson (SWSA), Aaron Carranza (NDSWC), Consultant (TBD)

This task involves summarizing known information about artificial drainage in the Souris River Basin. It is expected that this will be an important issue on the minds of the public. Most of the public's questions around drainage relate to the flow of water between Saskatchewan and Manitoba, but there are some potential questions that may arise for the ISRSB. To gain a better understanding of the impacts of artificial drainage in the basin on trans-boundary flow, a review of the existing literature, historical aspects and the current state of drainage will help to illuminate these questions and provide information to the public.

Sub-tasks:

	Task	Assigned to	Due Date/Timeline
1	Review of drainage legislation and practices in the Souris River Basin	Consultant	Sep 1 – 30, 2018
2	Review of artificial drainage science	Consultant	Sep 1 – Nov 30, 2018
3	Quantification of drainage in the Souris River Basin	Consultant	Oct 1 – Dec 31, 2018
4	Determine the potential influence artificial drainage has on trans-boundary flows	Consultant	Dec 1 – 31, 2018
5	Report Preparation	Consultant	Jan 1 – 31, 2019
6	Preparation of text for public fact sheet	Consultant	Jan 1 – 31, 2019
7	Presentation of information to International Souris River Study Board	Consultant	Feb 15, 2019

Timeline: September 2018 – February 2019

Est. Cost: $43K CAN, $0 US.

Resources: IJC Communications

Predecessor: n/a

Successor: n/a

Review: POS Board, PAG, IRG

Notes: The ISRSB should probably begin this before May 2018. Plus it may take more time to complete.

HH4-Flow Simulation Tools Development (MESH)

ISRSB leads: Bruce Davison (ECCC)

Technical lead: Moges Mamo (ECCC)

Technical team: Kamrul Hossain (WSA)

This task involves developing a MESH model so that it can provide simulated streamflow inputs to RESSIM. The MESH model is a coupled land-surface and hydrological model developed by Environment and Climate Change Canada. The database for the Souris River basin was built using digital elevation map (DEM) and land cover data (LC). Meteorological data extracted from the Canadian Numerical Weather Prediction Model (Global Environmental Multi-scale: GEM) and Canadian Precipitation Analysis (CaPA) are used to force the model.

MESH will be calibrated and validated from 2002 to 2016 so that it is ready to be used for downscaled climate model output to provide RESSIM with alternative climate change scenarios. Model calibration and validation will be set as follows:

April 1st 2002 – March 31st 2003 spin up period
April 1st 2007 – March 31st 2013 Calibration period
April 1st 2003 – March 31st 2007 and April 1st 2013 – December 31st 2016 validation period

In addition, there will be spatial validation in some sub basins. Once the calibration is completed and validated, comparison of streamflow with reconstructed streamflow will be completed.

Sub tasks:

	Task	Assigned to	Due Date/Timeline
1	Setup the model and perform an initial uncalibrated MESH run for the basin	Moges	Jan 1 – May 1, 2018
2	Generate input DSS files for RESSIM	Moges	Aug 1 – 31, 2018
3	Calibrate and Validate MESH from 2002 to 2016	Moges	Aug 1 – Oct

			15, 2018
4	Compare MESH streamflow with reconstructed hydrology streamflow	Moges	Oct 15 – 18, 2018
5	Run MESH with chosen climate change scenarios (recalibrate if needed)	Moges	Nov 30, 2018 – Feb 28, 2019

Timeline: January 2018- February 2019

Est. Cost: $76K CAN, $0 US.

Resources: ECCC, GWF, USGS

Predecessor: WFDEI and bias-corrected WFDEI testing

Successor: HH5, and HH9

Review: ECCC, ISRSB, IRG

Task HH5: ECCC Climate Change Supplies

ISRSB leads: Al Pietroniro (ECCC)

Technical lead: Bruce Davison (ECCC)

Technical team: Moges Mamo (ECCC), Angela Gregory (USGS), Cesar Perez-Valdivia (WSA), Chanel Mueller (USACE), CAG

This task involves developing climate change scenarios using atmospheric General Circulation Model (GCM) and/or Regional Climate Model (RCM) climate change predictions as inputs to hydrologic models under various climate-change-induced land-change scenarios.

Sub-tasks:

	Task	**Assigned to**	**Due Date/Timeline**
1	Determine appropriate GCM/RCM model output scenarios to use.	CAG	Oct 22 – Nov 30, 2018
2	Run MESH and analyze current operating plan and scenarios with climate model outputs.	Moges	Feb 28 – Oct 31, 2019

Timeline: October 22, 2018 – May 31, 2019.

Est. Cost: $47K CAN, $5K US.

Resources: Climate Change Advisory Group

Predecessor: HH2, HH4, and HH9

Successor: PF2

Review: Climate Advisory Group, ISRSB, IRG

Notes:

Task HH6: Reservoir Flow Release Planning (HEC-RESSIM)

ISRSB leads: Tim Fay (retired NDSWC), Rebecca Seal-Soileau (USACE)

Technical lead: Mitch Weier (USACE)

Technical team: Cesar Perez-Valdivia (WSA), Rachel Weller (ECCC), Moges Mamo (ECCC), Garrett Blomstrand (USACE)

This task involves updating an existing ResSim model with additional detail for evaluation of a range of operating scenarios including periods of both drought and flood. The ResSim model used in the Study will be based on two existing ResSim models that were developed as part of the ISRB's 2013 Regional and Reconstructed Hydrology effort and the 2017 USACE Feasibility Study.

The existing ResSim models were sufficiently detailed for their intended purpose, but additional detail is required to allow for evaluation of operating plans. Specifically, more refinement is needed to allow for apportionment releases during low flow periods and to allow for variable reservoir drawdown curves based on forecasts during times of flood.

The ISRB Hydrology Committee calculates the ratio of unregulated and regulated accumulated volume at Sherwood throughout the year. Saskatchewan is required to provide either 40% or 50% of the natural flow volume as measured at the border crossing near Sherwood, ND by the 1989 Agreement and Annex B. This apportionment is important during low flow years when water supplies are limited. This apportionment calculation involves many steps and will be approximated within the ResSim model to mimic apportionment releases from Canadian reservoirs during low flow periods to the extent practical.

Because reservoir drawdowns are a function of forecasted inflow during flood years within Annex A, some uncertainty and error must be added to the reservoir inflow inputs to allow for comparison to other operating scenarios. Accounting for the uncertainty that exists within forecasts will be completed as part of task HH10 (Forecasting Assessment).

Additional refinements to the existing model include improving routing, improving evaporative loss accounting, allowing the Boundary Diversion to divert water back and forth between reservoirs, releases from Lake Darling for J. Clark Salyer National Wildlife Refuge, and adding in major diversions and consumptive uses.

Calibration and verification of the model will be challenging because of the lack of historical operation. The reservoirs have only been in operation as a system since 1999 and fully operational for even less time. Some years deviations have been granted for reasons such as pending litigation. The model will be calibrated with data from the year 2000 through 2011 and verified with data from 2012 through 2016.

Sub-tasks:

	Task	Assigned to	Due Date/Timeline
1	Merging the upper and lower existing ResSim models into one continuous model.	USACE	June 15 – June 30, 2018
2	Include apportionment flow split that is detailed in Annex B and include major diversions and consumptive water use to better represent the ISRB apportionment calculation.	USACE	June 15 – September 15, 2018
3	Dynamic reservoir drawdown based on "forecast" datasets detailed in Annex A.	USACE	August 15 – October 31, 2018
4	Update and refine parameters	USACE	July 15 – October 31, 2018
5	USACE initial calibration	USACE	September 1, 2018 – October 31, 2018
6	Manual Calibration of RESSIM to Westhope from 2000 to 2011 (jointly between USACE, WSA, ECCC)	USACE/WSA/ECCC	November 1, 2018 – December 7, 2018
7	Validate RESSIM from 2011 to 2016 to Westhope	USACE/WSA/ECCC	November 1, 2018 – December 7, 2018
8	District Quality Control (DQC) Comment period of final model	USACE	December 10 – 21, 2018
9	Respond to DQC comments	USACE/WSA	January 2-11, 2019
10	Comments Back Check Complete – model ready to run alternatives:	USACE/WSA	January 14-25, 2019
11	Agency Technical Review	USACE/WSA	Jan 28- Mar 8, 2019

Timeline: June 2018-March 2019.

Est. Cost: $64K CAN, $65K US.

USACE cost estimate $65,000.

Resources: USACE

Predecessor: DW2, HH2, and HH10

Successor: HH9, and PF2

Review: USACE, ISRSB

Notes:

Data needs

- Relationship of forecasted runoff to observed runoff to add uncertainty in model drawdowns

Task HH7: Reservoir Flow Release Planning (HEC-RAS)

ISRB Point of Contact: Tim Fay (retired NDSWC)

Technical Lead: Michelle Larson (USACE)

Technical Team: Jeff Krut [MB], Cesar Perez-Valdivia (WSA) [SK], Chris Korkowski (NDSWC) [ND].

This task involves updating the HEC-RAS models in Saskatchewan, North Dakota, and Manitoba. Each province/state's unsteady-state hydraulic model using HEC-RAS.

Earlier models of Saskatchewan (2012) and North Dakota (2012-2016) portions of the model were previously combined in 2016-2017 to provide a continuous model for forecast and routing of flows from the Rafferty and Grant Devine Reservoirs to Lake Darling and downstream to the North Dakota / Manitoba border near Westhope, ND.

SK: The Water Security Agency in partnership with SaskPower is currently having Barr Engineering update the Saskatchewan portion of the Souris River model using newly acquired LiDAR data (May 2018), some new cross section survey data, new bridge information, and using an improved version of the HEC-RAS software. Survey data was collected during June 2018 for downstream of Rafferty Dam, Long Creek, and Moose Mountain Creek. The model is a one-dimensional unsteady-state hydraulic model. The use of a two-dimensional flow area may be added in the area where Long Creek and the Souris River come together near Estevan. This updated version of the model now includes Moose Mountain Creek downstream of the Grant Devine Reservoir. In the existing version of the model Moose Mountain Creek was included as an inflow point. The geometry was provided to USACE August 15th to be included into the updated HEC-RAS model. The final updated model of the Souris River in Saskatchewan is expected to be completed by November 15, 2018.

USACE: The HEC-RAS model in North Dakota has been updated several times since the 2011 flood using newer LiDAR data, updated channel survey data, and new bridge plans. The most recent update included merging a previous HEC-RAS model by USACE in the Lake Darling to Logan, ND reach with a full model of the Mouse (Souris) River in North Dakota by Barr Engineering (contracted with NDSWC) and updated channel survey data that was completed in January 2017.

The current effort by USACE is being done for a Corps of Engineers Water Management System Study (CWMS). The HEC-RAS modeling will include the last of the updated channel survey data from upstream of Lake Darling, updating the overbank geometry using the updated Ward County LiDAR data (available in Feb. 2018), two-dimensional flow modeling of the confluence

of the Des Lacs River with the Souris (Mouse) River near Burlington, ND, general model improvements and merging in the updated Saskatchewan portion of the model.

The CWMS project schedule has a geometry data review in early October 2018. The calibration of the full model from downstream of Rafferty and Grant Devine Reservoirs on the Souris River and Des Lacs National Wildlife Refuge on the Des Lacs River to the North Dakota / Manitoba border near Westhope is scheduled to be complete in June 2019.

MB: – Manitoba's one-dimensional hydrodynamic HEC-RAS model was completed in 2018. The model extends from the Canada/US border to the confluence with the Assiniboine River, a distance of approximately 273 km. Cross sectional surveys were completed in 2014 (142 cross sections) and 2017 (152 cross sections) and LiDAR data was captured in 2014. The model also includes a portion of Plum Creek, a tributary near the town of Souris, MB where 48 cross sections were collected in 2017. Six overflow weir structures and 26 bridge crossings are included in the model. Most of the bridges are road and rail crossings with intact deck and piers. However, some of the bridges have either failed or have been decommissioned with only the piers remaining in the river. The model was calibrated to the 2011 and 2014 flood events and then verified to the 1976 and 2017 events. The model has been run for the estimated 200- and 300-year flood events and the inundation mapping is currently underway.

Sub-tasks:

SK: The Water Security Agency has provided Barr the following information:

- Existing un-steady state HEC-RAS model with all its documentation
- Steady state HEC-RAS model for Moose Mountain Creek
- New survey data for downstream of Rafferty dam, Long Creek, and Moose Mountain creek previous consultation with Barr.
- Bridge drawings for the bridges that were replaced after 2011
- Aerial imagery from the 2011 flood event
- Outflows from all three reservoirs for the calibration and validation
- Inflow hydrographs for the gauged and ungauged areas below the reservoirs
- River stages along the Souris River for high and low flows

The Water Security Agency will review and provide comments on the draft and final versions of the model that will be submitted by Barr Engineering.

USACE: Through the CWMS study, model updates will be completed and the Saskatchewan model will be incorporated into the North Dakota model and calibration completed. Through Plan of Study there will be ongoing coordination with Saskatchewan and Manitoba regarding modeling practices, assumptions, data sources, and hand-off points. Coordinate with Tasks HH1 and HH2 regarding input data and scenarios to be modeled. Coordinate with RES-SIM to verify routings.

MB: Modeling is complete.

	Task	Assigned to	Due Date/Timeline
1	Creating a new HEC-RAS model using updated	WSA	June 15 – November

	LiDAR, channel surveys and bridges		30, 2018
2	Update and improve an HEC-RAS model using updated LiDAR and limited channel surveys. Includes incorporating Saskatchewan model for a continuous model through SK and ND.	USACE	June 15, 2018 – June 15, 2019
3	Update and improve the HEC-RAS model in Manitoba	MB	June 15, 2018 – October 31, 2018
4	Perform model runs as needed using the draft or final HEC-RAS model from USACE to evaluate alternatives.	ND	March 1, 2019- September 30, 2019

Timeline: March 2018-September 2019

Est. Cost: $3K CAN, $16K US.

USACE cost estimate $16,000

Resources:

Predecessor: DW2

Successor: HH9, and PF2

Review: Internal Agency Reviews

Task HH8: Develop PRM Model

ISRSB leads: Tim Fay (retired NDSWC)

Technical lead: Nate Anderson (USACE)

Technical team: Cesar Perez-Valdivia (WSA), Mark Lee (MSD), Beth Faber (USACE-HEC), Sara O'Connell (USACE-HEC), Chris Korkowski (NDSWC)

This task involves developing a HEC-ResPRM model to be used in optimizing flow schemes in the basin. The objectives currently being optimized in PRM are: Water Supply and Flood Control.

Apportionment was intended to be a third HEC-ResPRM input function. Issues with input format and software capabilities have forced reconsideration of the best way to implement apportionment in the optimization and in the study as a whole.

Sub-tasks: Build the PRM model. Calibrate the model. Run single objective scenarios. Run paired objective scenarios. Review and analyze results. Balanced model runs. Model results implementation guidance. Documentation production.

Phase	**Task**	**Assigned to**	**Due Date/Timeline**

1	**Pilot Model**		Jul 2018 - Complete
a	Assemble data and develop basic Souris HEC-ResPRM model	Anderson / O'Connell	
b	Run model with basic draft objective functions	O'Connell	
c	Review and document results in presentation for Pilot model	O'Connell	
2	**PRM Model**		Sep 1 - Nov 15 2018
a	Add Performance Indicators for the Objectives to PRM model	Sara O'Connell	
b	Run single-objective model scenarios	Sara O'Connell	
c	Run paired-objective model scenarios	Anderson/ O'Connell	
d	Review and Analyze results	HH8 Team	
e	Model Documentation	Sara O'Connell	
5	**Potential to add additional Performance Indicators**	Anderson/ O'Connell	Feb 2019 – TBD

Timeline: April 2018 - February 2019

Est. Cost: $4K CAN, $72K US

Phase 1 = $22,000. Phase 2 = $50,000. Phase 5 = estimate $20,000/ Indicator added

Resources: USACE

Predecessor: DW4, HH2, and HH10

Successor: HH9, PF2, and PF3

Review: USACE, ISRSB

Task HH9: Model System Integration

ISRSB leads: Al Pietroniro (ECCC) and Michael Bart (USACE)

Technical lead: Bruce Davison (ECCC)

Technical team: Tim Fay (retired NDSWC), Mitch Weier (USACE), Cesar Perez-Valdivia (WSA), Angela Gregory (USGS), Moges Mamo (ECCC)

This task involves coupling RES-SIM and RAS models in a CWMS or WAT model on the US side and coupling MESH with RAS on the Canadian side.

Sub-tasks:

	Task	Assigned to	Due Date/Timeline
1	MESH and RESSIM model coupling with DSS files	Moges	August 1, 2018 – September 30, 2018
2	Stochastic hydrology and RESSIM coupling with DSS files	Angela	September 1, 2018 – April 30, 2019

Timeline: September 2018- April 2019

Est. Cost: $28K CAN, $0K US.

Resources: ECCC, USACE

Predecessor: HH2, HH4, HH6, HH7 (US), and HH10

Successor: PF2, and HH5

Review: ECCC, USACE, ISRSB

Notes:

Task HH10: Forecasting Assessment

ISRSB Point of Contact: Jeff Woodward (SWSA)

Technical Lead: Curtis Hallborg (SWSA)

Technical Team: Laura Diamond (NWS), Cesar Perez-Valdivia (SWSA), Mitch Weier (USACE), TBD (Canadian)

The current operating plan, contained in Annex A of the 1989 Canada-US Agreement on Water Supply and Flood Control in the Souris River Basin, relies heavily on forecasting for the management of the system. Forecasts of the Sherwood Local and Sherwood Unregulated 30-day, 50% probability of exceedance volumes are used to determine if flood operations will be initiated and the 90-day, 90% probability of exceedance inflow volumes at the Canadian Reservoirs (Boundary, Rafferty, and Grant Devine) are used to determine reservoir drawdown requirements for snowmelt runoff events. The first forecast for the system is issued on February 1, typically two months in advance of the start of runoff and just past the mid-point of the snow accumulation season, to allow for the completion of any drawdown requirements prior to the start of the spring melt. Subsequent forecasts are issued on or near the 15th and last day of each

month up to the start of runoff. Every forecast has some level of uncertainty associated with it and there is typically some error/difference between the forecasted value and the true/observed value. Due to the need for forecasts to be issued months in advance, there is a greater amount of uncertainty since the rate of snowpack accumulation, timing of melt, and melt rate are all highly variable – not to mention the complex and challenging prairie pothole hydrology of the basin.

It is anticipated that forecasting will also play a key role in the Study's plan formulation and simulation tasks. Since there will always be some error in the forecasts, it would be imprudent to assume "perfect" forecasts during these simulations. This task will examine the errors associated with the forecasts at the key forecast points/durations noted above for the period 2009-2018. Beginning in 2009, the Saskatchewan Water Security Agency (SWSA) began coordinating with the US National Weather Service (NWS) on these forecasts, with the final values often being the average of the two forecasts. Therefore, to preserve homogeneity, the period for this assessment is being limited to the 10 year period between 2009 and 2018. This offers a mix of high and low runoff events. The observed/true runoff volumes will be extracted from the Regional and Reconstructed Hydrology (Study Task HH1) for the period 2009-2016 and estimated using the same methods for 2017-18. Statistical analysis will then be completed on the dataset to examine forecast skill at each location over time. The ultimate deliverable from this task will be a method/tool that could be employed to introduce forecast error, which would mimic the statistics of the observed forecast errors, at the plan simulation phase of the Study. Each jurisdiction has its own forecasting processes and models in place, and it is likely that will still be the case at the conclusion of this study. Good coordination takes place through the ISRB's Flow Forecasting Liaison Committee, and this study will only help to strengthen the ties between jurisdictions and their modelling capabilities. The Study Board may recommend changes to the exiting coordinating structure depending on its findings.

If time and resources allow, there are four other areas that the Technical Team is interested in investigating. The first is a quantitative index of basin moisture conditions that could be used in operational decision making at the reservoirs. Within the prairie pothole region, antecedent conditions, particularly storage available in wetlands and soil moisture conditions play a large role in runoff yields. When conditions are wet and wetland areas are at or near capacity, infiltration rates are diminished and the contributing drainage area increases resulting in higher runoff yields. In practice, this index could be used to bias reservoir operating decisions towards water supply security when conditions are dry and towards flood protection when conditions are wet. The Antecedent Precipitation Index (API) used by the Province of Manitoba could be examined for this purpose. The second area of interest is in assessing the forecasting skill of the U.S. National Water Model (NWM) and comparing it with the operational model used by the NWS's North Central River Forecast Center. It is expected that the NWM will not perform well in this basin due to the complex hydrological processes in the watershed, but a formal analysis would be useful. The third area of interest for the Team is examining the reliability/skill of both American and Canadian Quantitative Precipitation Forecasts (QPF). Currently, since there is a perceived lack of skill in numerical weather prediction models to accurately predict the placement and accumulations for rainfall events, reservoir operations in the basin are based on rain on the ground. Operating based on a forecast could have negative implications on the security of the water supply if the event does not develop as forecasted. If it were demonstrated that these models are reliable, additional flood protection could be provided by evacuating water

in advance of extreme rainfall events. The final area of interest is in evaluating the impact of incorporating more precipitation data into the Canadian Precipitation Analysis (CaPA) product. Some of the data that is available (e.g. WIN) to the SWSA is not ingested into CaPA and it is worth examining how much CaPA is impacted by incorporating such data.

The sub-tasks, timeline, estimated costs, resources, predecessors, and successors noted below are for the forecast error assessment task only. Additional time and resources will be needed if further investigations are undertaken by the team. The three additional areas of interest, which are not currently resourced, are listed in separate tables but sub-tasks have not yet been defined at this time.

Sub-tasks:

	Task	**Assigned to**	**Due Date/Timeline**
1	Assemble historical forecast values (2009-2018) for the 90-day, 90% inflow volumes to the Canadian Reservoirs and the 30-day, 50% Sherwood Local and Sherwood Unregulated volumes.	SWSA – K. Euteneier	August 24, 2018
2	Extracted estimates of the observed volumes from the Regional and Reconstructed Hydrology (HH1) for the period 2009-2016.	SWSA – C. Perez-Valdivia	August 24, 2018
3	WSA will estimate observed volumes for 2017 and 2018 using the same methods as used in HH1.	SWSA – C. Perez-Valdivia	August 24, 2018
4	Assess forecast skill of the U.S. NWM and NOAA operational model.	NWS	TBD
5	Complete an analysis of the errors associated with the forecasts.	SWSA – A. Chowdhury	August 24 – September 28, 2018
6	Develop a method to incorporate forecast uncertainty/error into the simulation process.	Technical Team	September 28 – October 19, 2018
7	Document the process, findings, and recommendations.	SWSA – K. Euteneier	October 19 – October 31, 2018

	Task	**Assigned to**	**Due Date/Timeline**
1	Assess forecast skill of the U.S. NWM and NOAA operational model.	TBD	TBD

	Task	**Assigned**	**Due**

		to	Date/Timeline
1	Assess the QPF forecasting skill of Canadian and US numerical weather prediction models in the basin.	TBD	TBD

	Task	Assigned to	Due Date/Timeline
1	Assessment/development of a quantitative index of basin moisture conditions	TBD	TBD

	Task	Assigned to	Due Date/Timeline
1	Incorporating more precipitation data into CaPA	TBD	TBD

Timeline: August 2018- October 2018.

Est. Cost: $175K CAN, $0K US.

Resources: Primarily SWSA staff time

Predecessor: HH1

Successor: HH6, HH8, HH9, and PF2

Review: USACE, NWS, ECCC

Notes:

Data needs

- Historical Souris River Basin Forecasts within SWSA files.
- Estimates of observed runoff volumes from the Regional and Reconstructed Hydrology

5.4 Plan Formulation

This study objective directly addresses the governments' Reference items 6 through 10. Reference item 6: *Identifying and, as appropriate, making recommendations regarding improvements to the Operating Plan contained in Annex A of the 1989 Agreement to reduce the flooding and water supply risks in the Souris River basin with consideration to low flow, apportionment, water quality and aquatic ecosystem health.* Item 7: *The evaluation, on a qualitative and quantitative basis, of the costs and benefits of a range of possible infrastructure and operational plans regarding flooding and water supply in the Souris River basin.* Item 8: *The evaluation of additional flood protection measures, beyond what is currently provided under the 1989 Agreement, which may include feasibility evaluations of increasing storage at existing dams, more efficient channel alignment and capacity, and the provision of flood control measures in and around communities within the basin.* Item 9: *Assessing possible adaptation strategies to address the potential future variability in water supplies associated with climate change.* Item 10: *Facilitating collaboration among various Federal, State, Provincial, local*

agencies, the public, as well as Native American Tribes, First Nations, and Métis located within the basin to share their views and provide input during the study process.

The core of the work and the central focus of the Operating Plan review are captured in this section. The current operations are based on the 1989 Agreement and the essential elements are captured in Annex 'A'. The purpose of this section is to explore what tools are available to carry out a structured approach in meeting the intents of the Task Force, ISRB and 1989 Agreement, while satisfying the needs of the original stakeholders identified in the Agreement and the emerging stressors on the system. Task PF1 involves hosting one or more workshops for key stakeholder representatives to determine their goals and objectives throughout the basin. Task PF2 involves developing and evaluating trial operational plans using the modelling systems and model inputs developed in earlier tasks. Task PF3 involves evaluating the safety of dam operations given new concerns resulting from the 2011 flooding. Task PF4 involves developing a roadmap to provide guidance for how the study products, particularly the integrated modelling system, could be altered and used in the future to address water quality and aquatic ecosystem health concerns. However, a key point for the overall study is that the goal is **not to build a tool** to manage reservoir operations, but rather **to build a plan** to manage reservoir operations.

Task PF1: Workshops and Engagement

ISRSB leads: Rebecca Seal-Soileau (USACE), Jeff Woodward (WSA)

Technical lead: Rebecca Seal-Soileau (USACE)

Technical team: Liz Nelson (USACE), Cesar Perez-Valdivia (WSA), Nate Anderson (USACE), Chris Korkowski (NDSWC)

PAG input: David O'Connell (PAG U.S Co-Chair), Debbie McMechan (PAG Canadian Co-Chair)

This task involves hosting a workshop (or series of workshops) of key stakeholder representatives to determine the goals and objectives of the stakeholders throughout the Souris River Basin. The key features that are needed for each of the identified reservoirs, river reaches and key locations throughout the basin are:

a) Each stakeholder group should provide their goals and objectives clearly;
b) The ISRSB will convert stakeholder goals into specific reservoir operation parameters (a function of storage, release, or flow) or other flow/stage variable for the river; and
c) The analyst must create a mathematical statement or evaluation metric of each objective at the target locations. These key mathematical statements allow the models to evaluate and compare alternative reservoir operating rules according to their performance.

In short, this task is to find out what range of storage or flows are important to maintain in various parts of the basin, based on stakeholder feedback.

Sub-tasks:

	Task	Assigned to	Due Date/Timeline

1	Identify key parts of the basin (reservoirs, reaches, locations)	Technical Team	Completed June 2018.
2	Identify, and meet with, key stakeholders	PAG/RAAG/ First Nations Métis, and Tribe Coordinators, and Contractor	PAG/RAAG near complete. FN-M-T: Ongoing
3	Contract facilitator	Bruce Davison	November 2018
4	Host workshop(s)	IJC Integration team/ Contractor/ ISRSB Leads	January 28-31, 2019 Sep 9-13, 2019
5	Write workshop report.	Contractor	February 25, 2019 October 15, 2019

Timeline: PAG and workshops should be held throughout study as needed. Main workshops should be completed by mid- to late October 2019.

Est. Cost: $209K CAN, $175K US

Resources: ECCC, USACE, ISRSB, IJC, PAG

Predecessor: DW4

Successor: DW4, and PF2

Review: ISRSB, reference document for the IRG

Task PF2: Run and Evaluate Alternatives

ISRSB leads: Michael Bart (USACE), Jeff Woodward (WSA)

Technical lead: Tim Fay (retired NDSWC)

Technical team: H&H sub-committee

Creating Alternatives: Mitch Weier (USACE), Nate Anderson (USACE), Chris Korkowski (NDSWC), Angela Gregory (USGS), Cesar Perez-Valdivia (WSA)

Running RESSIM: Mitch Weier, Chanel Mueller (USACE), Moges Mamo (ECCC), Rachel Weller (ECCC), Cesar Perez-Valdivia

Running RAS: Chris Korkowski, Cesar Perez-Valdivia

This task involves using the stochastic modeling in the HEC-RESPRM model to optimize different schemes in the basin. Then the stochastic and MESH model events along with historical events will be run through the more detailed RES-SIM and RAS models to determine the best operating plan. This will be an iterative process. Some form of screening or reduction of alternatives will likely be needed to stay within the budget.

Alternatives will be developed using information gathered a variety of sources including past flood events and dry period operation, input gained from the general public, tribal representatives, and agencies as part of DW4 (Data Collection for the Prescriptive Modeling System), insight gained from the Prescriptive Reservoir Model (PRM), and HH6 (Reservoir Flow Release Planning).

Screened alternatives will be selected and simulated using the system model (ResSim/RAS). Inputs to the system model will include historical measured and simulated streamflow (e.g. reconstructed hydrology, MESH model, stochastic streamflow).

The alternative performance will be assessed by using performance indicators as developed as part of DW4 Data Collection for the Prescriptive Modeling System). A post-process system will be developed to apply the performance indicators to the results of the system model.

Subtasks:

	Task	Assigned to	Due Date/ Timeline
1	**Run and evaluate using HEC-RESPRM**		
a	[Phase 3] Balanced runs	HEC, Nate, Chanel	November 2018 – December 2018
b	[Phase 4] Creating reservoir rules from the PRM results	Mitch, Nate, Brett, Chris, Cesar, Curtis	January 2019 – February 2019
2	**Run and evaluate using RES-SIM/RAS**		January 2019- September 2019
a	Creating Alternatives	Mitch, Nate, Brett, Chris, Cesar, Curtis Mark Lee	January 2019- February 28, 2019
b	Creating Scoring for Performance Indicators from ResSIM results	Mitch, Nate, Brett	January 2019- February 2019
c	Running Res-Sim	Chanel, Mitch, Garrett,	March 2019- September 2019

		Cesar, Moges	
d	Running RAS	Michelle	May 2019 – September 2019

Timeline: November, 2018 – September, 2019

Est. Cost: $173K CAN, $238K US.

USACE estimate = $238,000 ($100,000 for PRM, $138,000 for creating alternatives and running RES-SIM and RAS)

Resources:

Predecessor: DW4, HH1, HH6, HH6, HH7, HH8, HH9, and HH10

Successor:

Review: USACE, ECCC, ISRSB, IRG

Notes:

Task PF3: Dam Safety

ISRSB Leads: John Fahlman (WSA). Michael Bart (USACE)

Technical lead: Cesar Perez-Valdivia (WSA)

Technical team: Mitch Weier (USACE), Ken Bottle (USFWS)

This task involves evaluating the safety of dam operations given new concerns resulting from the 2011 flooding.

Sub-tasks:

	Task	**Assigned to**	**Due Date/ Timeline**
1	Review of Canadian PMF report	USACE	February 2018- December 2018
2	Using Res-SIM to determine impacts to Lake Darling.	USACE, USFWS	TBD

Timeline: February 2018- December 2018

Using Res-SIM to determine impacts to Lake Darling: September 2018-Dec 2018.

Est. Cost: $3K CAN, $75K US.

USACE cost estimate is $75,000

Resources: USACE, USFWS, WSA

Predecessor: HH8

Successor: n/a

Review: USACE, USFWS, WSA, ISRSB, IRG?

Notes:

Task PF4: Roadmap for taking study products to address apportionment, water quality, and aquatic ecosystem health concerns

ISRSB Leads: Gregg Wiche (retired USGS)

Technical lead: Bruce Davison (ECCC)

Technical team: TBD

The ISRSB has the resources to effectively address flooding and water supply issues, as well as to examine the impacts of alternative operating plans on apportionment. Impacts of alternative operating plans for the purposes of understanding water quality and aquatic ecosystem health concerns are beyond the resources (of time and money) that were made available to the board. However, the ISRSB can provide a roadmap to provide guidance for how the study products, particularly the integrated modelling system, could be altered and used in the future to address water quality and aquatic ecosystem health concerns. This task will also document, in one place, the impacts of alternative operating plans on the apportionment agreement.

Sub-tasks: TBD

Timeline: Sep – Dec 2019

Est. Cost: $0 CAN, $0 US. The expectation is that the study managers will complete this task with the support of the ISRB and the ISRSB.

Resources: ISRSB

Predecessor: n/a

Successor: n/a

Review: Internal review by ISRSB.

Notes:

6 Public engagement

6.1 Introduction

The IJC is committed to providing all interested parties with convenient opportunity to be heard, as required in the Boundary Waters Treaty. The IJC emphasizes the importance of public outreach, consultation and participation, and promotes policies and programs that enable community input in the decision-making process.

The IJC and ISRSB will strive to collaborate with existing regional organizations in developing and carrying out its communication and public outreach activities.

6.2 Objectives

Public participation in the study will be objectives-driven. The principal objectives are to:

- Ensure that the study process is open, inclusive and fair;
- Make the public aware of the study, its purpose, and process, including how decisions will be made;
- Provide opportunities to the public and stakeholders to participate;
- Enhance public understanding of factors that contribute to flooding in the basin;
- Identify and build on local expertise and information;
- Invite and consider public and stakeholder views of the principle issues;
- Identify and consider the public's priorities and preferences;
- Broadly disseminate study findings as they become available; and
- Encourage the public and stakeholders to share study findings.

The public refers to any person, association, organization or group that is affected, likely to be affected by, or has an interest in the study and any decisions that may ultimately be taken by the IJC in response to the findings or recommendations of the study. The public includes, but is not limited to, the following individuals and organizations representing the following interests: environment, recreational boating, local industry, agriculture, water supply and stormwater/sewage treatment; as well as riparian interests and municipalities. Stakeholder refers mainly to decision-makers, public opinion influencers and elected officials.

6.3 Communication Plan

A Communication Plan is an important tool for any complex study. The draft Communication Plan for the Souris River Study Board identifies:

- Public environment, annotating public and stakeholder interests, including historical IJC activities in the basin;
- Communication objectives over the course of the study;
- Target audiences, including partner organizations (municipalities, elected officials, First Nations/Tribes, local media, and interest groups.);
- Strategic considerations, including communication needs, opportunities, challenges; and
- Key communication deliverables from the Study Board, along with timelines and identification of leads and collaborators – this will include products to educate or inform, public engagement events, i.e., open houses/webinars/public meetings; and activities to promote the work of the study, i.e. social media, articles;

The Communication Plan is an evergreen document, and will evolve as the communication needs of the study become more clearly defined. As such, the effectiveness of the communications approach will be continually evaluated.

The Study Board will use three important means for public participation and outreach: public meetings, the Public Advisory Group (PAG), and the ISRSB web page.

6.4 Public meetings

The Study Board will conduct public meetings, as appropriate, holding at least one in each country per year. During these meetings, the Study Board Co-Chairs will invite comments from the public on specific or general issues associated with the study as well as provide opportunities for the public to express its views.

In order to inform and provide context for the technical investigations associated with the study, the public will be consulted at the beginning of the Study to identify the public's views on the principle issues, questions and study objectives, acquire any available knowledge in the form of historical data, anecdotal information indigenous knowledge as well as existing or future plans, activities and initiatives.

Other public participation activities or meetings will be conducted at strategic junctures throughout the study.

6.5 Public Advisory Group (PAG)

The IJC is committed to engaging with the public during the study on an ongoing basis through the Public Advisory Group (PAG). PAG members will represent multiple areas of interest and various geographic locations across the Souris River basin, and include an equal number of people from Canada and the US. PAG members will have the opportunity to provide advice on the Study Board's public participation activities laid out in its Directive. More specifically, the PAG will be asked to:

- Advise the Study Board on public consultation, involvement and information exchange;
- Serve as a conduit for public input to the study process, and for public dissemination of study outcomes;
- Review and provide feedback on Study Board approaches, reports, products, findings and conclusions as requested; and
- Advise the Study Board on the responsiveness of the study process to public concerns.

As such, PAG members will be asked to draw upon their knowledge, contacts and experience to provide informed input to the study.

- Develop effective techniques to engage the public and stakeholders on a wide range of issues;
- Facilitate outreach to First Nations and Tribes to encourage participation in the study;
- Use geospatial technologies (including geodatabases for archiving and analysis; GPS for geotagged imagery) to create a participatory mapping framework that captures stories, observations and other geospatial data across the basin.

6.6 ISRSB web page

The web is an important communication tool, serving as a primary means of providing information to a diverse public. As such, the IJC will keep the ISRSB web page up-to-date with information on the progress and achievements of the Study under the IJC's Rules of Procedure, and other information relevant to the study. Promotional resources, such as brochures, articles,

and social media posts will contain a consistent call to action directing target audiences to the web page.

The Study Board will also encourage public discussion by inviting comments from the public on specific or general issues associated with the study, and providing opportunities for the public to express its views by, among other means: publicizing a mailing address in each country for correspondence and submissions; establishing and promoting the use of a dedicated e-mail address; and hosting webinars, when warranted. In addition, the IJC will promote opportunities for public input on this web page and social media accounts.

The Study Board will develop the necessary communication tools and materials, ranging from posters and fact sheets, to videos and interactive maps, to educate the public on flooding and a flood mitigation aspect considered in the study, for use during and after the study is complete.

7 Study Review

7.1 Introduction

The Study Review section outlines the scope and level of peer review that will be needed for the Souris River Study defining four general levels of review: Sufficiency Review (by ISRSB) (SR) Agency Quality Control (AQC), Agency Technical Review (ATR), and Independent external review via an IJC managed Independent Review Group (IRG).

The Study review process is based on a few simple but fundamental principles:

i. Peer review is key to improving the quality of work in studies and so interim reviews, as well as the final reviews, are beneficial for checking methods and assumptions early when corrections are still feasible;

ii. Reviews will be scalable to the content of each component of the study, deliberately included as part of the study process throughout the life cycle of the study (scoping, interim products, and final products), and concurrent with recommendations to include previous work in the study and completion of new study phases/ products from each contributing agency/contractor and the study board;

iii. Since previously completed work products may have already undergone sufficient peer and independent reviews, products will be screened for level and need for review for the purposes of this study.

iv. An IRG level review will be completed on all recommendation and implementation documents and specific study products identified as fundamental to making those recommendations. For other products, the Study board will provide documentation of existing reviews and recommendations to the IRG for level(s) of review, and the IRG will provide their decisions on whether to perform additional review.

** It is important to acknowledge that the reviews may result in additional work for the study to address concerns that are not currently accounted for in timelines and budgets.

7.2 Sufficiency Review (SR)

A preliminary review of existing/ completed products and their documented peer and independent reviews. This review can be done by the ISRSB or Technical work groups of the Board. These reviews ensure consistency and coordination across all study components.

Lists of products recommended for use without further independent review will be provided to the IRG with background documentation. The IRG can request to review or other additional reviews of these products at their discretion.

7.3 Agency/Contractor Quality Control Review (AQC)

AQC is the internal quality control process performed by the Study Task supervisors, senior staff, peers and the TWG. AQC consists of the following:

Quality Checks and reviews. These are routine checks and reviews carried out during the development of products by peers not responsible for the original work. These are performed by staff such as supervisors, technical leads or other senior designated to perform internal peer reviews.

PDT reviews. These are reviews by the production team responsible for the original work to ensure consistency and coordination across all project disciplines.

Expert reviews. These reviews will be conducted by regional experts that have not been involved in the development of the products. These experts may include water management and modeling experts from U.S. and Canada and expertise from Partner Agencies.

7.4 Agency/Contractor Independent Technical Review (ATR)

The objective of ATR is to ensure consistency with established criteria, guidance, procedures, and policy. ATR's assess whether the analyses presented are technically correct and comply with published guidance, and that the document explains the analyses and results in a reasonably clear manner for the public and decision makers.

Peer review typically evaluates or critiques the clarity of hypotheses, accuracy of assumptions, the validity of the study design, the quality of data collection procedures, the appropriateness of the methods, the extent to which the conclusions follow from the analysis, and the strengths and limitations of the overall product. Reviewers check that methods used to collect data and produce results are defensible and adequately documented; facts and interpretations are presented straightforwardly, without apparent bias; conclusions are based on the best available data interpreted with sound scientific reasoning that avoids speculation; forecasts and predictions of natural hazards are scientifically sound; and the manuscript is clear in presentation.

ATR will be conducted by qualified reviewers that are not involved with the day-to-day production of the program/product. ATR teams will be comprised of senior personnel and may be supplemented by outside experts as appropriate.

Organizations producing products for the study may have an existing Agency Quality Control (AQC) and Peer Review/ATR equivalent processes that they are required to follow. Information

on those process and product specific reviews will be provided to the Study Board as part of the product documentation supplied to the IRG.

Documentation on some agency peer review processes will be expanded to include additional processes as organizations provide products.

7.5 Independent Review Group (IRG)

The Independent Review Group (IRG), appointed by the IJC, will provide independent technical review and documentation of appropriate Study components and documents produced jointly during the Study process. Anticipated involvement of the IRG will occur at strategic milestones such as review of selected products, draft work plan, and the final review of the study. IRG members can provide advice on the Study as a whole, as well as in regard to their respective subject-matter expertise. The IRG provides its reports through IJC staff for consideration by the Study Board and the IJC. Elements the IRG will review include:

1. Initial draft of DW3: Review of Hydrometeorological Data Network Improvement Report.
2. Report for Task HH3: Artificial Drainage Impacts Review.
3. Initial findings of DW4/HH8: Data Collection for the Prescriptive Modelling System/Develop PRM Model. Including: Suggested performance indicators, trade off curves, and a set of initial alternatives. This review is to verify that the study is properly using the public's input and there are no critical gaps. (mid-March-April 2019)
4. Several Tasks have subtasks with climate change considerations including: HH2: Stochastic Hydrology Dataset development, HH4: Flow Simulation Tools Development (MESH), HH5: ECCC Climate Change Supplies, and PF2: Run and Evaluate Alternatives. – This review will consider what assumptions that were used, quality of the alternatives used to test assumptions and ranges of results from the analysis.
5. Results from alternative development and evaluation Task (PF2: Run and Evaluate Alternatives (this may require several iterations to define and choose final short list of alternatives).
6. Periodic check-ins with respect to overall study progress. Study Board could report to IRG via IJC advisors when significant milestones are completed.

7.6 Peer Review Plan

A Peer Review Plan (PRP) will be developed by the ISRSB in collaboration with the IJC liaisons to the study and the IRG Co-chairs. The PRP will provide guidance on how reviews of products will be managed including processes for review comment resolution, documentation, and certification of completion. The PRP will be a living document with Tables of products to be reviewed, reviewers, review schedules, and budgets that are updated as products and information become available.

8 Information and Data Management.

The Study Board recognizes that the research under the “Plan of Study: For the Review of the Operating Plan Contained in Annex A of the 1989 Agreement Between the Government of Canada and the Government of the United States of America (2013)” as referenced in July 2017 and directive of September 2017 will generate a number of reports and large quantities of purchased, acquired and leveraged data and information, models and associated documentation.

This collection represents a significant investment and legacy of the study. As a result, the Study Board will pursue the following principle with regard to information management - “The International Souris River Study Board encourages unrestricted access to data. Data collected by the Souris River Study will be made available online once it has been approved for distribution by the Study Board and IJC. Most of the data collected by the study will be available to the general public by the completion of the review, scheduled for mid-2020. However, there may be licensed or proprietary information that may not be made available publicly.”

The Study Board, with the technical assistance of the IJC, will address the information management needs of the study. Options and recommendations for the archiving and dissemination of the study’s data assets will be developed. The Study Board will also develop an Information Management and Dissemination process to provide external parties with access to the study’s data and information to help meet water level analysis and management objectives.

The Study Board will explore using web-based tools such as Office 365 and dynamic decision-mapping system to ensure the transparency of the Study Board’s decisions similar to the one developed for the International Upper Great Lakes Study (http://www.iugls.org/Decision_tree_tool)."

9 Secretariat

The study managers will provide secretariat support to the study. Some additional staff will be hired to support the study managers.

10 Study Management

Effective study management is necessary so that the study is conducted efficiently, within fiscal limits, is coordinated, and that proper oversight and study decisions are being made. This study management is provided by the Study Board, study co-chairs, and study managers.

11 Study Products, Timeline and Budget

This section summarizes the major products to be produced from this study, timelines of study activities and a summary of study costs by major task. As previously mentioned, this Work Plan is considered a living document and will be revised on a regular basis, as the Study progresses, work scope is modified, funding levels change, results become available and stakeholders and public inputs are provided.

Table 2 outlines the key reports that are currently envisioned to answer the joint References' objectives. A critical path for these objectives will be developed by first quarter of 2018. Reports will be jointly written by key individuals, reviewed as deemed necessary by the ISRSB, reviewed by the IRG, approved by the Study Board and presented to public.

All tasks have been placed into five groups of activities and the estimated cost for each group is listed in table 1. The cost for each task will be finalized in March 2018, and table 1 will be updated with the cost estimates.

Table 2 Key products and reports from the ISRSB

Study's main reports	**Lead Organization(s)**	**Completion date (year-month)**
1989 Agreement Language Review Report (Task OR1)	SWSA/USACE	2018-02
Summary of POS Projects and Report Progress since 2013 (Task DW1)	ECCC	2018-09
Initial repository of datasets and models for ISRSB (Task DW1)	ISRSB/IJC	2018-10
Report and data for all existing and additional data collected for the POS. (Tasks DW2, DW3, DW4)	ECCC/USGS/USACE	2019-01
Artificial Drainage Impacts Documentation and Public Materials (Task HH3)	SWSA/MB/IJC	2019-02
Hydrology and Hydraulics Report (Tasks HH1, HH2, HH4, HH5, HH6, HH7, HH8, HH9, HH10)	SWSA/MB/ECCC/USACE/USGS	Mid-study (when all models are setup and ready to go for plan formulation)
Plan Formulation Report (Tasks PF1, PF2)	SWSA/MB/ECCC/USACE/USGS	End of Study
Final repository of datasets and models for IJC (All tasks)	ISRSB/IJC	2019-12

Dam Safety Report (Task PF3)	SWSA/USACE	TBD

Table 11.2 summaries proposed costs for the Study's main objectives over the course of the entire study. A critical path for these deliverables will be developed.

Old No.	New No.	Name	Group	Canada Costs (CND)	USA Costs (USD)
1a, 1b, 2	OR1	1989 Agreement Language Review	Operating Rules Review	6	0
				6	0
3	DW1	Summarize POS Projects and Report Progress since 2013	Data Collection and Management	3	0
4	DW2	Lidar and Bathymetry for Reservoirs		75	0
5	DW3	Review of Hydrometerological Network Report		15	0
6	DW4	Data Collection for PRM		0	85
				93	85
7	HH1	Regional Hydrology	Hydrology & Hydraulics	44	25
8	HH2	Stochastic Water Supplies		6	185
9	HH3	Artificial Drainage Impacts Review		43	0
10	HH4	Flow Simulation Tools Development (MESH)		76	0
11, A4	HH5	ECCC Climate Change Supplies		47	5
12	HH6	Reservoir Flow Release Planning (RES-SIM)		64	65
13	HH7	Reservoir Flow Release Planning (HEC-RAS)		3	16
new	HH8	Develop PRM Model		4	72
new	HH9	Model System Integration		28	0
new	HH10	Forecasting Assessment		175	0
				490	368
14, A1, A3, A5, A	PF1	Workshops and Engagment	Plan Forumlation	209	175
15, 16, 17	PF2	Run and Evaluate Alternatives		173	238
new	PF3	Dam Safety		3	75
new	PF4	Roadmap for apport., water quality, and aquatic eco. health		0	0
				385	488
	A1	Administration - Independent Review Group		47	33
	A2	Administration - Study Manager (Canada)		165	0
	A3	Administration - Study Manager (U.S.)		0	106
				212	139
			Total	1186	1080

Table 11.2 Summary of Study Costs

Cited References

Kolars, K.A., Vecchia, A.V., and Ryberg, K.R., 2016, Stochastic model for simulating Souris River Basin precipitation, evapotranspiration, and natural streamflow: U.S. Geological Survey Scientific Investigations Report 32015-5185, 55 p., https://doi.org/10.3133/sir20155185