

**Contract No.: G-0515-204-00-D**

**WORLD WILDLIFE FUND CANADA**

**FLOW AND FLOOD EXTENT MAPPING  
FOR SELECT ST. JOHN RIVER VALLEY COMMUNITIES**

**FINAL PROJECT REPORT**

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### **Background and Purpose**

This project was supported by WWF-Canada with the general aim to produce maps that enable communities to visualize the hydrological conditions within and around their areas, at high resolution. Having such maps enables collaborative communications and actions to restore and sustain the health of the St. John River and its water-contributing watersheds. The communities selected for this project refer to Florenceville-Bristol, Hartland, Woodstock, Meductic, and Nackawic. The specific objective of this project refers to the mapping of drainage-challenged and flood-prone areas using Light Detection and Ranging (LiDAR) Digital Elevation Model (DEM) data, as outlined and analyzed by Murphy et al. ( 2009, 2001). In detail, the mapping effort refers to:

1. Delineating all areas that would flood, with and without roads and bridges being completely blocked.
2. Delineating depressed areas where water would pool.
3. Extending the mapping beyond the LiDAR DEM coverage, using best available provincial DEM at 10 m resolution.
4. Refining the mapping with community information regarding hydrological infrastructure (culvert locations, ditches, stormwater lines).
5. Presenting the project results to community representatives, and delivering the project results to WWF (c/o Simon Mitchell)

### **Data Compilation**

The project-used data refer to bare-earth and full-feature LiDAR DEM datasets at 1m resolution (from Leading Edge Geomatics Inc.) for the St. John River bordering communities of Florenceville-Bristol, Hartland, Woodstock, Meductic, and Nackawic. Additional GIS data sources were also as follows:

- NB Provincial bare-earth DEM data at 10m resolution (for areas beyond community LiDAR data extent)

- State of Maine bare-earth LiDAR data at 2 foot resolution (eastern Canada / US border area)
- State of Maine NED data bare-earth data at 10m resolution (used for Meduxnekeag River)
- NB Provincial hydrological network data (mapped streams, wetlands, and waterbodies)
- State of Maine hydrological network data (mapped streams, wetlands, and waterbodies)
- NB Provincial road network and infrastructure data
- State of Maine road network and infrastructure data
- Google satellite imagery
- SNB aerial photo imagery
- Soil survey and surficial geology maps
- Landuse data / maps
- Additional hydrological infrastructure data (available for Woodstock only)



**Figure 1.** Topographical map identifying communities and their primary contributing watersheds. Orange highlighted boundaries represent the extent of high-resolution DEM data (LiDAR). Red dots represent the flow-point at which major contributing watershed areas were delineated.

## Procedures

ArcMAP software and tools were used for deriving the main project deliverables (see below). Careful attention was given to bring out the best conformance between the DEM-derived flow channels and actual stream channels. This was done through manually breaching elevated roadbeds to ensure flow continuity through engineered structures such as bridges, culverts, and dams. Prime locations for breaching are those locations where the unbreached LiDAR-derived DEMs imply major water impoundments upslope of roads. These would actually be incurred in case culverts and bridges are blocked. Manual attention also needed to be given towards connecting the 10-m resolution derived flow channels with the 1-m derived flow channels along the LiDAR-DEM border. The stormwater lines of the hydrological infrastructure data layer for Woodstock were burnt 2 m into the LiDAR DEM to direct the DEM-based flow accumulation algorithm to direct adjacent water flow downwards into and through these lines.

Since road-stream crossings are vulnerable to flooding and wash-outs, the project included determining the basin areas above each such crossing, in hectares. These areas can then be used to determine stream discharge rates for any particular storm event, which – in turn – suggests which culvert diameters or bridge spans would be needed to accommodate major storm events (e.g., 100 year storm events).

For the project, a distinction was made between riverine flooding and stream- and depression-based flooding. The former occurs when the river rises. The latter occurs during each storm event which may not necessarily lead to significant river flooding. The zero-point for flooding (cartographic zero depth to water, or DTW = 0) was set equal to full channel widths and shore lines. Areas subject to potential riverine flood risk were projected to extend up to 15m above the river banks, in m intervals, to include the elevation extent of any historical and possibly expected flood events (e.g., Spring 1987 flood +43.9m ASL in Woodstock; Spring 2008 flood +47.91m ASL in Hartland).

The mapping of wet areas, soil drainage and riverine as well as stream-based flooding at 10 m was done by incorporating all already mapped water / stream features. The LiDAR-DEM 1m-resolution wet-areas and stream flooding maps (“WAMs”) were produced for all five communities, with upslope streamflow initiating areas of 4, 2, 1, 0.25 ha. The 4 ha and 0.25 ha thresholds correspond to local water-filled stream channel networks during late summer and spring after snowmelt, respectively. The other thresholds emulate the change in flow network and wet-area extent from high to low soil saturation conditions. Of special note are the wet-area maps that correspond to the 1-ha flow-initiation stream network, because this particular network can be used to determine where to start placing small to temporary culverts across roads and trails.

Since the communities need to be cognizant of the entire watershed areas that feed water into and through the communities, it was deemed important to stretch the mapping of wet-areas and flood extent beyond the area-limited LiDAR DEM extent.

The do so, it was necessary to update of several GIS and DEM data layers, by extending the mapping / modeling across the Canada – US border into the State of Maine. For this purpose, high-resolution LiDAR and coarser-gridded provincial and NED DEMs were used together with current (i) land use: forested versus non-forested or cleared landcover, (ii) hydrological network, and (iii) wetlands. Figure 2 provides an updated topographic map for the Meduxnekeag River Watershed drainage basin.



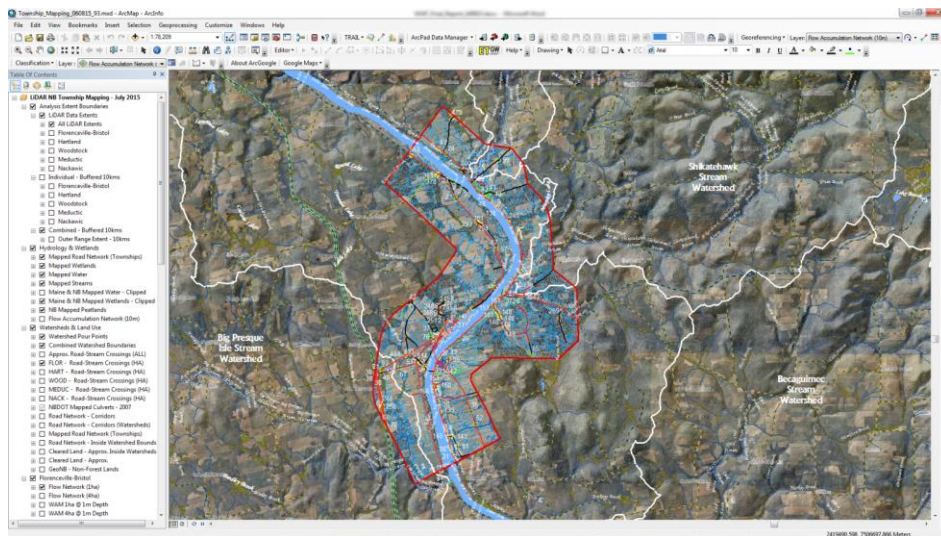
**Figure 2.** Topographic map for the Meduxnekeag River Watershed drainage basin.

## Project Deliverables

1. Community / township maps in GeoPDF format (36"x36" @ 600dpi resolution – 500MB per map document), for Florenceville-Bristol, Hartland, Woodstock, Meductic, Nackawic.
2. Full and complete working ARCGIS mapping projects (with all associated data – Figure 3)
3. Additional full and complete ARCGIS mapping project & data for the Meduxnekeag River Watershed
4. Project presentations, attended by community representatives, and organized by Kim Reeder and Simon Mitchell
5. Printed posters for each community regarding wet-areas & flood risk mapping (See attached maps).
6. All GIS data, GeoPDF documents, and related information including the power-point presentations were provided on an external hard drives (Kim Reeder and Simon Mitchell).

While not included, the project deliverables can also be used

- a. to inform locations with erosion and mudslide hazards,
- b. to build new trails and roads or to relocate these towards less vulnerable locations
- c. to ascertain which areas are affected by the spreading of waterborne spills
- d. to provide base layers for hydrologically based municipal planning regarding the placement of residential, industrial, and conservation developments
- e. to ascertain off-road trafficability by weather/season
- f. to map crop yields as affected by soil drainage across fields
- g. to delineate vegetation type and habitats based on soil moisture regime preferences



**Figure 3.** ArcMap GIS project deliverable snapshot, focused on the northern most community of Florenceville-Bristol.

## Acknowledgements

This project was in part supported by WWF. ACASA provided the financial support to acquire the LiDAR DEMs from Leading Edge Geomatics. The acquisition of the Maine DEMs (LiDAR and otherwise) occurred through University of Maine (CFRU) supported research initiatives. The refinement of the NB DEMs occurred through NB ETF support. We much appreciate the facilitative support received from Jeff Hoyt and Reed McLean (NBELG), Kim Reeder, and Simon Mitchell (WWF). Technical assistance was provided by Brittany Hartery and Clara Ndekuringe Dennis.

## References

- P.N.C. Murphy, J. Ogilvie, P.A. Arp. 2009. [Topographic modelling of soil moisture conditions: a comparison and verification of two models](#). *European Journal of Soil Science*. 60:94-109.
- P.N.C. Murphy, J. Ogilvie, F.-R. Meng, B. White, J.S. Bhatti, P. Arp. 2011. [Modelling and mapping topographic variations in forest soils at high resolution: A case study](#). *Ecol. Model.* 222:2314-2332.

## Appendix

### **Wet-areas and Stream and River Flooding Projections for Florenceville-Bristol, Hartland, Woodstock, Meductic, and Nackawik along the Saint John River in New Brunswick.**

The following five community posters locate the following hydrologically relevant features:

- Wetlands
- Flood extent 2008
- Roads and culvert sizes
- Depression depths
- Cartographic depth to water along stream channels, also indicative of the extent of stream-based flooding at 0.1, 0.25, 05, and 1 m depth
- Riverine flood extent, in 1 m intervals, up to 12 m
- LiDAR DEM extent, graded by elevation, showing elevation of all features (bare-ground, houses, trees)
- LiDAR DEM extent surrounded by NB satellite imagery (geoNB), roads, and culvert locations and size.

# Flood extent, depressions, and wet areas mapping: Nackawik, NB

0 0.5 1 km

## Wetlands



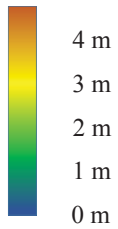
## Flood extent

2008

## Culvert size

- 0.6 m
- 1.2 m
- 1.8 m
- 2.8 m

## Depression depth

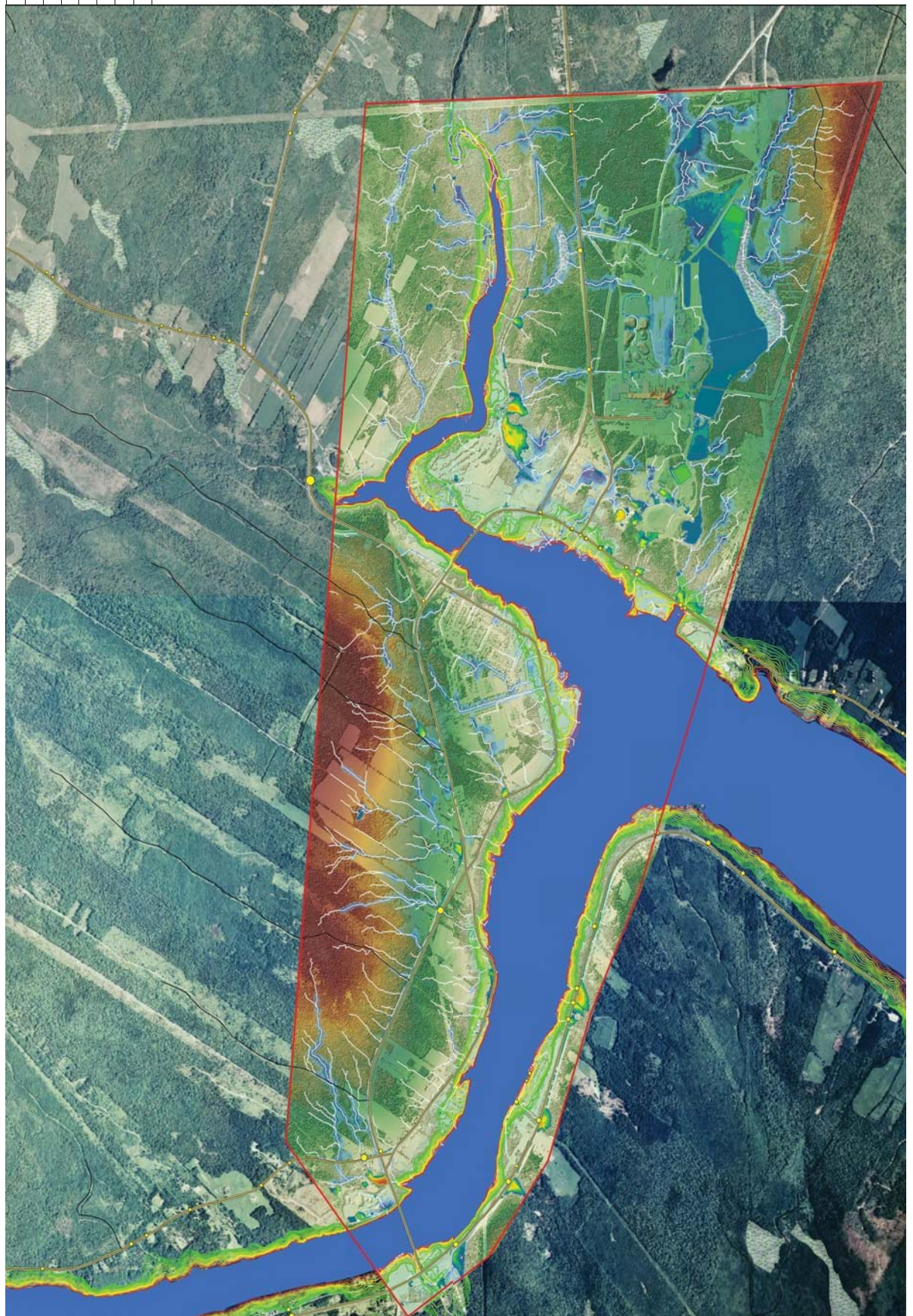
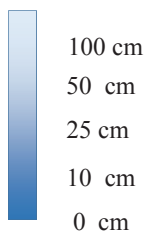


## Flood contours above Saint John River, LiDAR elevation, m

- 2
- 4
- 6
- 12

## Wet-areas mapping, by depth-to-water classes (DTW) from all flow channels with a 4 ha flow initiation area

## DTW



# Flood extent, depressions, and wet areas mapping: Florenceville – Bath, NB

0 1 2 km

## High-lighted area

Full-feature  
LiDAR DEM

showing  
buildings, trees

White lines:  
Flow channels,  
with 1 ha flow initiation

## Wetlands

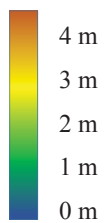


## Flood extent 2008

## Culvert size

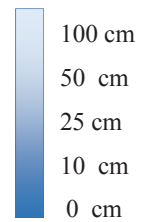
- 0.6 m
- 1.2 m
- 1.8 m
- 2.8 m

## Depression depth

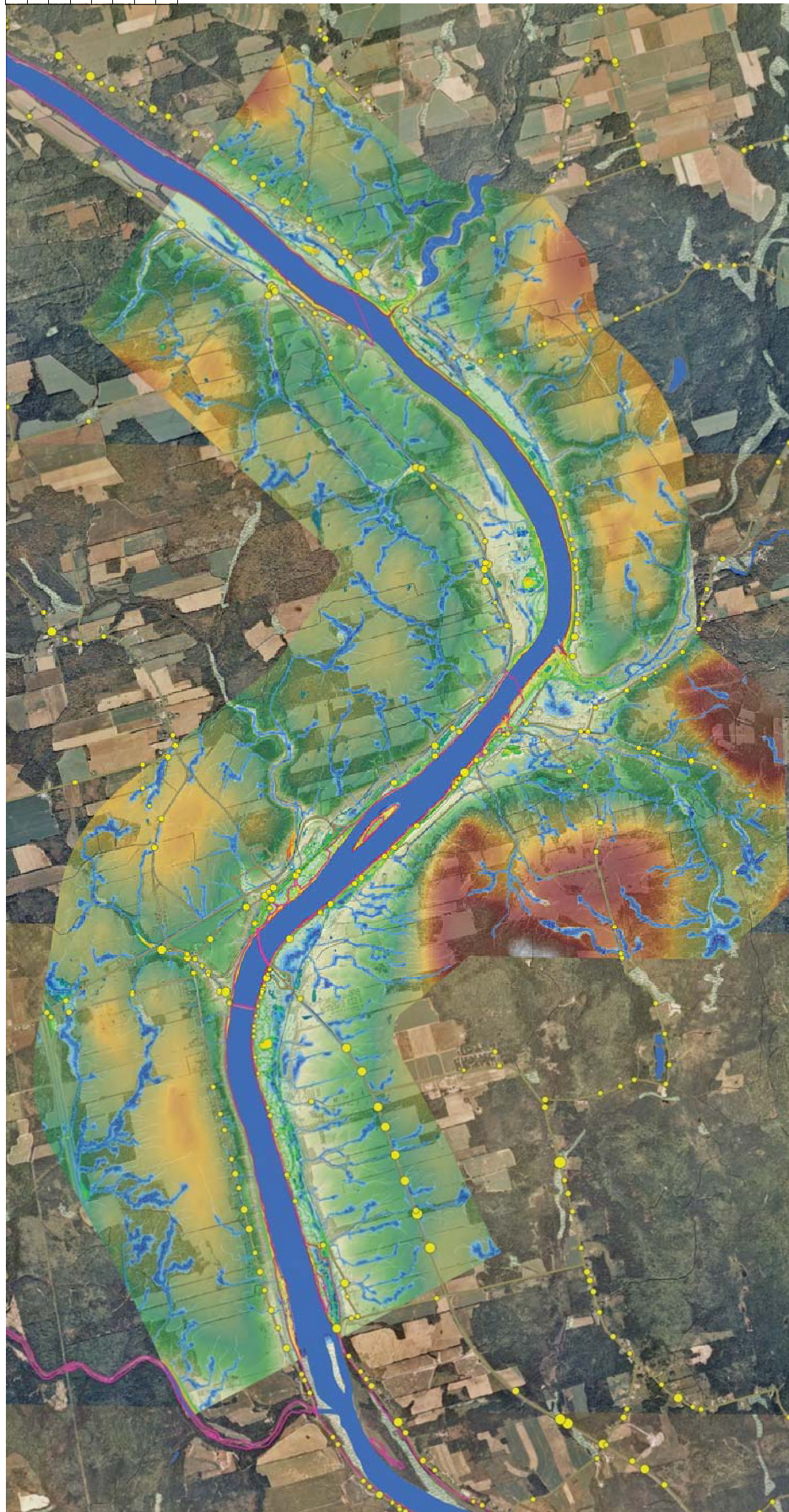


**Wet-areas  
mapping, by  
depth-to-  
water classes  
(DTW) from  
all flow  
channels with a  
4 ha flow  
initiation  
area**

## DTW



**Flood  
contours  
above Saint  
John River,  
LiDAR  
elevation,  
m**



# Flood extent, depressions, and wet areas mapping: Meductic, NB



**Wetlands**  



**Flood Extent 2008**  


**Culvert size**  
 • 0.6 m  
 • 1.2 m  
 • 1.8 m  
 • 2.8 m


**Depression depth**  


**Wet-areas mapping, by depth-to-water classes (DTW) from all flow channels with a 4 ha flow initiation area**

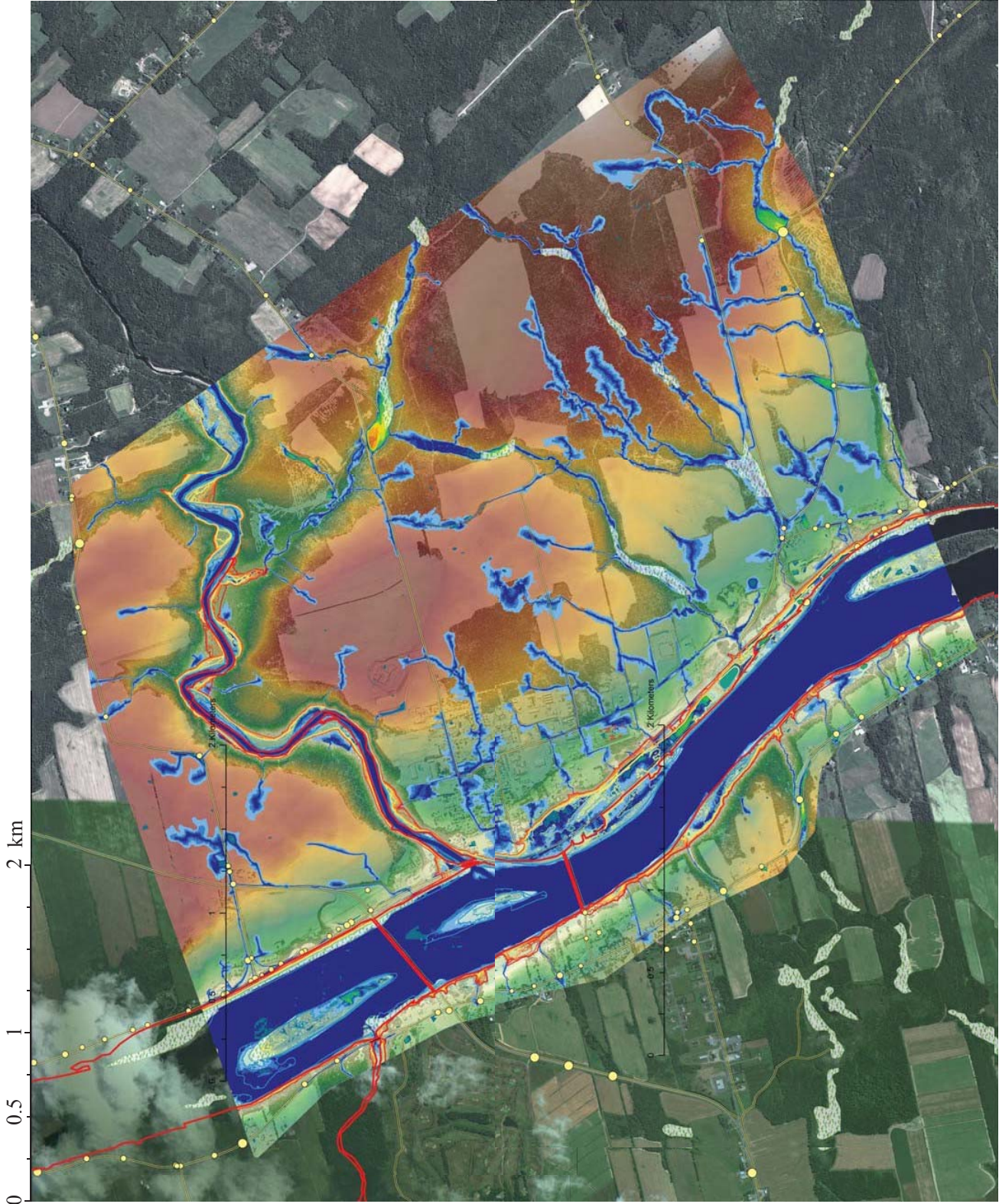
**DTW**  
 100 cm  
 50 cm  
 25 cm  
 10 cm  
 0 cm



**Flood contours above Saint John River, LiDAR elevation, m**  
 2  
 4  
 6  
 12



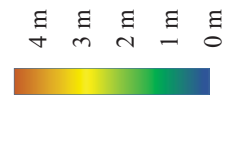
# Flood extent, blocked depression, and wet areas mapping: Hartland, NB



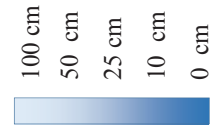
**Wetlands**  

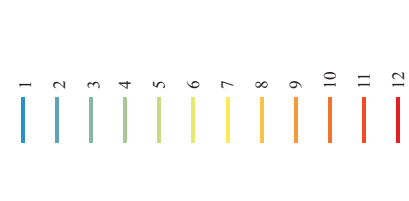

**Flood extent 2008**  


**Culvert size**  
 • 0.5 m  
 • 1.0 m  
 • 1.5 m

**Depression depth**  


**Wet-areas mapping, by depth-to-water classes (DTW) from all flow channels with a 4 ha flow initiation area**

**DTW**  
  
 100 cm  
 50 cm  
 25 cm  
 10 cm  
 0 cm

**Flood contours above Saint John River, LIDAR elevation, m**  
  
 1  
 2  
 3  
 4  
 5  
 6  
 7  
 8  
 9  
 10  
 11  
 12

# Flood extent, depressions, and wet areas mapping: Woodstock, NB

