Watershed Health Indicators – Flood Depth Damage Curves

THE DISTRICT MUNICIPALITY OF MUSKOKA

This project is part of the extended **Integrated Watershed Management (IWM)** initiative, focusing on reducing flooding impacts and enhancing Muskoka River Watershed (MRW) health. It's one of seven chosen for expansion from the original twelve projects. This initiative supports and advances the implementation for an IWM approach for the entire MRW.

You can find more information on the Phase One Reports "Operational Adjustments and Scoping Study for the MRW Plan" and Structural and Watershed-scale Flood Mitigation" along with their accompanying factsheets at **www.muskoka.on.ca/iwmprojects**

Background

Two flood risk reduction projects were undertaken in Phase I of the IWM initiative. One focused on operational adjustments and planning, while the other targeted larger-scale flood mitigation through changes in water management and flow paths. However, determining the most effective options posed a challenge as it didn't accurately reflect the true extent of flood damage.

At Issue

In the MRW, recent severe flood events caused significant damages. Managing floods is complex due to competing water interests among various stakeholders such as hydropower operators, cottagers, Indigenous communities, tourists, and recreationalists. Challenges in flood mitigation arise from development in floodplain areas. Although completely preventing floods is unrealistic, targeted mitigation strategies could be employed to reduce the severity of flooding in specific localities.

Scope

✓ The project aims to evaluate **tangible damages** directly impacting buildings and various infrastructures (such as roads, bridges, culverts, and water facilities) due to a regulatory flood event in the Muskoka River Watershed. The approach is adapted from methodologies used in Alberta.

✓ The assessment involves developing depth-damage curves in the following primary zones:

1. Big East River and Lake of Bays
2. South Branch of the Muskoka River
3. Lake Muskoka to Bala

Defining Flood Depth-Damage Curves

The Federal Guidelines define flood depth-damage curves as mathematical relationships linking water depth to building damage. These curves typically represent the average damage for similar buildings in a community affected by flooding. They are based on historical data or expert-derived assumptions and can categorize damages as either tangible (assignable a monetary value) or intangible (e.g., emotional stress, illness, loss-of-life).

Methodology Overview:

FDE = Flood Damage Estimation

Data Collection	Gathered information from diverse sources (floodplain maps, studies, indices, and manuals) to create depth-damage curves for buildings in the flood-affected area.
Depth-Damage Curve Creation	Developed curves to analyze flood depth's impact on building, road, and waterway damages, with a focus on building content and structural damage due to floods. Adapted methodologies from Alberta and Ontario studies.
Buildings FDE	Classified residential and non-residential buildings by floor area, number of stories, and MPAC codes, assigning Flood Damage Codes. Reviewed exceptional cases in detail and reclassified them when necessary.
Indexing Adjustments	Modified depth-damage curves using recent data to adjust for flood vulnerability in household items and construction costs, accounting for temporal and provincial differences.
Total Damage Calculation	Calculated the total damage estimate for the Regulatory Flood Event by applying depth-damage curves and adjustments.
Roads, Bridges, and Culverts FDE	Utilized road data and estimated complete replacement costs for bridges and culverts. For unclassified road segments, estimated flood length and calculated costs per lane kilometer.
Water & Wastewater Facilities FDE	Estimated damage using replacement cost information provided by DMM, considering limitations due to incomplete cataloging of visible components in aerial imagery.
Boathouse FDE	Utilized residential depth-damage curves for an approximate assessment, considering potential inaccuracies. Compared property values between residences and boathouses, revealing higher boathouse values per area. Derived scaling factors to enhance boathouse damage assessment within depth-damage curves.

Assumptions and Limitations Summary

Lack of Local Data:
Using Greater Toronto Area (GTA) data may not accurately reflect Muskoka, affecting accuracy.

Unverified Codes:
Flood Damage Codes lacked field verification, impacting reliability.

Incomplete 2023 Data:
Limited data for recent years may affect estimates in Muskoka.

Building Height Estimation:
Data used may be influenced by vegetation cover.

Excluded Basements:
Study didn't consider basement flooding due to lack of specific data.

Single MPAC Code:
Using one code per structure may not capture damage in multi-use buildings.

Campground Classification Issue:
Small campgrounds' exclusion impacted accuracy.

No Boathouse Damage Curve:
Lack of specific damage assessment for boathouses.

Water Facilities Data Limitation:
Incomplete representation impacted water facility damage assessment accuracy.

GIS Data Preparation

- Reviewed and selected recent GIS datasets.
- Validated for accuracy before organizing into discipline-specific file geodatabases (FGDB) for model scripting.
- Applied a custom transformation to align various horizontal datums in the District of Muskoka's GIS.

Building Data Enrichment

- Enhanced DMM's building data with critical attributes for flood damage estimation, using GIS tools and overlays.
- Made necessary assumptions about data collection dates, building height estimation, and floor calculations to ensure accuracy in the absence of detailed information.

Results

Key Findings -Damage Curves

- Expensive homes experienced higher content damage per floor area compared to cheaper homes. Single-story homes had more content damage per square foot than two-story residences.
- Apartment buildings with more stories had slightly lower content damage per floor area due to the potential distribution of belongings across multiple floors.
- Higher-value homes had higher structural damage costs compared to less expensive ones.
- Two-story residences showed more structural damage per floor area than single-story homes.
- Some anomalies were observed in structural damages between different class buildings without explanation.
- Non-residential content damage varied across building classes, with "General Merchandise" buildings showing the highest damage.
- Unusual behavior in damage patterns was noted for certain buildings like "Theatres," explained by their architectural design.
- Non-residential structural damage indices differed across building types, and the values aligned with the expected patterns based on the function and construction prices of the buildings.

Key Findings – Indices

- Indices showcased differences in content and structural damage between Ontario and Alberta, highlighting variations in damage assessments across different locations and timeframes.

Key Findings – Regulatory Event Damage Estimate

- Majority of the damage comprised structural damages, with content damages being relatively lower.
- Replacement was necessary for two unaccounted water/wastewater buildings.
- Lake Muskoka and Lake of Bays experienced severe damages, impacting numerous buildings, while other water bodies had fewer damages.
- Building damages were the most predominant, but Huntsville Narrows notably suffered significant water/wastewater building damages.
- Normalized damages per meter of shore length were highest at Huntsville Narrows, Lake Muskoka, and Lake Vernon, with the lowest reported at North Muskoka River Upstream of Mary Lake.
- Higher average structural damage per building area was observed in areas like Port Carling, Lake Muskoka, and Lake of Bays.
- The significance of infrastructure was highlighted, exemplified by substantial replacement costs for infrastructure such as the Mountain View Wastewater Treatment Plant.

Regulatory Event Damage Estimate Summary

Category	Damage Estimate
Buildings	$863,035,723
Water Structure Buildings	$10,960,200
Roadways	$49,992,061
Bridges	$2,586,119
Culverts	$571,950
Grand Total	**$921,858,263**

Sensitivity Analysis

A sensitivity analysis was conducted to explore how different factors could change the estimated flood damage.

Tested	Results
Application of Boathouse Scaling Factors	Adjusting for boathouses increased the Damage Estimate to $1.104 billion.
Minimum Building Elevation for Floor Height vs. Average	When estimating with the lowest floor height, the total rose to $1.124 billion.
Inclusion of Mobile Homes	Including all mobile homes, irrespective of size, resulted in a total of $865 million.

Summary

Total direct damages from the Regulatory Flood in the study area amounted to around $1.065 billion, covering buildings, roads, culverts, bridges, and water/wastewater facilities.

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For the complete report and further information on Integrated Watershed Management (IWM), the twelve projects (including the seven extended ones), and efforts towards an Integrated Watershed Management approach for the Muskoka River Watershed, please visit www.muskoka.on.ca/iwmprojects.

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