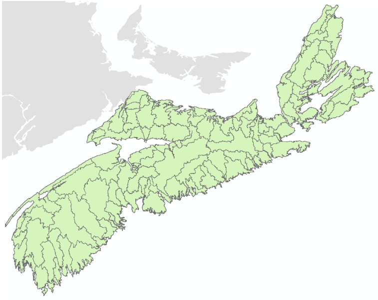


Nova Scotia Watershed Assessment Program
Part A – Initial Assessment

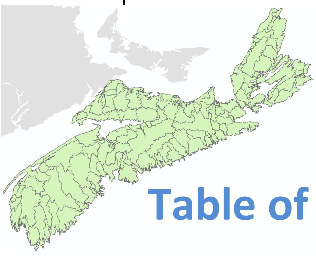
Summary Report

Hydrologic Systems Research Group

DALHOUSIE UNIVERSITY
Inspiring Minds
Faculty of Science

NOVA SCOTIA
Environment
Natural Resources

HydroLogic
Systems Research Group



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1 Introduction

The Nova Scotia Watershed Assessment Program (NSWAP) has been developed to increase our knowledge on the current state of watersheds in Nova Scotia. NSWAP was designed as a two stage approach to characterize the state of the watersheds across the province by analyzing a variety of water resource management objectives. Key products of the NSWAP will be the identification of priority watersheds (i.e. watersheds which need to be studied further due to their susceptibility to impacts) and the provision of baseline data in a Geographic Information System (GIS) Geodatabase.

This assessment of watershed impacts focuses on the issues of water quality, available water, surface erosion, fish habitat and riparian zones. The outputs from the NSWAP Part A and Part B are directly related to individual components of the Water For Life Water Resource Management Strategy and the Climate Change Action Plan, including:

- The identification of priority watersheds in Nova Scotia and ranking watersheds by impact;
- The completion of a vulnerability assessment of our water resources: identification of areas with increased likelihood of risks for erosion and sedimentation, climate change-induced increases in flooding and available water, and fish habitat loss, and
- The identification of watersheds that are the best candidates for restoration projects such as salmon habitat restoration and liming.

Part A was completed as a rapid, preliminary assessment of the watersheds in Nova Scotia at a provincial scale. It was limited to only using the mapping information currently available at the provincial scale. A key output of the Part A assessment is the identification of future information needs to conduct a more rigorous and robust watershed assessment. In Part B, additional watershed information will be collected as necessary to complete a comprehensive assessment of watershed impacts. The advantage of completing a rapid assessment prior to an extensive, robust assessment is that areas of priority can be identified in the rapid assessment and future resources can be focused on those higher priority watersheds.

2 Background

2.1 Origins

The Nova Scotia Watershed Assessment Program (NSWAP) was initiated to increase our knowledge on the current state of watersheds in Nova Scotia. At this time, there was a knowledge gap on the pattern of watershed issues we faced. We did not know which watersheds were most impacted or at risk, and there was no provincial-scale picture available of the status of watersheds in Nova Scotia. Initial discussions on the NSWAP were initiated by Dr. Shannon Sterling at Dalhousie University in July 2009 and held with members of the Water and Wastewater Branch at Nova Scotia Environment (NSE).

In 2010, a decision was made to implement the NSWAP in two parts (A and B), in order to increase feasibility. Part A is designed to be an initial and simplified assessment of the watersheds of Nova Scotia, with the scope set for completion in a seven-month period (Jan-July 2011). In December 2010, the NSWAP Part A was launched as the first research project under the Nova Scotia Water Strategy (Government of Nova Scotia 2010). In January 2011 work began on the project, and it was completed seven months later, in July 2011.

The team working on the NSWAP between January and July 2011 include Kevin Garroway (NSE), Peter Horne (Dalhousie), Shannon Sterling (Dalhousie), and Gavin Kennedy (Nova Scotia Department of Natural Resources). Individuals also contributing to the NSWAP include Charlie Williams (NSE), Emily Rideout (Dalhousie), Gillian Fielding (Dalhousie), and Anthony Kelly (Dalhousie).

2.2 Objectives

The goal of the NSWAP is to develop a water resource management tool to assess priority areas in Nova Scotia where significant threats and important water uses dictate further action and protection efforts. To achieve this goal the following objectives have been set:

1) characterize of the state of watersheds in Nova Scotia;

2) identify priority watersheds;

3) identify watersheds most vulnerable to future climate and direct human changes;

4) identify what information is missing that is needed to make basic watershed assessments; and

5) create a standardized provincial-scale database that is accessible to stakeholders involved in water resource management.

2.3 Scope

In order to facilitate the rapid production of Part A and reduce reporting costs, it was decided that an abbreviated report would accompany the completion of Part A that: summarizes the preliminary watershed assessments, identifies information needs for a complete assessment, presents maps summarizing the main results, and makes recommendations for the next stage of the NSWAP.

This report describes the following seven steps:

1. Definition of NSWAP Approach
2. Definition of Watersheds in Nova Scotia
3. Data Gathering
4. Creation of a Geodatabase
5. Selection of Watershed Status Indices
6. Model generation and collection of information for each watershed
7. Identification of data limitations

3 NSWAP Approach

3.1 Definition of Part A and Part B

Part A is a rapid, preliminary assessment of the watersheds in Nova Scotia. It can be completed quickly due to a strategic design that is based on mapping information that is currently available at the provincial-scale. The Part A design employs recent innovations in software technology, computer processing power and newly available geospatial information.

A key output of the Part A assessment in turn is the identification of future information needed to conduct a more rigorous and robust watershed assessment. It is anticipated that in the next stages of the NSWAP (here identified as Part B), additional watershed information will be collected as necessary to complete a comprehensive assessment of watershed impacts. The NSWAP Part B will be designed to conduct watershed assessments at a smaller scale, which will require more data and a broader approach to the risk/impact assessment. The following table (Table 1) explains the differences between, and outlines the outputs of, the NSWAP Part A rapid assessment and the NSWAP Part B robust watershed analysis.

Table 1. Definition of NSWAP Part A and B

	Part A	Part B
Highlights	• **preliminary** assessment • information-driven • ~6 months to complete	• **thorough** assessment • question-driven • >2 years to complete

Goals	• To create a **preliminary assessment** for each major watershed that summarizes:
	  ○ physical properties
	  ○ watershed values
	  ○ key human impacts
	• To produce a provincially-consistent **GIS watershed database** that will be built upon in Part B
	• To identify **information needs** to do a thorough assessment,
	• To identify **limitations** of the Part A Level 1 Assessment, and make recommendations for the more thorough Part B assessment
		• To complete a **robust characterization** of the state of watersheds in Nova Scotia for each major watershed that summarizes:
		  ○ physical properties
		  ○ watershed values
		  ○ key human impacts
		  ○ areas of priority water usage
		• To produce a **GIS Watershed database** as a resource for the government, community, industry and academia that contains all summary and monitoring information

Approach	• Analyze **existing provincial-scale** mapping information provided in a GIS • Develop **preliminary variables** to be measured to characterize watersheds; the choice of these variables will be dependent on	• Expand or refine key watershed variables that need to be measured to clearly assess watershed impacts. • Collect additional information required for the measurement of these variables. • Incorporate additional data from

	Part A	Part B
	readily available information • A detailed task list is presented in Appendix B.	community watershed groups, water quality studies, for example, ○ culvert inventory ○ water quality monitoring sites • Complete a more detailed GIS analysis expanded by additional information, building upon Appendix A
Watersheds Assessed	• Primary Watersheds in Nova Scotia (n=~46), separated into major and residual watersheds • Sub-basins not analyzed	• Sub-basins of major watersheds and selected individual residual watersheds • Regional areas of interest (e.g., Bras d'Or Lake)
Stakeholder & Community Outreach	• Stakeholder only, primarily government, in order to get a rapid preliminary assessment	• Involves more stakeholders and incorporating appropriate information provided by the stakeholders in the assessments
Output	• Preliminary GIS watershed database • Completed preliminary assessment report cards for each watershed • Maps showing the preliminary results of impact indicators and preliminary ranking of the watersheds throughout the province	• Complete GIS watershed database • Completed comprehensive assessment report cards for each watershed • Maps showing comprehensive results of impact indicators • Maps showing comprehensive ranking and assessment of watersheds in the province to risk for 1) water quality, 2) available water, 3) terrestrial ecosystems, 4) aquatic habitat, and 5) surface erosion • Maps of watershed rankings by impact, value, and physical properties • Maps showing areas of greatest risk for impact

3.2 Definition of Watersheds in Nova Scotia

By scientific convention, a watershed is defined as an area of land that drains into a point of interest (Figure 1). The point of interest may be at a river mouth, or at a dam, or another location on the land surface, depending upon the particular objective of the watershed analysis.

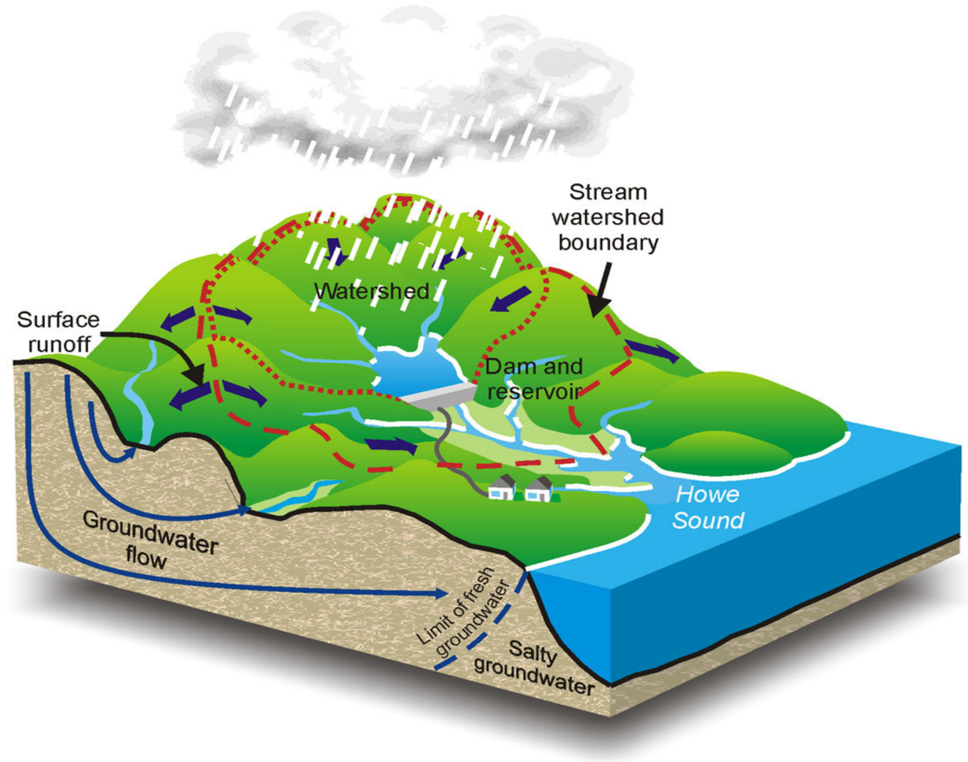
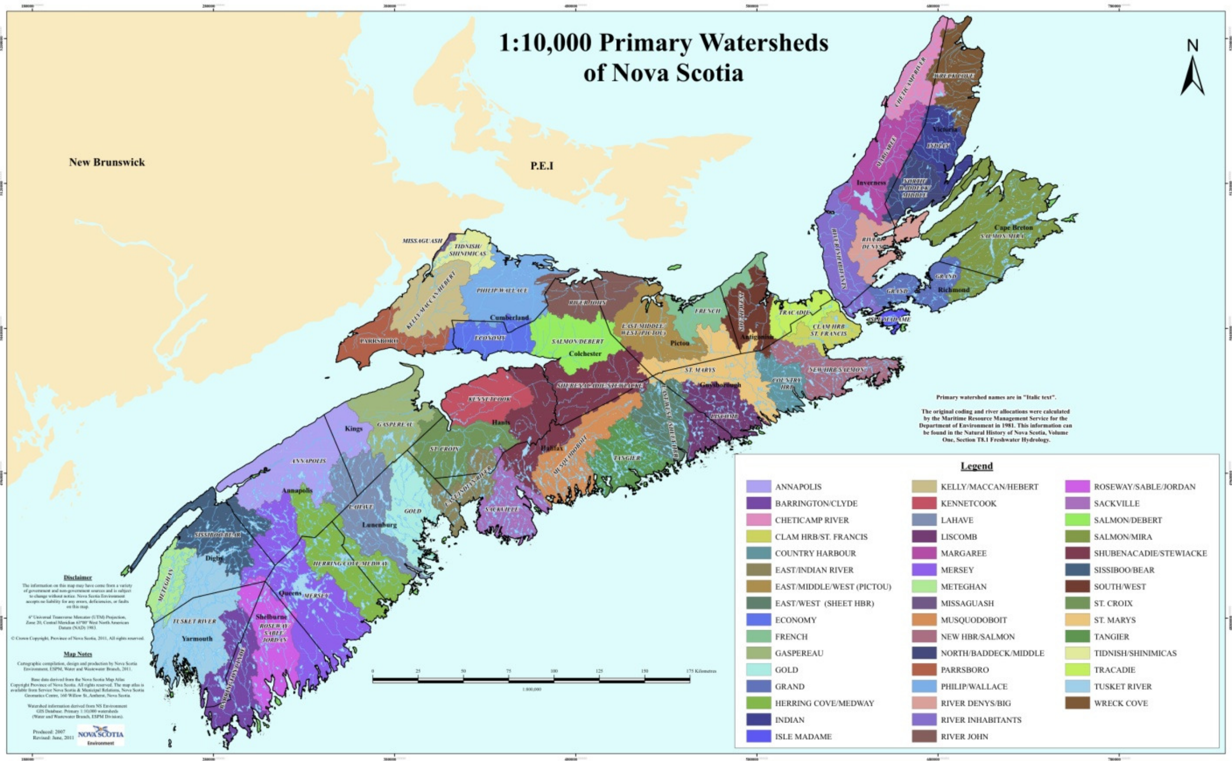


Figure 1. Definition of two watersheds, one with a point of interest at a dam, and another with a point of interest where the river meets the ocean. From Natural Resources Canada (Turner et al., 2005).

Nova Scotia is unique in that it is composed of many smaller watersheds that flow directly into the ocean, as opposed to being dominated by large watersheds (e.g., Alberta, New Brunswick, Sackatchewan, Manitoba, or British Columbia). In recent years the convention in Nova Scotia has been to separate the landscape into 46 “Primary Watersheds” using a classification that is not consistent with the scientific definition (Figure 2) as the “Primary Watersheds” watersheds are not hydrologic units. In order to maintain the “Primary Watershed” structure, but to gain hydrologic meaning for the NSWAP, we divided each of the 46 Primary Watersheds into two parts: 1) the largest hydrologically defined watershed and 2) the remaining residual watersheds (Figure 3), based on the the province's secondary watershed layer (NSE, 2010)

Figure 2. Original Primary Watershed Classification of Nova Scotia (Nova Scotia Environment)



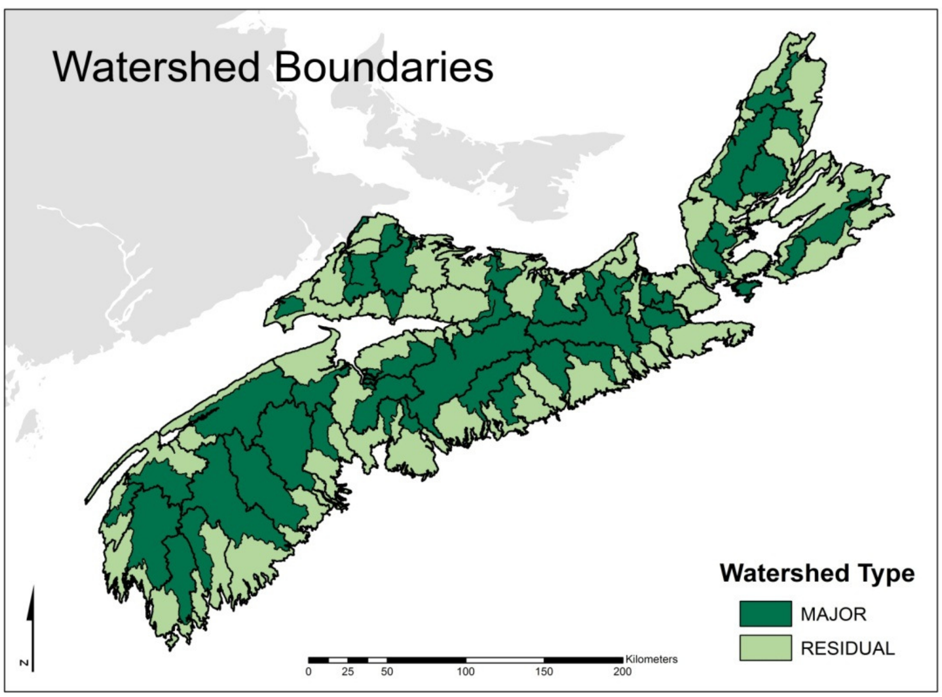


Figure 3. Major and Residual watersheds used in NSWAP Part A.

3.3 Data Gathering

Nova Scotia Environment and Nova Scotia Department of Natural Resources facilitated the gathering of geospatial data required for watershed assessments. This is an ongoing process, and to date 24 geospatial layers have been collected (Appendix A).

The criterium for the inclusion of data layers in the Part A assessment was that they be limited to available geospatial information with coverage extending over the entire province. Information was collected from sources such as the Department of Natural Resources, Nova Scotia Environment, Environment Canada and Dalhousie University.

3.4 The NSWAP Geodatabase

The NSWAP Geodatabase stores the geospatial watershed information and is divided into three main datasets: 1) watershed datasets, 2) raw datasets and, 3) the provincial dataset. The datasets are parent folders to data layers that reside inside. There are 46 watershed datasets representing all primary watersheds of Nova Scotia. (Figure 4)

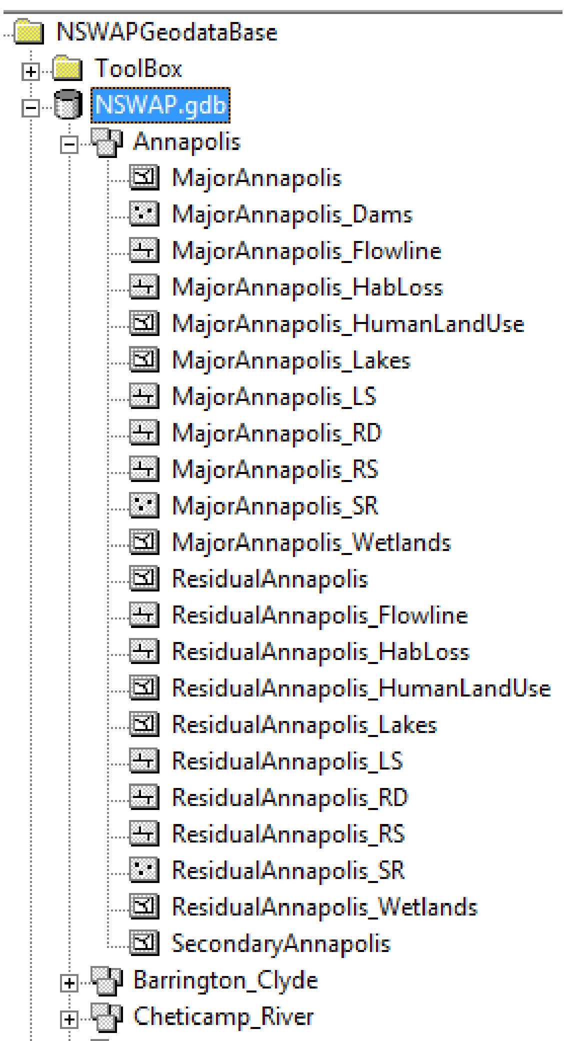


Figure 4. File organization in the NSWAP Geodatabase, example of the Annapolis Watershed

Inside each of the watershed datasets are all of the outputs of the NSWAP project that pertain to that watershed, along with raw data that has been clipped to the watershed level such as road and stream layers.

The raw dataset contains all raw data that was gathered and used within the NSWAP project. These files are used by the models within the NSWAP tool box in order to generate the watershed impact indicators and final map outputs which are housed both within the provincial dataset and watershed datasets.

The provincial dataset holds all of the outputs of the NSWAP project at the provincial scale.

3.5 Selection of Watershed Impact Indicators

Eleven watershed impact indicators were chosen to evaluate the relative risk of impact of the watersheds (Table 2). These indicators were chosen to be simple and meaningful, and depended upon the data layers available. Method pages are produced for each watershed impact indicator (Appendix B), including a definition, data sources used, limitations, and recommendations for future improvement.

Table 2. Watershed Impact Indicators used in NSWAP Part A. The Indicators "Length of roads on erodible soils" and "Proportion of watershed with erodible soils" were not calculated because the data layers were not available in time.

Watershed Impact Indicator	Symbol	Calculation	Definition
Road Density	**R**	Length of Road (km) / Watershed area (km^2)	The total length of roads within a watershed divided by the area of the watershed.
Dam Density	**D**	Number of dams / Watershed stream length (km)	The number of dams per total stream length within a watershed.
Surface Water Usage	U_S	Surface water usage (m^3/ day)	The total volume of daily surface water withdrawal within a watershed.
Groundwater Usage	U_G	Groundwater usage (m^3/day)	The total volume of daily groundwater withdrawal with in a watershed.
Portion of Stream Bounded by Human Land Use	L_S	Total Impacted stream length (km) / Watershed stream length (km)	The length of stream adjacent to human land use compared to the total stream length within a watershed.
Portion of Stream Length Behind Dams	**S**	Stream length behind dams (km) / Watershed stream length (km)	The total length of streams behind dams divided by total stream length within a watershed.
Length of Road Within 100m of Streams	R_S	Total length of roads within 100m of streams (km) / Watershed stream length (km)	The length of roads within 100 m of streams per watershed normalized by the total stream length within the watershed.
Proportion of Watershed with Human Land Use	L_A	Area of Human land use (km^2) / Watershed area (km^2)	The area of land within each watershed that has been altered by human activity, normalized by the area of the watershed.

Watershed Impact Indicator	Symbol	Calculation	Definition
Acid Rock Drainage Risk	**A_R**	Area of potentially exposed Acid Rock (km^2)/ Watershed area (km^2)	The area of acid bearing rock that has been exposed due to human activity within a watershed, normalized by the area of the watershed.
Stream/Road Crossings	**S_R**	Number of Stream/Road Crossings / Watershed stream length (km)	The number of intersections between a road and a stream per length of stream in a watershed
Road Length on Erodible Soil	**E_R**	Length of road on erodible soil (km) / Watershed area (km^2)	Not calculated because data not available
Portion of Watershed with Erodible Soils	**E_S**	Total area of erodible soils (km^2) / Watershed area (km^2)	Not calculated because data not available
Acidification Index	**A_{AR}**	mg L^{-1}	Acid neutralization capacity from surface water samples in Nova Scotia as measured by Gran alkalinity titration method. Values are interpolated for the province from sample sites (Clair et al., 2004).

Each watershed impact indicator was normalized by either watershed area or stream length to facilitate the watershed comparisons. For the stream length calculation we removed the portion of the stream lengths that were within lake polygons. Therefore, the overall stream length measurement used to normalize other variables only represented the length of streams and not lakes. Watershed impact indicators were then classified into five areas of concern for Nova Scotia that represent potential risk's to watershed health. (Table 3).

Table 3. Some Areas of Concern in Nova Scotia and the associated Watershed Impact Indicators.

Areas of Concern	Relevant Watershed Impact Indicator
Hydrologic Change (flooding, water availability)	L_A, D, R,U_S, U_G
Instream Habitat	L_S, S_D, S_R, R_S, R, L_A, A_{AR}, A_R
Water Quality	L_A, A_{AR}, A_R, S_R, R_S
Surface Erosion	E_R, E_S, S_R, R_S, R
Terrestrial Ecosystems	L_A, A_{AR}, L_S, R

4 Model Generation and Calculation of Watershed Impact Indicators for Each Watershed

A series of models in ArcGIS 9.3 were created to generate each watershed impact indicator. These models are described in the Method Page for each indicator (Appendix B). The models can be run repeatedly to track trends, explore scenarios, and to generate results with new input data.

4.1 Comparison of Watershed Impact Indicators for Each Watershed

Watersheds are compared based on a ranking relative to each other. This technique was employed to mitigate the absence of numerical threshold values, or guidelines, for each impact indicator variable. The ranking system is qualitative and is usually based on a 5-category equal-interval classification (except for Acid Rock Drainage which was based on natural breaks).

The ranking system is not based on physical thresholds and does not indicate whether the watershed is “healthy” or “not healthy”, but instead compares the watersheds by their watershed impact indicator value.

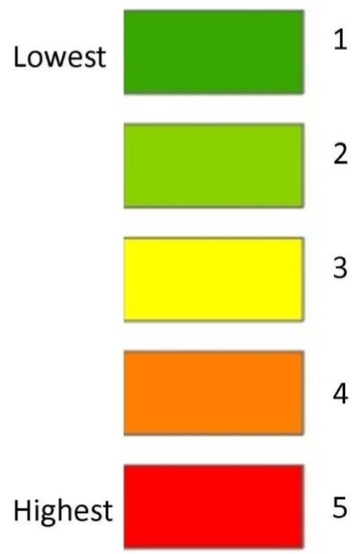


Figure 5. Watershed ranking system for each watershed impact indicator

For example the impact indicator “Proportion of watershed covered by human land use (L_A)” is defined as the area of land within each watershed that has been altered by human activity and normalized by the area of the watershed. In this example lower values (i.e. percentage of area affected by human landuse) would indicate more land available within the watershed that had not be affect by human landuse, and was therefore less impacted. The equal interval classification scheme would be employed to show that low percentages were classified as low categories and higher percentages as high categories. Because these categories have been normalized by the area of the watershed they are comparable across watersheds.

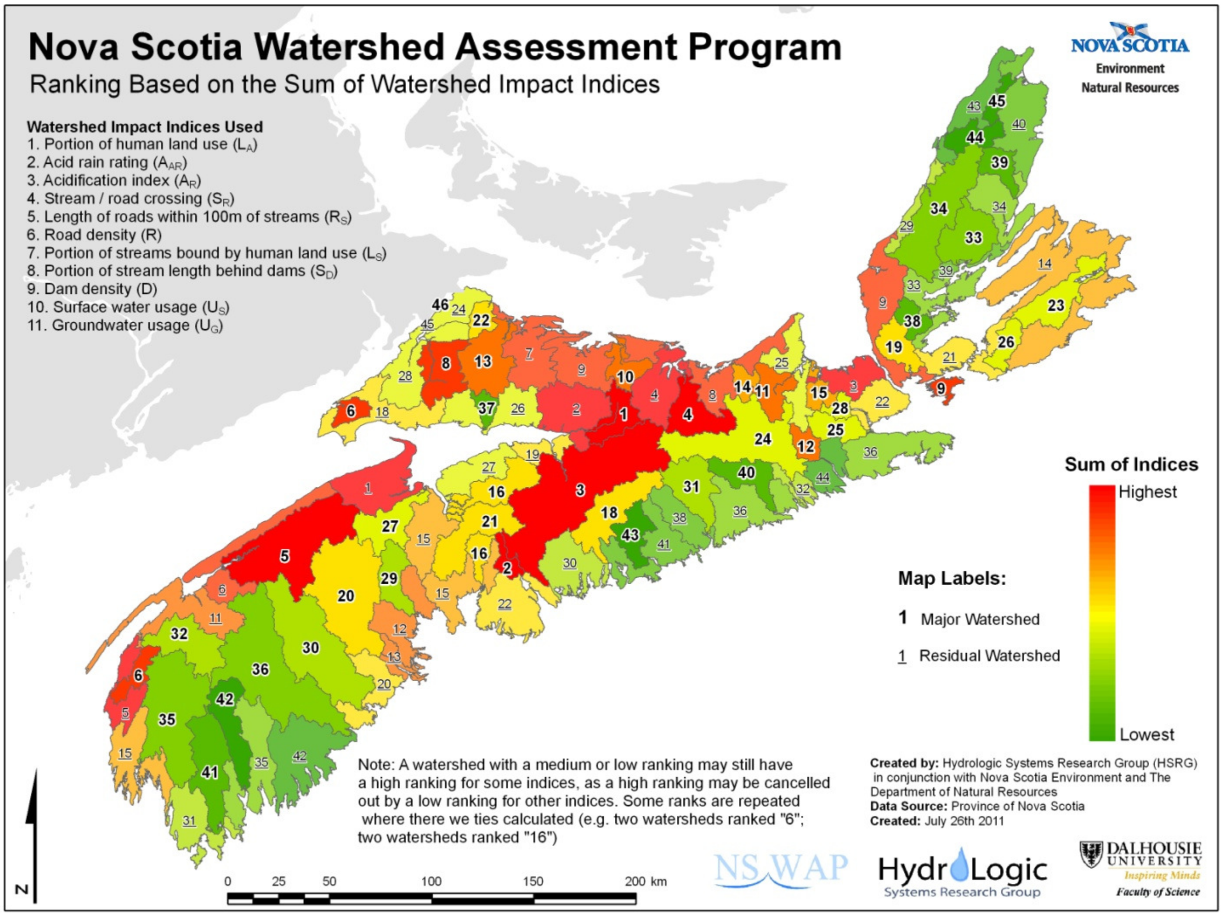
Results of the watershed impact indicator calculations are presented in:

- provincial maps for each watershed impact indicator (Appendix C);

- provincial maps ranking watersheds for each watershed impact indicator (Appendix D)
  - These maps provide context by evaluating indicators for each watershed and show "hotspots" for each indicator; and
- Report cards for each watershed summarizing ranking results (Appendix E).

If we sum the ranking for all the watershed impact indicators for each watershed, we can calculate an overall rank (Figure 6). Note that for some watersheds, such as the Mersey, a high ranking (e.g., proportion of stream length behind dams) is cancelled out by a low ranking in other variables (proportion of stream bound by human land use).

Figure 6. Preliminary ranking of watersheds in Nova Scotia, based on a sum of the rankings for all watershed impact indicators. Major and residual watershed groups are ranked separately. A low ranking does not indicate the absence of watershed impacts.



5 Identification of Data Limitations

The assembly and analysis of geospatial layers reveals some limitations to the base data (Appendix A). These include:

1. The secondary watersheds have two boundary issues that have been identified. There are a number of streams that cross watershed boundaries (figure 7). There are also a number of artifact polygons classified as secondary watersheds that are data errors left from the digitizing process. This study has noted both of these limitations and suggests that improvements be made to the secondary watershed file. Once new watershed boundary and stream data becomes available, the NSWAP model can be run again to update the report cards.
2. The stream layer (NS Hydrologic Network) is not a networked GIS layer, and therefore when modelled in the GIS the flow for all stream sections does not flow in the proper direction (i.e. downstream); there are some stream sections with flow upstream. The standard is to digitize streams with the direction of flow, but it is not clear at present how the streams were digitized. The provincial Digital Elevation Model (DEM) cannot be used to establish flow directions because the coarse scale of the DEM will result in many instances of model error.
3. The land cover layer (NS Forestry Landcover) is outdated (2006).
4. The road layer derived from the Nova Scotia Topographic Database provided from the Geomatics centre is missing forestry-related roads.
5. The dam location layer from Nova Scotia Environment has dams that are not located on a stream (Figure 8).

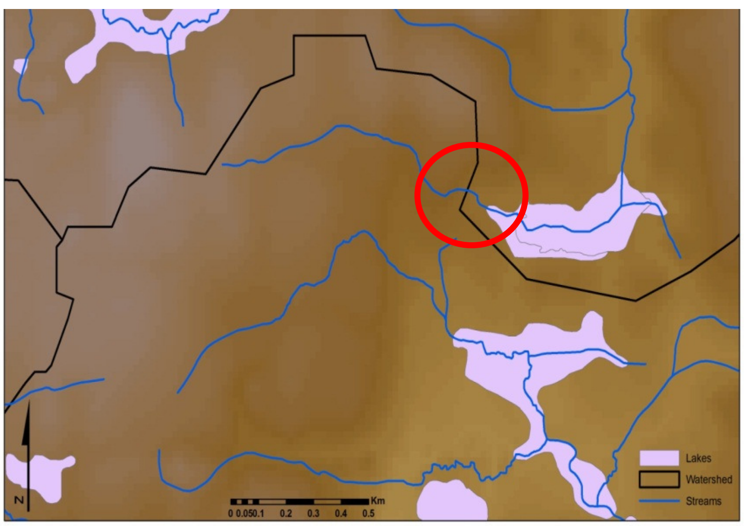


Figure 7. Example of a stream crossing a watershed boundary near the western end of the New Harbor watershed.

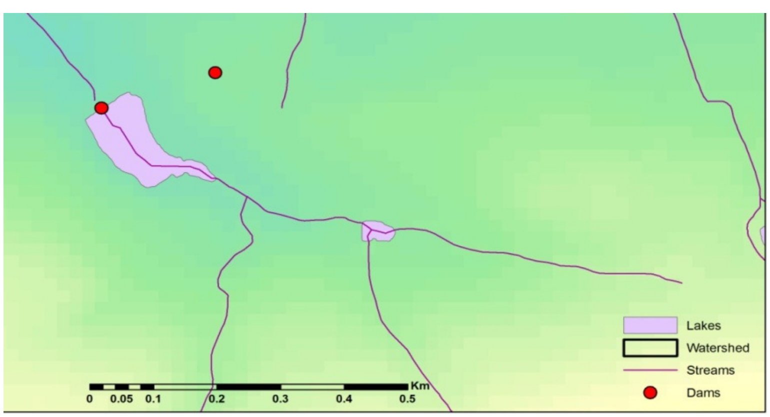


Figure 8. Example of dam location discrepancy on the Canard River tributary near Port Williams

6 Limitations of NSWAP Part A

As a product of the definition of the scopeof NSWAP Part A, there are three important limitations that need to be addressed in the next stages of the assessment: 1) lack of evaluation at a sub-basin scale and for priority areas, 2) lack of inclusion of point/time-series water quality information in the assessment, and, 3) lack of information of water budget information and subsequent inability to assess the risk to available water.

6.1 Lack of Sub-basin Analysis

There is a need for the NSWAP watershed impact indicators to be assessed at the sub-basin scale (Figure 9), and in key areas of interest. The coarse-scale of watersheds analyzed in Part A result in the under-representation of smaller "hotspot" areas. This can occur when watershed indicator values are averaged over a large watershed area. For example, in the case of potential acid rock drainage stress, the Sackville residual watershed is ranked as "medium", but the sub-basin of the Sackville residual watershed that includes the Halifax Peninsula has a large proportion of its area classified as potential acid rock drainage stress (Figure 10).

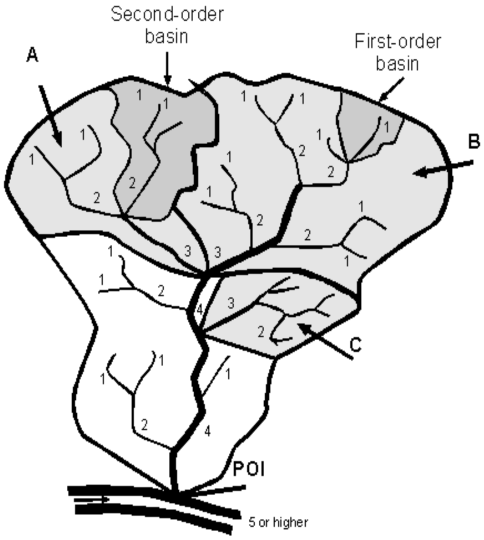


Figure 9. Example of watershed sub-basins, as defined by stream order, following the Watershed Assessment Procedure of British Columbia (Forest Practices Code of BC Act 1995). POI is the point of interest for the watershed.

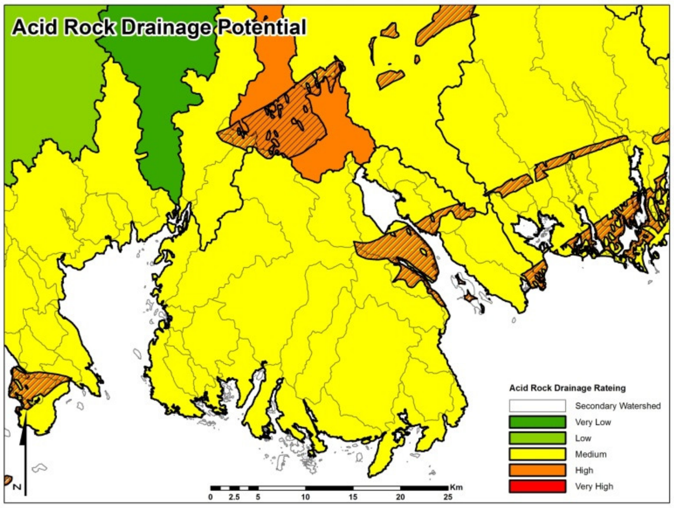


Figure 10. The importance in analyzing the watershed status indicators at the sub-basin scale. An example of acid rock drainage potential in the Halifax Peninsula.

In addition, the watershed impact indicators should be analyzed for priority areas. Some areas of residual watersheds, for example, along the Eastern Shore and the South Shore, have major population centres and citizens may wish to target the analysis for the sub-basin watersheds for these centres. Another example is the Bras d'Or Lake drainage basin. While the area that drains into Bras d'Or lake is not technically a major watershed the area contains many watersheds of significance and the citizens in the area may wish to know the characteristics of the land that drains into this important community resource (Figure 11), particularly since the Bras d'Or Lake has a low rate of circulation.

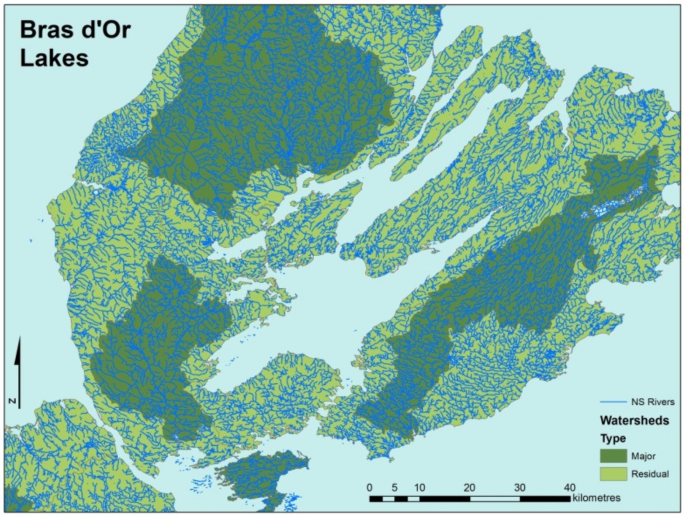


Figure 11. Major and Residual watersheds surrounding the Bras d'Or Lake - an example of a potential area for re-calculation of watershed impact indicators.

6.2 Water Quality Information

The scope of Part A is limited to geospatial information that was readily available at the start of the NSWAP Part A, January 2011. There is much data on water quality collected in Nova Scotia. But because water quality data is most often time-series data collected at a point, and not summarized at the provincial level, it could not included in this analysis. As a result, current information on the concentrations of water constituents such as nitrate, phosphorus, and organic compounds are not included in the watershed assessments.

6.3 Water Quantity Information

A limitation of the NSWAP Part A is the lack of information on water budgets for Nova Scotia. The NSWAP includes a summary of surface and groundwater usage (Surface Water Usage U_S and Groundwater Usage U_G), but without comparison to the amount of available water in each watershed, the risk for changes to available water and water quantity cannot be established. To do this, annual average water budgets (precipitation, evapotranspiration, and runoff) and need to be estimated. It is also recommended water budgets also be estimated for the future, for example, for 2050 and 2100 future scenarios – this calculation can be based on ensemble climate model projections (as in Campbell et al., 2011). The completion of this analysis will address four key questions for integrated water management:

- What parts of Nova Scotia are at risk for water shortages?
- Where in Nova Scotia is more at risk for flooding?
- What have been the trends from climate change in the past 20 years?

- Which areas are most likely to have increased flooding or reduced available water in 2050 and 2100?

7 Recommendations for NSWAP Next Steps

7.1 High Priority Recommendations.

We recommend three items as high priority for future work on the NSWAP in order to address the key limitations identified above:

1. **Conduct Sub-Basin Analysis**. Conduct the NSWAP impact indicator analysis at a sub-basin scale and for priority areas,
2. **Incorporate Water Quality Data**. Include more water quality data in the assessment, and include water quality data in the NSWAP Geodatabase.
3. **Calculate Water Budgets**. Calculate water budgets, particularly the amount of available water in each watershed, so that managers can determine which areas are at greatest risk for water shortages and increased flooding.

7.2 Other Recommendations

1. Include non-provincial-scale data in the geodatabase, including data from municipalities and community groups;
2. Include non-government data into the geodatabase, for example, previous studies on Nova Scotia such as Cheng and Lee, 2009.
3. Break down land cover analysis into separate anthropogenic land covers (e.g., divide anthropogenic land cover for the watershed impact indicator "L_A" into agriculture, forestry, secondary forest, and urban areas;
4. Analyze the values of the watershed impact indicators, beyond the ranking comparison conducted here. This will improve the identification of which watersheds are actually at risk, instead of "more or less" at risk;
5. Add forest roads from a forest road layer to the road layer from the NSTDB;
6. Link the geodatabase with other initiatives such as CURA H_2O, Community-Based Watershed Monitoring (Conrad, 2011);
7. Include existing flood plain area mapping from the federal Flood Damage Reduction Program to assess risk;
8. Include point source data such as Municipal Wastewater Sites, other industrial discharge locations, landfills, and areas of land serviced by sewage treatment plants;
9. Incorporate wetlands mapping layer into the assessment; and
10. Incorporate other areas of significance such as drinking water supply areas, protected water areas, salmon habitat, and Canadian Heritage Rivers.

8 Project Team and Acknowledgements

The project team includes the following individuals

Name	Affiliation	Role
Peter Horne	Hydrologic Systems Research Group, Environmental Science, Dalhousie University	Creator of geodatabase Designer of models Research associate Report production
Dr. Shannon Sterling	PI, Hydrologic Systems Research Group, Environmental Science, Dalhousie University	Project Director Scientific Advisor Report Production Initiated and designed NSWAP
Kevin Garroway (MSc)	Nova Scotia Environment	Advisor and partner on Geodatabase and NSWAP Part A implementation
Gavin Kennedy (MSc, PGeo)	Nova Scotia Department of Natural Resources	Advisor and partner on Geodatabase and NSWAP Part A implementation
Charlie Williams	Nova Scotia Environment	
Emily Rideout	Hydrologic Systems Research Group, Dalhousie University	Report production Riparian zone assessment Honours student
Gillian Fielding	Hydrologic Systems Research Group, Dalhousie University	Dam and upstream river analysis Honours student
Jessica Paterson	Nova Scotia Environment	Initation of NSWAP
John Theakston	Nova Scotia Environment	Initiation of NSWAP
Anthony Kelly	Hydrologic Systems Research Group, Dalhousie University	Research assistant Production of report cards

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10 Appendix A. List of Geospatial Layers used in the NSWAP Part A Analysis

Data Layer	Type	Description	Year last update	Source
NS Hydrologic Network	Flow-line	Stream network for Nova Scotia	Missing	Nova Scotia Hydrographic Network is derived from the Nova Scotia Topographic Database (NSTDB).
	Coastline	Outline of the coast and Islands	2007	
	Obstacle	Dams both man-made and natural	2005	
	Shoreline Bank	Outline of river banks, lakes and shorelines	2007	
	Virtual Lines Separating Water Bodies	Line of intersection for lakes , rivers and coastlines	2007	
	Rapids	Area of rapids	2006	
	Virtual Neat Line	Connecting line segment end-points of rivers, lakes, and coastlines	2006	
Dam_From_NSE_Oct_2010	Dam	Water control structure inventory, in progress.	2010	Nova Scotia Environment
	Fish Ladder	Presence or absence of fish ladder. No indication of functioning status.	2010	
NS Topographic Database	Road Network	Roads within Nova Scotia	2004	Nova Scotia Topographic Database (NSTDB) Copyright Her Majesty the Queen in Right of the Province of Nova Scotia
	Contours	Contour lines at 5 m intervals	2005	
	Culverts	Culvert lines	2003	
NS Forestry Landcover	Land Cover	Land cover class (e.g., Forested, Urban, Wetlands, Barren)	2006	Nova Scotia Department of Natural Resources
	Wetland	Marsh, swamp, saltmarsh, open water, bog or fen	Missing	
National Soils Database	Soil Drainage	Rating of soil drainage from very poor to rapid	1960's	CanSIS
NS Watersheds	Primary Watersheds	Primary watersheds within NS	*2010*	Province of Nova Scotia
	Secondary Watersheds	Secondary watersheds within NS	*2010*	
NS_Agri_Inventory	Agricultural	Agricultural land use within NS	1997	Agricultural Lands Inventory Program
Geology	Surficial	Surfical geology for the Province of NS	1993	Province of Nova Scotia, compiled by R. R. Stea, H. Conley and Y. Brown, 1992
	Bedrock	Bedrock geology for the Province of NS	2000	Province of Nova Scotia, compiled by J. D. Keppie, 2000
RLUL	Multiple Land Uses	Multiple land use types (e.g., parks, wilderness sites)		Province of Nova Scotia
Water Withdrawl	Groundwater	Groundwater withdrawal from wells	2010	Nova Scotia Department of Natural Resources
	Surface Water	Surface water withdrawal	2010	Province of Nova Scotia
IDW_Alk	Acid Neutralization Capacity	Gran titration ANC interpolated from stream measurements throughout Nova Scotia	2007	Tomas A. Clair, Environment Canada

11 Appendix B. Method Pages

12 Appendix C: Watershed Impact Indicator Maps

13 Appendix D: Ranking of Watersheds by Watershed Impact Indicator

14 Appendix E: Watershed Report Cards