WDPM Case Studies within the Land and Infrastructure Resiliency Assessment (LIRA) Framework

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Introduction to LIRA

- Sub-component of AAFC funded Climate Adaption and Resiliency Assessment (CARA) project (Lead: Harvey Hill
- Goal: Assist in identifying vulnerabilities to flooding and explore mitigation strategies within economic assessment frameworks
- Key input: inventory of land uses and on-the-ground assets intersected by potential flood hazards
- Phase 3 LIRA : First pilot study at Corman Park, SK (2010)
  - Key hydrologic / hydraulic modeling issues ☹

Phase 4 LIRA : Prairie Pilot Studies

- Wetland DEM Ponding Model runoff algorithm introduced as a diagnostic research tool for Prairies studies (fall 2010 - 2011)
  - Given current complexities of hydrological modeling and for simplicity: no consideration for infiltration, other water losses or antecedent conditions → DEM snapshot is the storage state condition
  - Key questions: Where might excess water flow across the landscape and accumulate? Which essential assets might be located in or near a flood hazard, or impacted by flooding elsewhere?
  - Key goal: identify potential runoff accumulation zones and backwater ponding areas; i.e. maximize *potential* flood hazard information at "hot spot" locations
  - Need to find reasonable way of associating potential flood hazard areas with the relative probability of such a flood event occurring??

Phase 4 LIRA: Refinement & Validation

Exploring methodology in different parts of the Country (2011 – 2013)

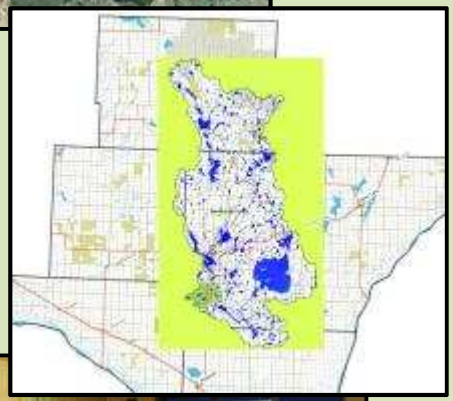
Lessons learned

Nappan, Nova Scotia

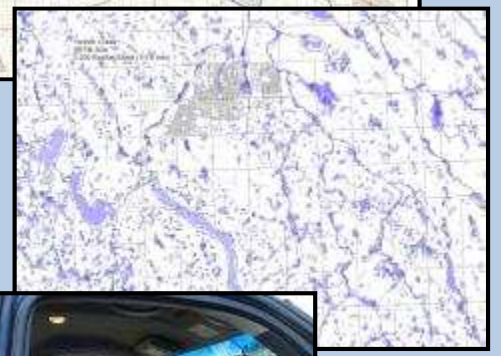
Storm surge concerns
Breaching of dykes
Protection of valuable ag land
Defined stream channels

Redberry Lake Watershed, SK

Typical prairie basin



Assiniboine River Watershed, SK



Application of WDPM for LIRA

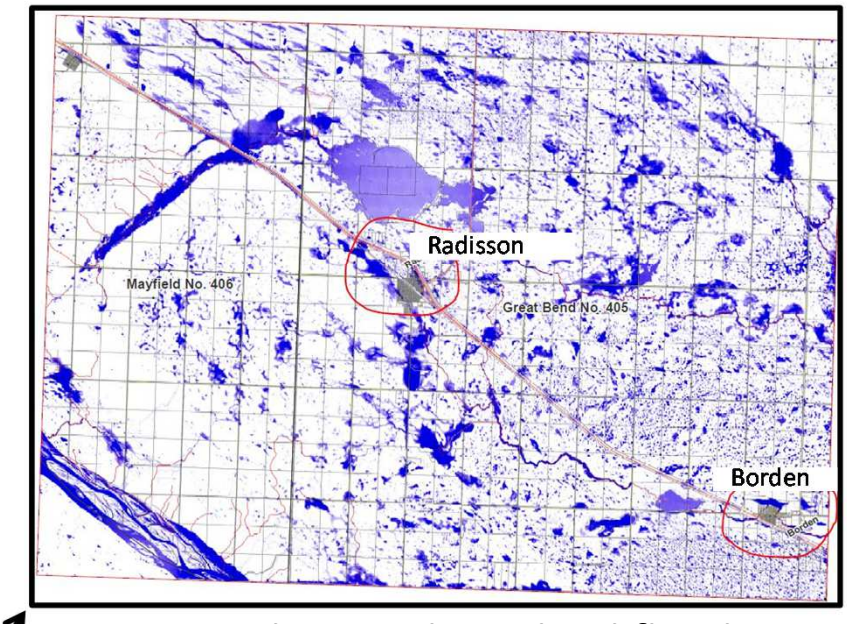
- There are various ways to determine reference water depths!
  1. A simple “What If” scenario to directly address community concerns: e.g. a Vanguard flood event; 300 mm applied to an entire DEM
  2. Extreme value analysis: 1:100 year maximum 24 hr accumulated rainfall totals applied to DEMs → not equivalent to the flood frequency return period!
  3. Probable maximum precipitation and IDF amounts adjusted for watershed areas; difficult for massive areas so not considered practical
  4. Physically-based hydrological modeling of prairie processes to determine distributed snow melt runoff depths; requires integration of Cold Region Hydrological Model (CRHM platform) analysis

- Options 1 and 2 were more practical: based on modeling complexities; given the time constraints; for a proof of concept for a new diagnostic approach

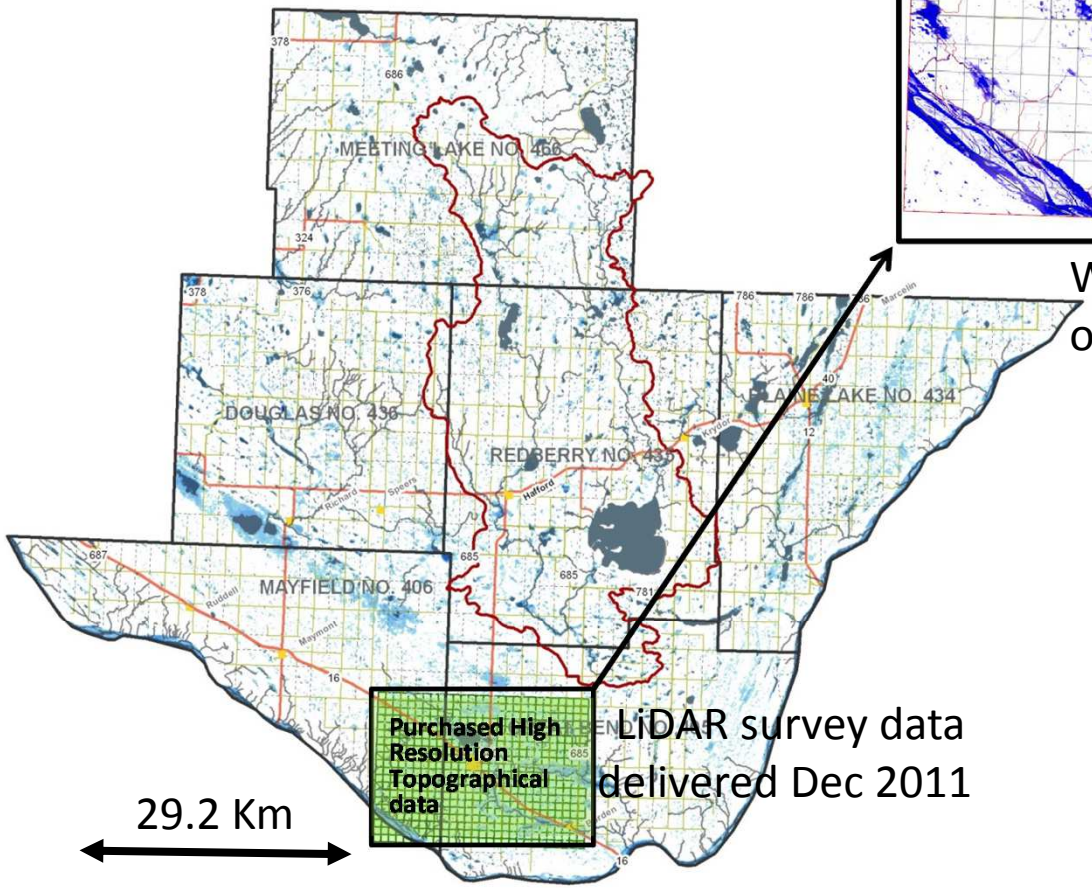
Redberry Lake LIRA Pilot Study example

Building Climate Resiliency through Adaptation

The value in data acquisition,
GIS analysis and landscape modeling



Widespread overland flooding occurred during the spring of 2013



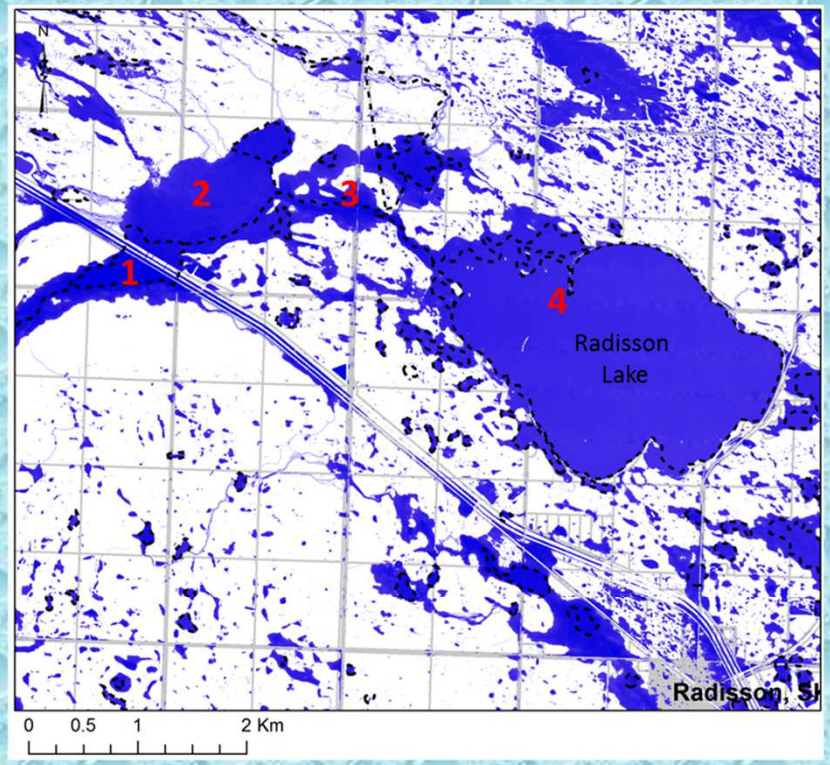
LiDAR survey data delivered Dec 2011

High Resolution Topographic data (Lidar) allows for more detailed:

1. Run-off hazard maps

2. Adaptation options

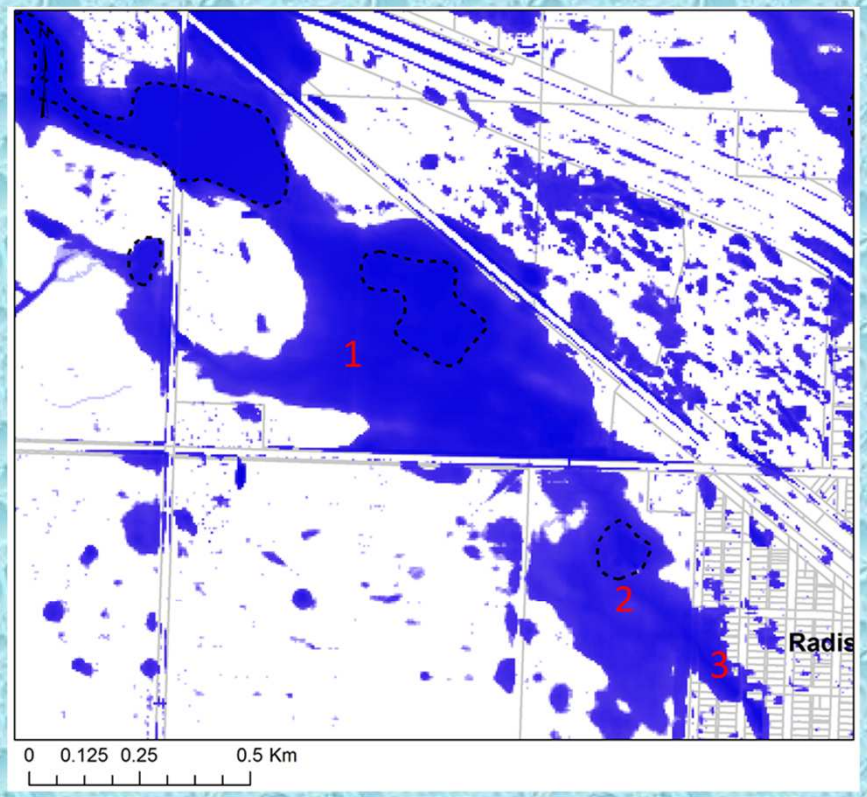
Radisson / Borden Region (100 mm applied)

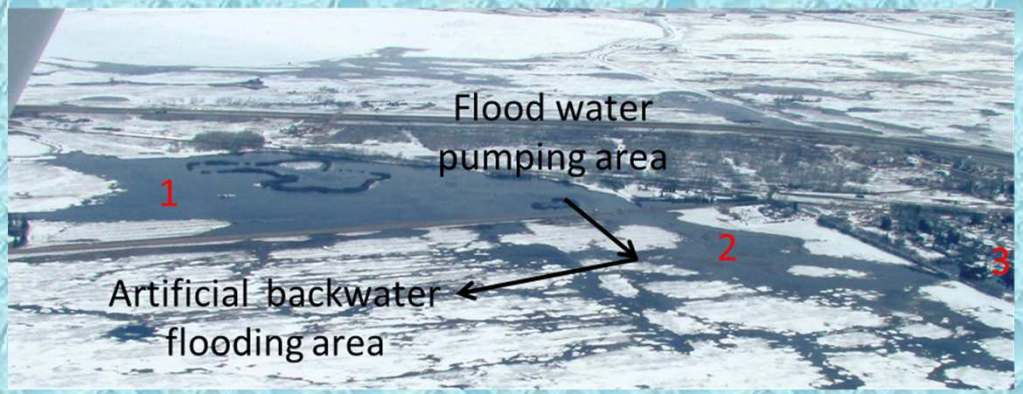


Dashed black lines show "known" hydrography

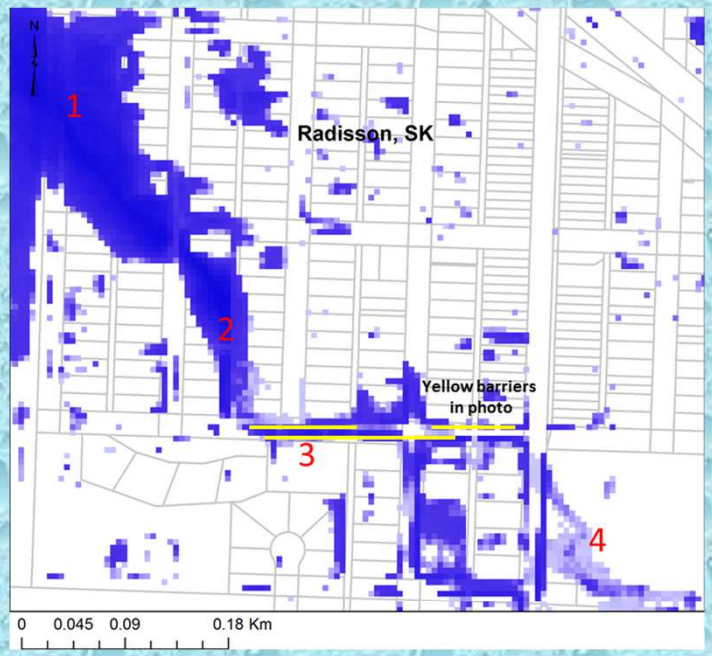
Some ponds and lakes known; linkages…not so much!

Radisson / Borden Region (100 mm applied)





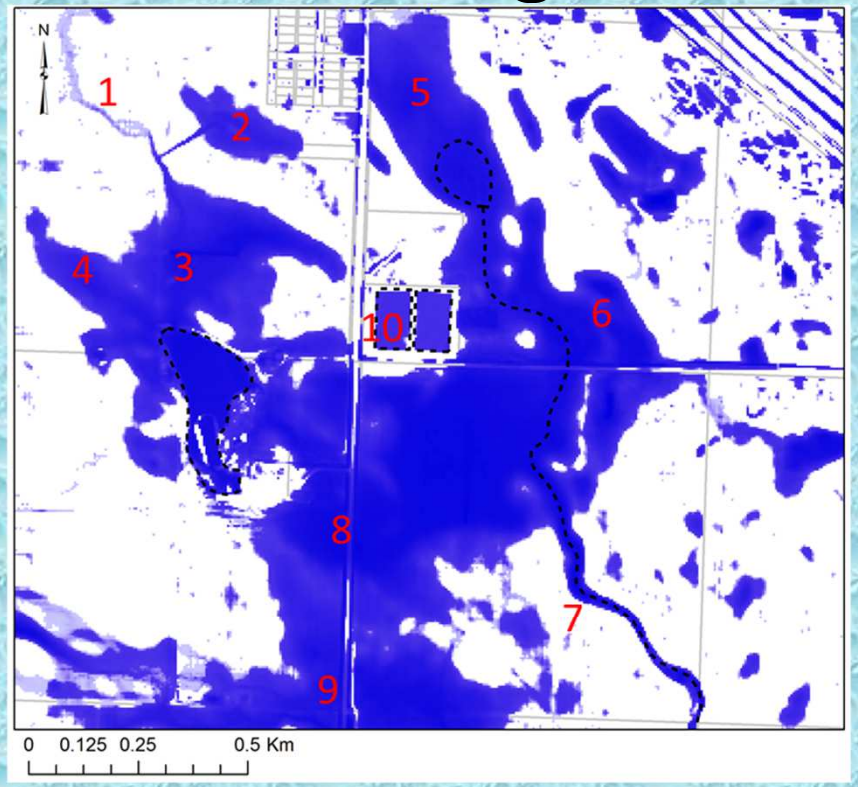
Radisson / Borden Region (100 mm applied)

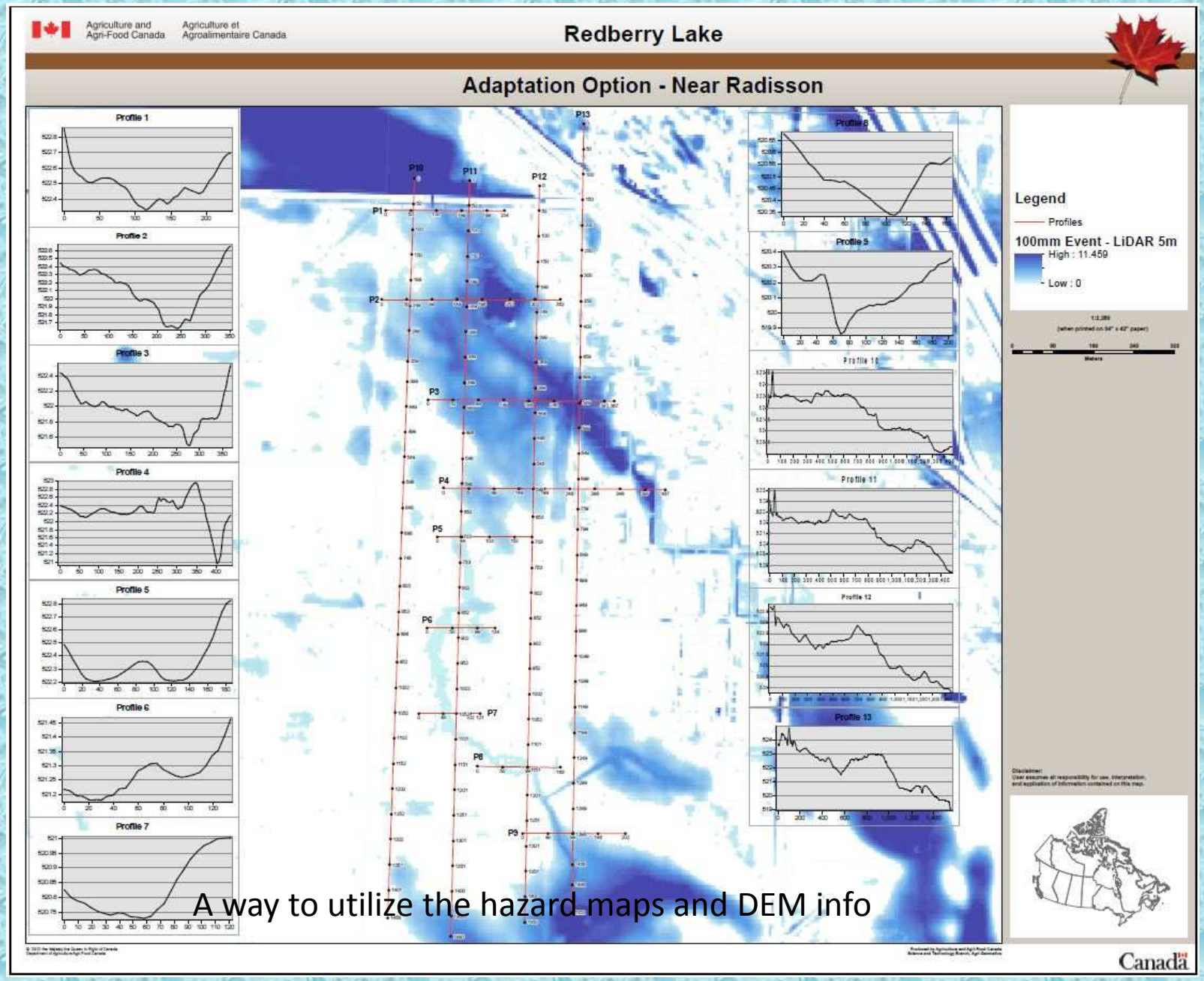


"still-water" flood hazard exceed extent of actively flowing water hazard

Flood controls where used in the town

Radisson / Borden Region (100 mm applied)





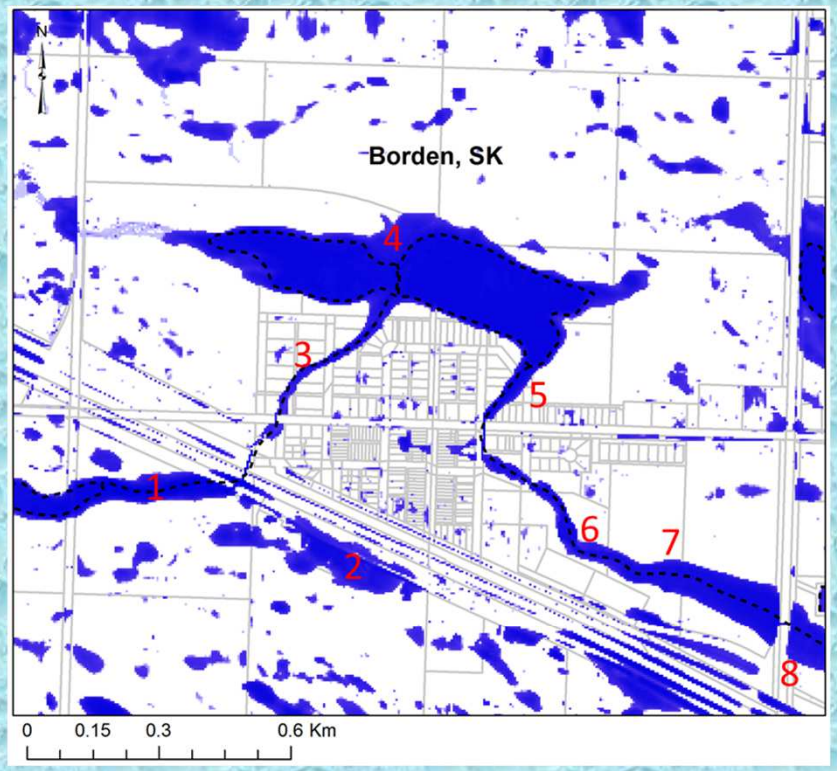
A way to utilize the hazard maps and DEM info

Surface Run-off Model Validation

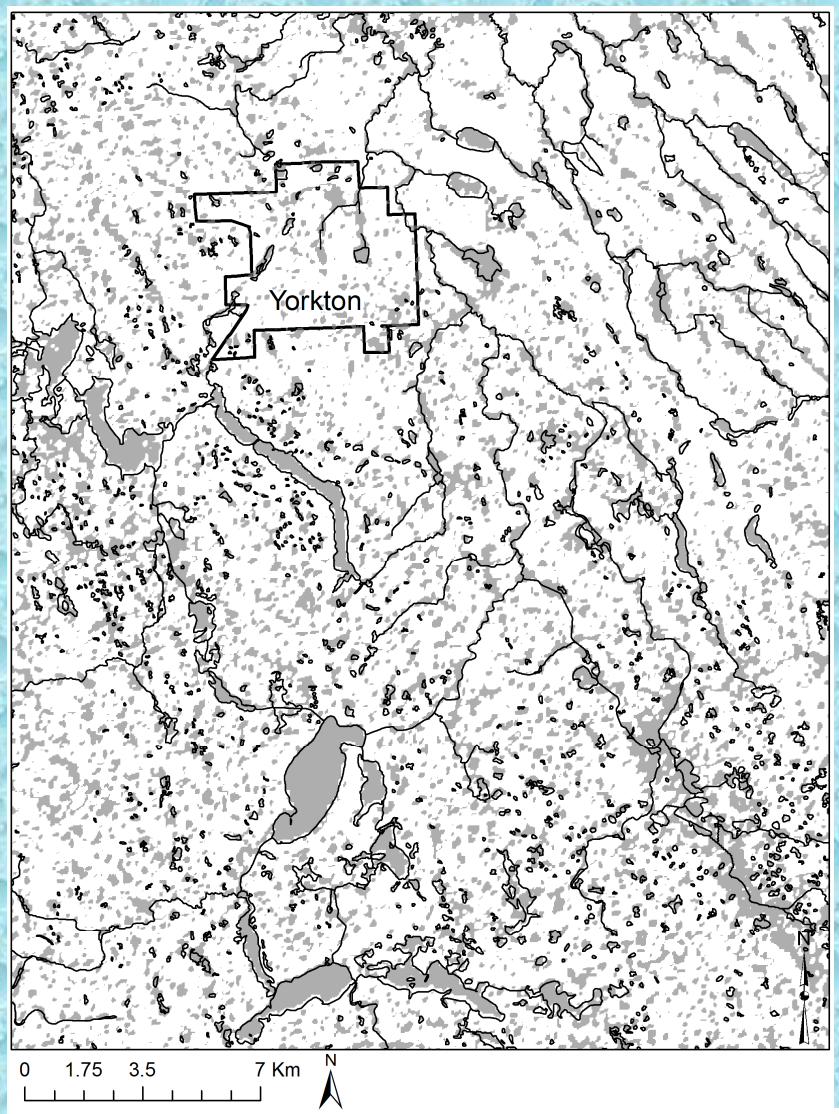
Are the runoff risk maps realistic? How useful is the information provided? Would this type of adaptation option prevented flood damages? Is it cost effective relative to any other options?

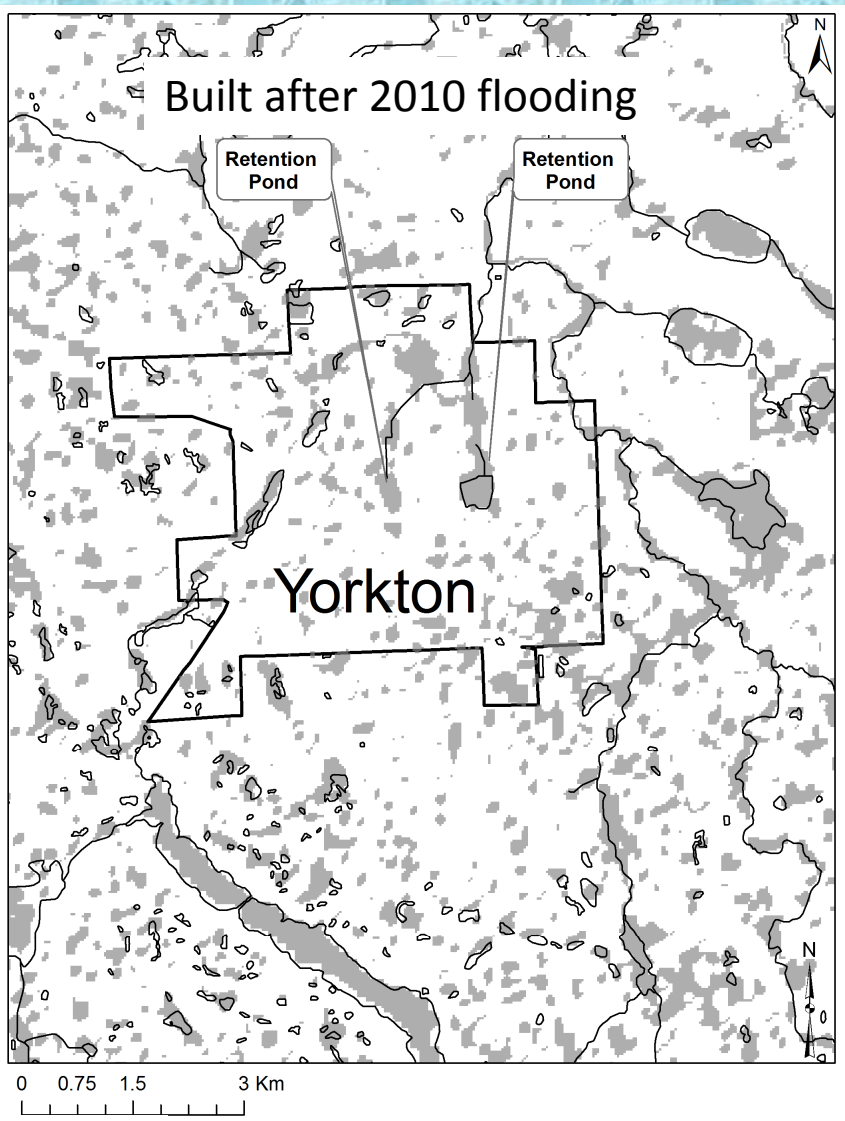
LiDAR 5m - Radisson (100mm Runoff)
Adaptation Scenario

Radisson / Borden Region (100 mm applied)



Assiniboine Watershed (~ 110 mm applied)

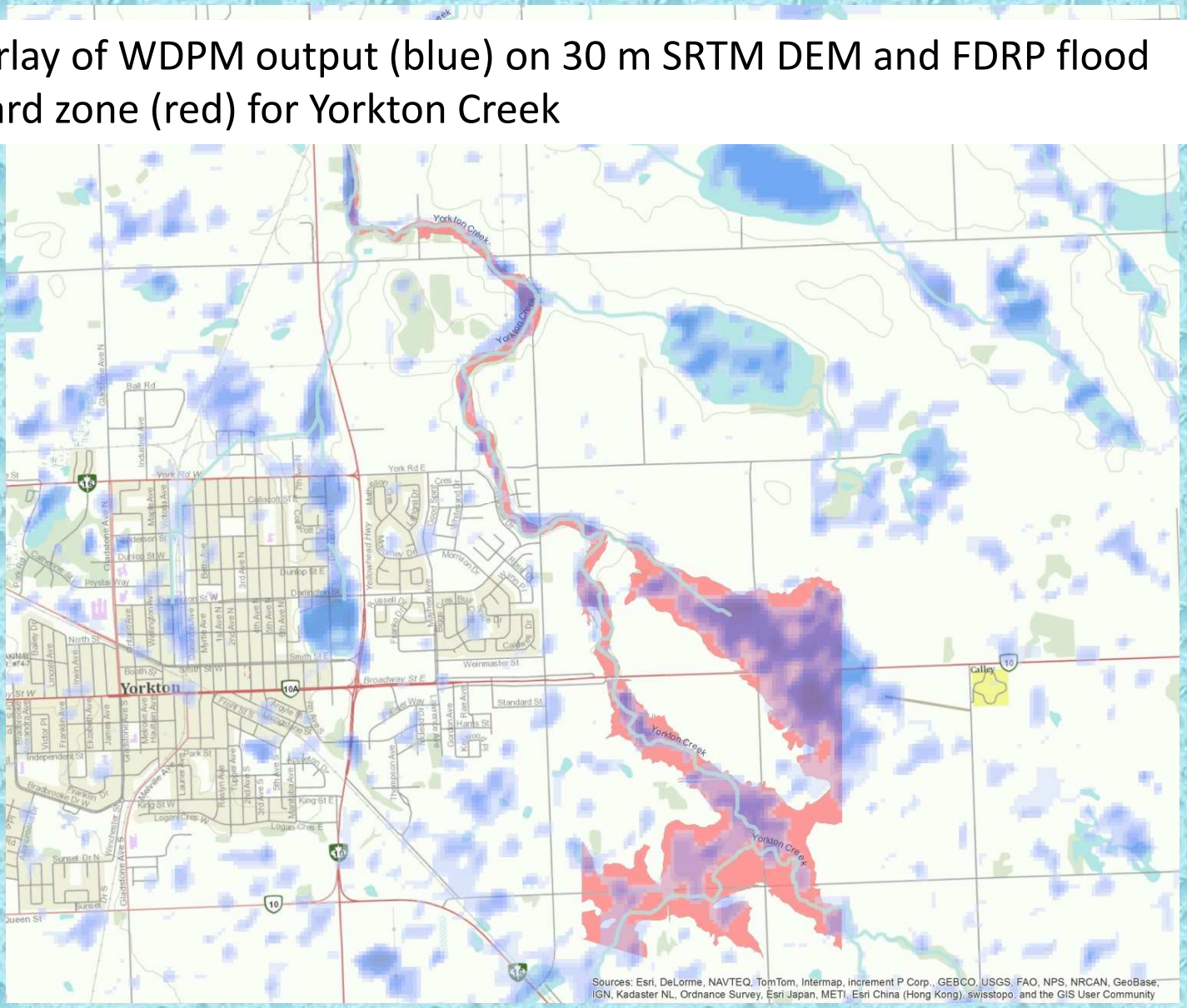




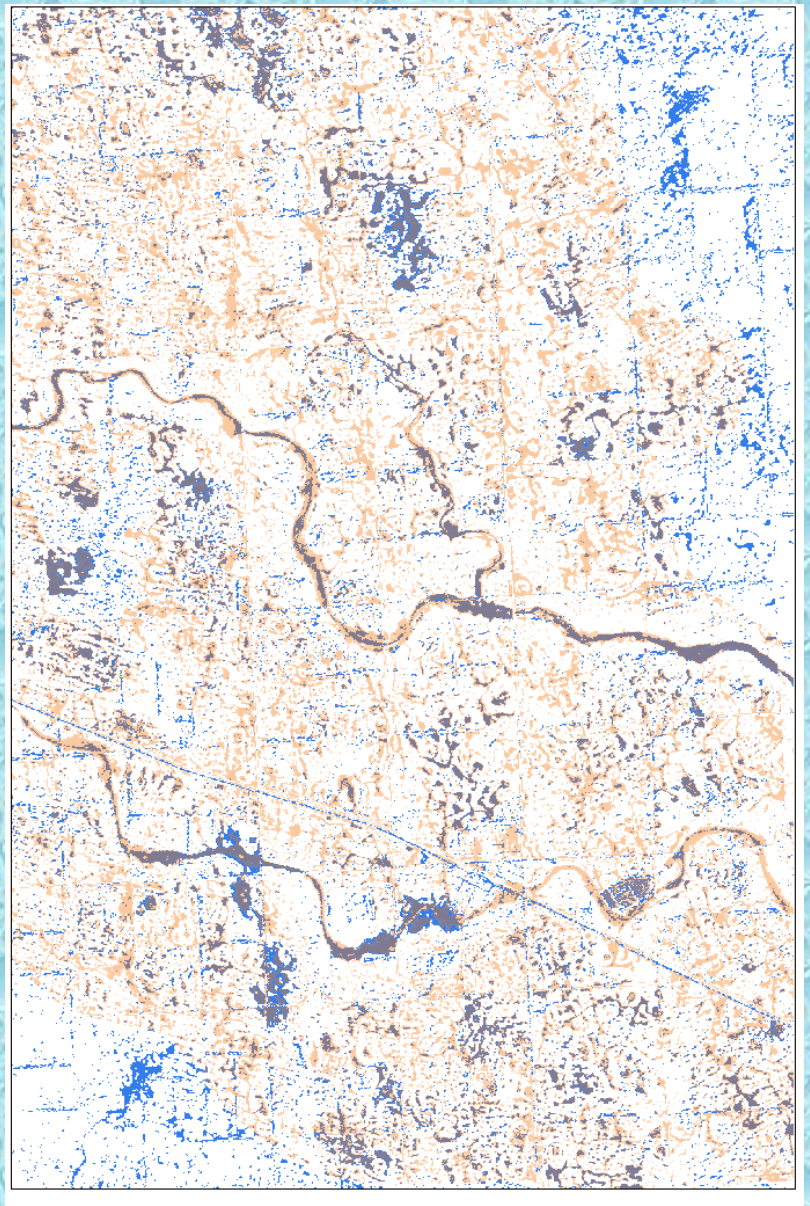
30 m SRTM DEM: currently offline

Assiniboine Watershed (~ 110 mm applied)

Overlay of WDPM output (blue) on 30 m SRTM DEM and FDRP flood hazard zone (red) for Yorkton Creek



Smith Creek (100 mm applied)



- SAR flood mask before main flooding (DUCs) in blue – SAR data not very accurate
- WDPM output in orange
- Dark grey = overlap

- Rapid eye imagery available after flooding (not shown)

- Smith Creek is highly drained and presents challenges
  - LiDAR already outdated at time of pilot study

- Drain algorithm not applied but might have been useful

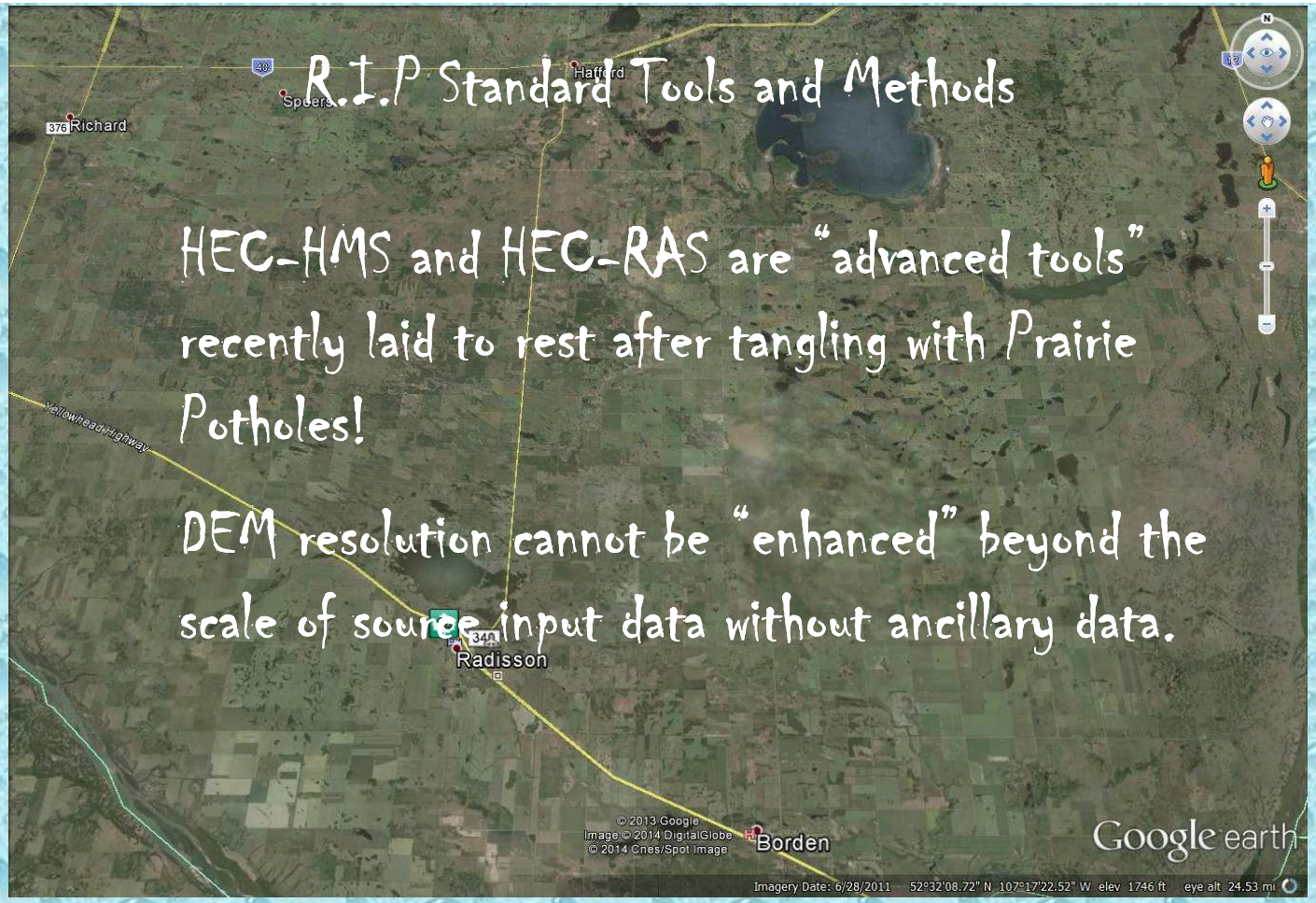
Flood masks are another way to verify the relative accuracy of flood hazard depictions

Value of WDPM within LIRA

- Simple, relatively fast and spatially explicit iterative simulation
- In the short term, it has allowed for ad-hoc flood hazard mapping in hydrologically complex environments
- The diagnostic level assessment is reasonably accurate overall and surprisingly detailed when LiDAR is available
- Has provided useful flood hazard information over entire landscapes which has not been previously available or possible
- Future improvement?? → Hydrologic analysis that provides runoff depth estimates that can be applied to a DEM

Welcome to the Prairie Pothole hydrological / hydrodynamic modeling Graveyard

- *User beware*: All DEMs contain errors and have limitations… especially where the prairie pothole region is concerned!!



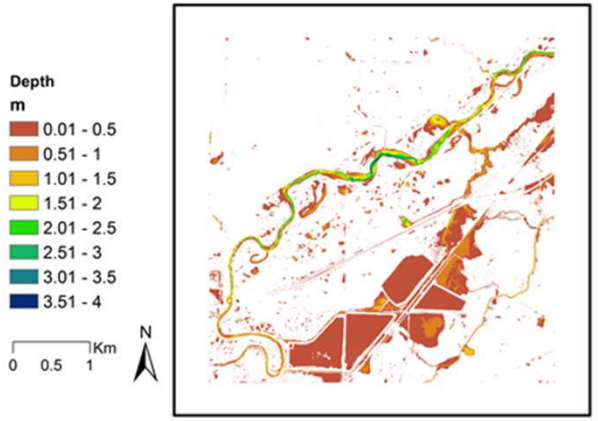
DEM Limitations and Issues

DEM Dataset	Cell Resol. (m)	Standard Format	Vertical Acc. (m)	General Issues
LiDAR	5	real	± 0.3 – 0.5	Cost; Data volume; Editing drainage connectivity among road networks (e.g. at culvert locations)
Ortho - DEM models	5, 20, 30	Integer OR real	± 1.5	Mathematical autocorrelation / interpolation issues; Subjectivity of ancillary data collection; Adequate capture of road networks
CDED	30	Integer	Varies by source data and location	Contour artifacts and integer format values result in terraced-like landscapes
SRTM	30 & 90	Real	± 12 – 16	Winter survey, backscatter (e.g. low relief, dense vegetation) & Grid coarseness
ASTER	30	Integer	± 20	“Mole runs” & 30-50 m deep pits

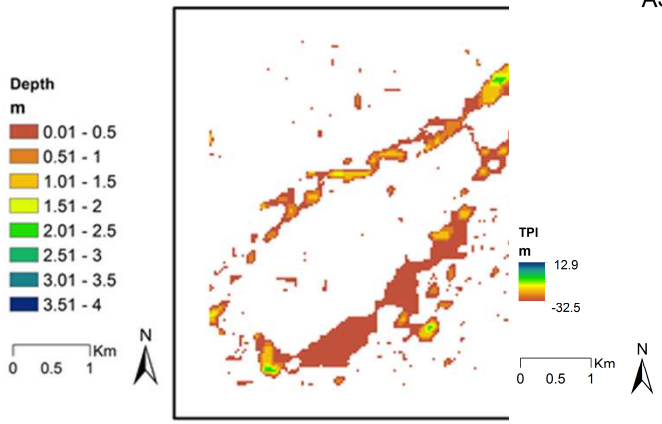
DEM Comparison Study:

Swift Current Creek, SK (80 m relief; 73 mm applied)

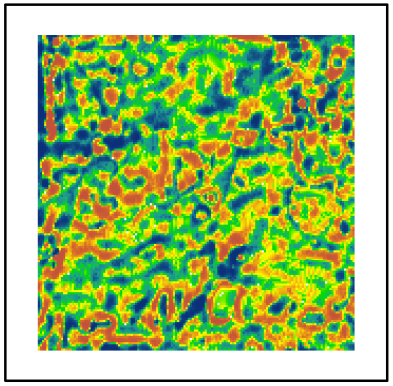
LiDAR 5 m Runoff Distribution at Swift Current, Sask



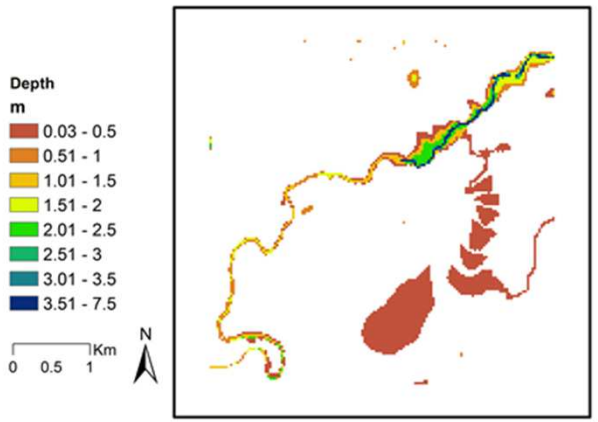
SRTM 30 m Runoff Distribution at Swift Current, Sask



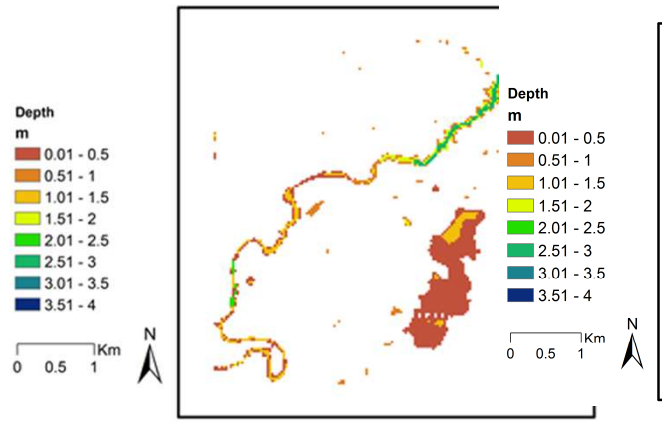
ASTER 30 m Relative Position Index at Swift Current, Sask



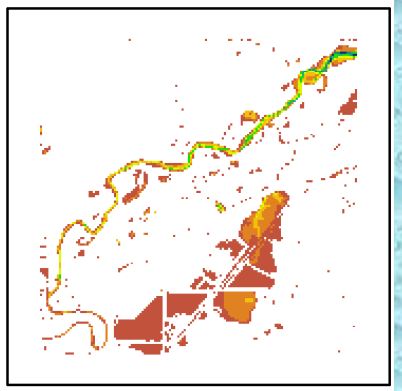
CDED 30 m Runoff Distribution at Swift Current, Sask



Ortho_SGIC 30 m Runoff Distribution at Swift Current, Sask



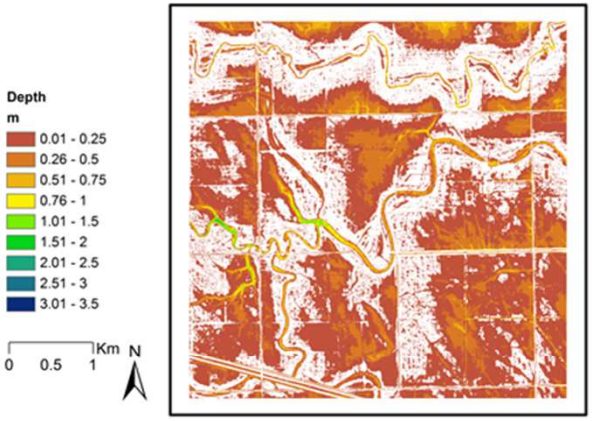
LiDAR 30 m Runoff Distribution at Swift Current, Sask



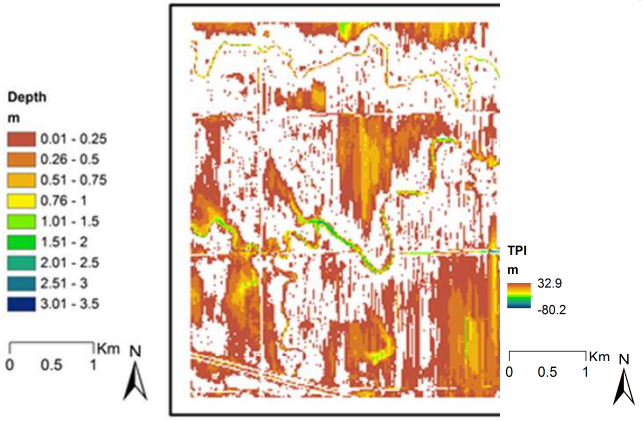
DEM Comparison Study:

La Salle River Basin, MB (8 m relief; 116 mm applied)

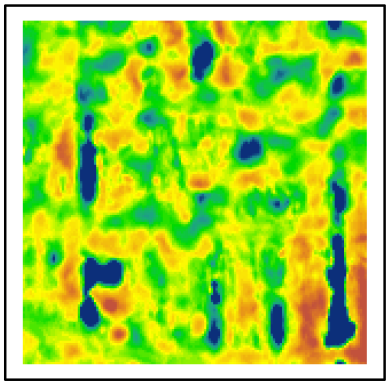
LiDAR 5 m Runoff Distribution Near Winnipeg, Man



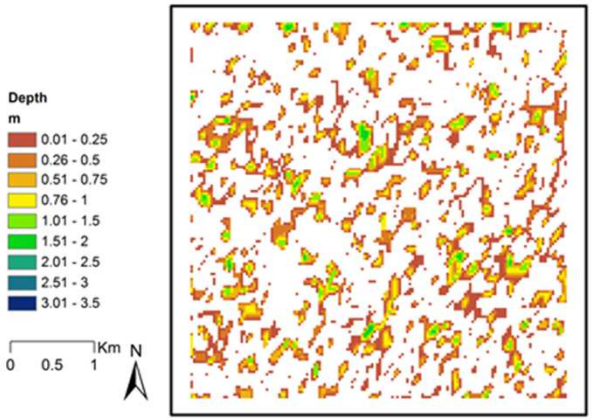
Ortho 20 m Runoff Distribution Near Winnipeg, Man



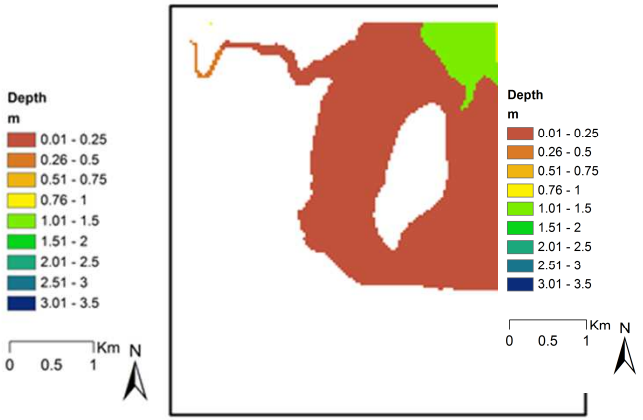
ASTER 30 m Relative Position Index Near Winnipeg, Man



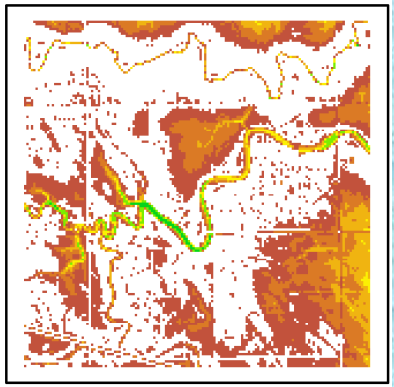
SRTM 30 m Runoff Distribution Near Winnipeg, Man



CDED 30 m Runoff Distributio Near Winnipeg, Man



LiDAR 30 m Runoff Distribution Near Winnipeg, Man



SGIC OthoPhoto Mapping Program

- DEMs used for orthorectifying air photos
- Photogrammetry is a science with inherent challenges!
- Reviewed several products for LIRA needs
- Submitted a brief but detailed report on technical problems and systematic errors of the previous versions
- <u>Newest 5 m version has potential to be a viable product:</u>
  - Reviewed 2 sample DEM tiles (March 10 – 11); all previous issues resolved
  - True 5 m spatial resolution: masspoints → DEM grid
  - Wetland storage viable
  - But capturing road networks directly remains uncertain

Summary

- DEM development is a science!
- All DEMs have surface representation issues and their suitability for specific applications need to be verified
  - *the integer format creates contour artifacts that are particulary problematic in prairie pothole landscapes*
- Future SGIC 5 m Ortho-DEM product has potential value for a variety of applications; requires further validation where LiDAR exists