Beyond the Storm: Risk-Based Process and Tool to Enable Better Understanding and Management of Climate Change Risks

Great Lakes and St Lawrence Cities Initiative Webinar

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City of Toronto

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Louisiana or Toronto?

Flooding of Roads
Increase in Insurance Claims
Power Outage
Heat Wave
Increase in WSIB Claims
Infrastructure Degradation
Loss of Tree Canopy
Rail Tracks Undermined
Loss of Traffic Signal Control
Washout of Roads
Rutting of Roads
Collapse of Catchbasins
Loss of Communication
<table>
<thead>
<tr>
<th>Drivers</th>
<th>Challenges</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic Development</td>
<td>Outdated climate info, codes &amp; standards and procurement policies</td>
</tr>
<tr>
<td><strong>Safety</strong>: avoid harm to residents, staff and customers</td>
<td><strong>Aging infrastructure</strong>&lt;br&gt;<strong>Cost and time</strong> required for infrastructure upgrades&lt;br&gt;<strong>Increasing concentration of built assets</strong></td>
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<tr>
<td>Customer service</td>
<td>Structural damage, system degradation and loss of function</td>
</tr>
<tr>
<td><strong>Cost avoidance:</strong></td>
<td>Identify sectoral interdependencies and synergistic risk</td>
</tr>
<tr>
<td>• damage from extreme weather</td>
<td></td>
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<tr>
<td>• credit &amp; insurance risk rating of City &amp; taxpayers</td>
<td></td>
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<tr>
<td><strong>Legal liability</strong> of organizations &amp; individuals</td>
<td>Disruption of operations and emergency response capability</td>
</tr>
<tr>
<td>Evidence of <strong>due diligence</strong></td>
<td>Need for enhanced coordination among departments, agencies, sectors and governments</td>
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To mitigate the impacts from materializing

To minimize impact by response to, recover from and mitigate the impact of disaster
Beyond the Storm: Climate Change Risk Assessment
City of Toronto’s Climate Change Risk Assessment

The process comprises four (4) steps, each consisting of component sub-steps.

The process is linear but also iterative for flexibility.

<table>
<thead>
<tr>
<th>Step</th>
<th>Sub-Steps</th>
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<tbody>
<tr>
<td>2. Risk Identification</td>
<td>2.1. Identify Sources/Factors/Causes</td>
</tr>
<tr>
<td>3. Risk Analysis</td>
<td>3.1. Estimate Magnitude &amp; Severity of Consequences (Current/Future)</td>
</tr>
<tr>
<td>4. Risk Treatment</td>
<td>4.1. Identify Risks to be Treated</td>
</tr>
</tbody>
</table>
Step 1. Establish the Context

1. Establish the Context

1.1. Establish External Context

1.2. Establish Internal Context

1.3. Establish Risk Assessment Scope

1.4. Establish Risk Assessment Criteria

- Social, economic, cultural, infrastructural and environmental issues
- Key stakeholders
- Key business assets, infrastructure, services and activities
- Key organizational objectives
- Organizational structure, roles and accountabilities
- Policies and the strategies in place to achieve the organizational objectives
- Key organizational capabilities (e.g. knowledge, resources)

Identify risk receptors and exposure units that are under the control of municipal business units, those that influence the business units, as well as those that the business units do not have control over.

Beyond the Storm: Climate Change Risk Assessment
2. Identify risks

Identify the potential sources, causes, and factors that may initiate or produce a risk event/impact.

2.1. Identify Sources / Causes / Factors

- Extreme rain
- Extreme heat
- Drought
- Extreme cold

2.2. Identify Current Vulnerabilities andExisting Controls

Identify current adaptive capacity through existing controls and identification of vulnerabilities.

- Population density, cultural factors, poverty
- Existence of early-warning systems
- Scientific understanding, public awareness
- Construction/building structure

2.3. Identify “what if” Risk Scenarios

Identify the combination of sources, events/impacts and vulnerabilities that could create risks despite existing controls.

- Extreme rain leading to culvert failure
- Week-long heatwave and excessive electricity demand
- Major snowfall followed by freezing rain
- Warmer winters, temperature around 0C

Beyond the Storm: Climate Change Risk Assessment
Risk is defined as a combination of the consequences of a risk scenario (including changes in circumstances) and the associated likelihood of occurrence.

3. Risk Analysis

3.1. Estimate Magnitude & Severity of Consequences (Current/Future)

3.2. Estimate Likelihood of Occurrence (Current/Future)

3.3. Determine Risk Rating (Current/Future)
<table>
<thead>
<tr>
<th>Rating</th>
<th>Insignificant (1)</th>
<th>Minor (2)</th>
<th>Moderate (3)</th>
<th>Major (4)</th>
<th>Catastrophic (5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Premises/Infrastructure/Assets</td>
<td>• No or very limited loss of physical assets&lt;br&gt;• Isolated assets affected</td>
<td>• Limited loss of physical assets&lt;br&gt;• Isolated or a few assets affected</td>
<td>• Loss of large but replaceable physical assets&lt;br&gt;• Most assets affected but impact on broader system / network is moderate</td>
<td>• Loss of significant physical assets&lt;br&gt;• System / network wide impact leading to some loss of infrastructure / premises/ asset function</td>
<td>• Loss of key physical assets&lt;br&gt;• System / network wide impact leading to total loss of infrastructure / premises/ asset function</td>
</tr>
<tr>
<td>Cost/Time (including Reputation)</td>
<td>• Costs / damages incurred represent &lt;1% capital / operating budget variance&lt;br&gt;• No or very minor media attention</td>
<td>• Minor costs / damages incurred representing 1-5% capital / operating budget variance&lt;br&gt;• Localized community/ interest group/ stakeholder concern and some media attention</td>
<td>• Moderate costs / damages incurred representing 5-10% capital / operating budget variance&lt;br&gt;• Localized community/ interest group/ stakeholder concern and moderate media attention</td>
<td>• Significant costs / damages incurred representing 10-25% capital / operating budget variance&lt;br&gt;• Significant loss of confidence in City products and services and considerable media attention&lt;br&gt;• Public / media outcry for removal of government official</td>
<td>• Massive costs / damages incurred representing &gt;25% capital / operating budget variance&lt;br&gt;• Complete loss of confidence in City products and services and sustained media attention&lt;br&gt;• Public / media outcry for change in administration and council offices</td>
</tr>
<tr>
<td>Environment</td>
<td>• Very minor, non-permanent environmental release promptly contained / damage requiring no clean-up measures&lt;br&gt;• No regulatory action</td>
<td>• Small uncontained release below legal limit&lt;br&gt;• Non-permanent environmental damage requiring very limited clean-up efforts&lt;br&gt;• Regulatory warning or order</td>
<td>• Moderate environmental damage with moderate clean-up required, no permanent damage.&lt;br&gt;• Permits violation&lt;br&gt;• Charges leading to fines</td>
<td>• Major environmental damage / extended clean-up required/ some permanent damage&lt;br&gt;• Charges leading to fines and/or criminal liability</td>
<td>• Irreparable, significant damage to environment&lt;br&gt;• Criminal charges and/or civil liability</td>
</tr>
<tr>
<td>Logistics (Supply Chain, Utilities and Transport Infrastructure)</td>
<td>• No disruption of City supplies&lt;br&gt;• Utilities and transport system continue to function as usual, with no impact on City operations or clients</td>
<td>• Limited disruption of supply chain due to isolated events, with City inventory able to cope&lt;br&gt;• Isolated incidences of power / water outages / transport system delays, with limited impact on City operations or clients</td>
<td>• Suppliers experience moderate delays, with City inventories experiencing shortages&lt;br&gt;• Numerous/localized incidences of power / water outages / transport system delays, with moderate impact on City operations or clients</td>
<td>• Suppliers are unable to provide materials for a prolonged period of time, with City inventory shortages leading to temporary disruption of services&lt;br&gt;• Widespread power / water outages / transport system delays, with significant impact on City operations or clients</td>
<td>• Suppliers are unable to provide materials for an extensive period of time, with City inventory shortages leading to lengthy disruption of services&lt;br&gt;• Total failure of power / water / transport system, leading to shut-down of City operations and massive disruption of clients</td>
</tr>
<tr>
<td>People (Staff, and Clients of City Services)</td>
<td>• No injuries/ medical treatment&lt;br&gt;• No impairment of well-being / quality of life</td>
<td>• Minor injuries / first aid or minor illness&lt;br&gt;• Minor discomfort or displacement</td>
<td>• Serious injuries to clients or staff resulting in non-permanent injury / Lost time incident&lt;br&gt;• Workplace/living conditions are temporarily rendered unusable/unliveable, with moderate disruption to productivity and living arrangements/ quality of life (e.g. need temporary shelter)</td>
<td>• Serious injuries to clients or staff resulting in some permanent disability&lt;br&gt;• Staff/ clients/ residents are unable to use City facilities and services for a sustained period with significant impact on work and living arrangements / quality of life (e.g. displaced from own residences)</td>
<td>• Death and/ or significant permanent disability of clients or staff&lt;br&gt;• Staff/ clients/ residents are permanently unable to use City facilities and services --with catastrophic impact on work and living arrangements / quality of life (e.g. unable to find suitable alternative living arrangements)</td>
</tr>
<tr>
<td>Corporate Processes &amp; Functions, &amp; Service Delivery</td>
<td>• No or very minor disruption in delivery of essential services, projects or processes&lt;br&gt;• No increase in demand for services</td>
<td>• Minor disruption in delivery of essential services, projects or processes&lt;br&gt;• Minor increase in demand for services, but manageable within existing budget</td>
<td>• Moderate disruption in delivery of essential services, projects or processes&lt;br&gt;• Moderate increase in demand for services, requiring increasing frequency of delivery and minor budget provision</td>
<td>• Significant disruption in delivery of essential services, projects or processes&lt;br&gt;• Significant increase in demand for services, requiring large increase in frequency/breadth of delivery and moderate budget provision</td>
<td>• Unable to perform essential services , projects or processes for extended period</td>
</tr>
</tbody>
</table>
Sample Definitions

### Insignificant (1)
- No or very minor disruption in delivery of essential services, projects or processes
- No increase in demand for services

### Moderate (3)
- Moderate costs / damages incurred representing 5-10% capital / operating budget variance
- Localized community/ interest group/ stakeholder concern and moderate media attention
Step 3.2. Estimate Likelihood

<table>
<thead>
<tr>
<th>Risk Scenario</th>
<th>Qualitative Probability Estimate</th>
<th>Quantitative Probability Estimate</th>
<th>Recurrence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td><strong>Almost Certain</strong> – the risk will occur</td>
<td>90-100% probability</td>
<td>1/1 year event</td>
</tr>
<tr>
<td>4</td>
<td><strong>Very Likely</strong> – the risk will probably occur</td>
<td>55-90% probability</td>
<td>1/5 year event</td>
</tr>
<tr>
<td>3</td>
<td><strong>Likely</strong> – the risk could occur</td>
<td>30-55% probability</td>
<td>1/25 year event</td>
</tr>
<tr>
<td>2</td>
<td><strong>Unlikely</strong> – the risk may occur</td>
<td>5-30% probability</td>
<td>1/100 year event</td>
</tr>
<tr>
<td>1</td>
<td><strong>Rare</strong> – the risk will occur only in exceptional circumstances</td>
<td>&lt;5% probability</td>
<td>1/500 year event</td>
</tr>
</tbody>
</table>

Prob. of Risk Scenario, \( D\% = A\% \times B\% \times C\% \)
Step 3.3. Calculate Risk Rating

- Consequence and likelihood scores will be combined to yield a risk rating matrix or ‘heat map’.
- Assessed risk will be considered current risk with existing controls in place.

<table>
<thead>
<tr>
<th>Likelihood</th>
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<th>Minor</th>
<th>Moderate</th>
<th>Major</th>
<th>Catastrophic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Almost Certain</td>
<td>M</td>
<td>M</td>
<td>H</td>
<td>E</td>
<td>E</td>
</tr>
<tr>
<td>Likely</td>
<td>L</td>
<td>M</td>
<td>H</td>
<td>H</td>
<td>E</td>
</tr>
<tr>
<td>Possible</td>
<td>L</td>
<td>M</td>
<td>M</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>Unlikely</td>
<td>L</td>
<td>L</td>
<td>M</td>
<td>M</td>
<td>M</td>
</tr>
<tr>
<td>Rare</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>M</td>
</tr>
</tbody>
</table>
4. Risk Treatment

Risk treatment will identify the high priority risks to be addressed through new / modified controls and a reassessment of risk (residual) with these controls in place.

4.1. Identify Risks to be Treated

4.2. Identify Potential Control Options

4.3. Assess Risk Scenarios with New / Modified Controls

4.4. Assess Effectiveness of Controls (Residual Risk)
## Transportation Services – Level of Effort

### Risk Sources

- Extreme Freezing Rain
- Extreme Rain
- Extreme Heat
- Freeze/Thaw
- Extreme Snowfall
- Extreme Cold
- Extreme Wind

### High Priority Assets and Critical Services

- **Roads, Bridges, Culverts:** Inspection, Maintenance and Construction
- **Traffic Controls Signals,** RESCU Operation; Traffic Control Systems; Business Continuity Plan
- **Road Operation:** Equipment; Staff Health and Safety; Winter Maintenance; Road Repairs; Street Sweeping Service; Inspections and Patrolling; Investigations
Transportation Services
Overall Climate Change Risks Results

Beyond the Storm: Climate Change Risk Assessment
<table>
<thead>
<tr>
<th>Current Controls</th>
<th>Proposed Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Monitoring of controllers</td>
<td>• Perform a study to determine the relationship between the temperature inside</td>
</tr>
<tr>
<td>• New resilient Controllers, fans and heaters inside controllers</td>
<td>the controller cabinet versus ambient air temp</td>
</tr>
<tr>
<td>• Conflict monitor inspection every 6 months</td>
<td>• Staff to monitor the use of the heater and cooling fan to see if the frequency</td>
</tr>
<tr>
<td>• Maintenance and installation is 100% contracted</td>
<td>of use is increasing</td>
</tr>
<tr>
<td></td>
<td>• Routine inspections, include the inspection of the heating/cooling system</td>
</tr>
<tr>
<td></td>
<td>• Third party verification of cabinet performance under extreme heat</td>
</tr>
<tr>
<td></td>
<td>• Improve relationship between Toronto and Bell</td>
</tr>
<tr>
<td></td>
<td>• Accelerate the installation of environmental controls in cabinets</td>
</tr>
<tr>
<td></td>
<td>• Install air conditioners in cabinets for critical intersections – emergency</td>
</tr>
<tr>
<td></td>
<td>routes</td>
</tr>
<tr>
<td></td>
<td>• Install UPS – uninterrupted power supply for critical intersections – emergency</td>
</tr>
<tr>
<td></td>
<td>routes</td>
</tr>
<tr>
<td></td>
<td>• Engineering vulnerability risk assessment of cabinet performance</td>
</tr>
<tr>
<td></td>
<td>• Implement an Asset Management System</td>
</tr>
</tbody>
</table>
ADAPTATION

Develop Strategies, for Prioritization, Action Plan, Communication Plan

Assess Impacts

Identify Roles, Responsibilities, Interdependencies

Select Events, Assets, Services
Benefits of the CCRA

- Identifies nature and severity of risks to assets and services;
- Identifies most obvious vulnerabilities and short and long term adaptation measures that are practical and achievable;
- Identifies areas where more detailed engineering vulnerability analysis;
- Recommend new designs, retrofitting and rehabilitation;
- Operationalizes climate change;
- Assists in the development of a Adaptation Strategy;
- Ensures consistency and accountability – due diligence through a structured, documented approach; and
- Provides a mechanism for communicating climate change risk
Some Lessoned Learned

• Establish a **policy foundation**;
• Use a **Top-Down and Bottom-Up** approach
• Undertake a **prioritization** of the organization’s high priority assets and critical services;
• Establish a **work program** for the risk assessment;
• Identify a **lead risk assessor**;
• Identify **interdependencies and synergistic risks**;
  - Select **risk assessor** and train within each of the functional groups; and
  - Risk assessment process captures **existing adaptation controls** that provides evidence of due diligence.
Transportation Association of Canada
Risk Analysis and Responding to Climate Change Project


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