Justification for ... and Purpose of the Study

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Justification for the Study (i)

Questions & Issues

- City Council Adopted Policy Direction
  - Climate Change, Clean Air & Sustainable Energy Action Plan (2007)
  - Ahead of the Storm (2008) rec. Analysis of Toronto’s Changing Climate

- Major Questions and Issues
  - How HOT will it be?
  - How much RAIN & SNOW can we expect?
  - How much SMOG will occur?
  - How DRY will it be?
  - How WINDY will it be?
Limitations of Global-Regional Climate Models

- **Depict Very Large Areas** - Weather & Climate of Toronto is the same as North Bay & Buffalo

- **Don’t Include Local Effects** of Great Lakes, Niagara Escarpment, Oak Ridges Moraine, Tall Buildings etc

- Based on **30-year Weather “Normals”** (exclude more recent & rapid changes – i.e. the “hockey stick” data)

- **Weather/Climate Means Don’t Address** the City’s Exposure to Costs of Extreme Events
Toronto’s Recent Extreme Weather Records

- **Warmest Summer** in 63 years (2002)
- **Warmest January** in 165 years (2005)
- Record one-day power demand of 27,005 MW due to summer heat (August 1\textsuperscript{st}, 2006)
- **Earliest Heat Wave** (June 19-21, 2012)
- **Highest Summer Rainfall** Ever (2008)
- Three **1 in 100 year storms** in less than 12 years: (July 2000, August 2005, July 2012)
New & Innovative Local Model Approach

- Global Climate Models + Regional Climate Models + Local Weather Model (1km² Cells)
- **SENES Consultants** ran the computer models
- **ADVISORS & PEER REVIEW GROUP**
  - Environment Canada
  - Ontario Ministry of the Environment
  - Toronto Regional Conservation Authority

New Elements

…. To Include: New Influences

- Included Influence of the Great Lakes, Niagara Escarpment and the Oak Ridges Moraine.

…. To Model: Two 10 Year Periods

- The “Present” 10 Year Base Period 2000-2009
- A “Future” 10 Year Period 2040-2049

…. To Examine: Toronto within the GTA
New Questions

To Answer: New Questions

- Focused on obtaining data concerning:
  Future Extremes-of-Weather
  (e.g., Heat Waves & Torrential Storms)
  rather than …
  Future Averages-of-Climate
  (e.g., Average Temperature & Average Rainfall)

But examined such “Averages” to check model validity!
Results of the Study
What We Did

- Obtained data output relevant to Ontario from combined Global Climate Models (Coarse km Resolution) and Regional Climate Models (Medium km Resolution) from the Hadley Meteorological Centre UK.

- Used that data as the starting point to run Toronto’s Local Weather Model (Fine km Resolution) regarding 2000-2009 (the “Present”) and regarding 2040-2049 (the “Future”).

- Analyzed the Data Created and Analyzed the Results against rational Meteorological Science and Local Influences (the “Climate Drivers”).
Results: Warmer Temperatures (2040’s)

- *Average annual temperatures increase by 4.4°C*
- Projected *average winter* temp. increases by *5.7°C*.
- Projected *average summer* temp. increases by *3.8°C*.
- The *extreme daily minimum* temperature - "becomes less cold" by *13°C*.
- The *extreme daily maximum* temperature - "becomes warmer" by *7.6°C*. 
Confidence in Results: Temperature

- **Compared with Monitored Means (2000-2009)**
  - Monitored Data from Lester Pearson Airport = 8.7°C
  - Toronto’s Climate-Weather Model = 8.7°C
  - Environment Canada’s Model = 6.7°C
  - *Our model approach is closer!*

- **Compared with Other Models (2040-2049) for GTA**
  - *Comparing High Resolution (Toronto) versus Low Resolution Models’ re: Delta Temperature Values*
  - Our 4.4°C compares favourably with Low Resolution Models showing changes from -2.7°C to 6.3°C
Results: Changes in Precipitation

Snowfall & Rainfall
- Less Snow & More Rain -- in Winter
- More Rain in July (80%) & August (50%)

Extreme DAILY Rainfall (>25mm/day)
- Fewer Rain Storms >25 mm in Winter
- Same Number of Storms in Summer
  BUT these = Much More Intense Storms !!
Modelled Daily Extreme Rainfall

**Highest Rainfall** is shown over Finch Avenue.

- Captured by Modelling, but NOT by Standard Environment Canada Monitoring at Pearson International Airport because the centre of the storm was distant from the airport monitoring station.
- Monitoring stations can only identify what happens at a particular station.
- Modelling this at RCM Scale put it well into New York State with less intensity
## Expected Changes .... Some Examples

<table>
<thead>
<tr>
<th>WEATHER EXTREMES</th>
<th>PARAMETER</th>
<th>UNITS</th>
<th>2000-2009</th>
<th>2040-2049</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Extreme Rainfall</strong></td>
<td>Maximum Amount in One Day</td>
<td>mm</td>
<td>66</td>
<td>166</td>
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<tr>
<td></td>
<td>Number of Days with More Than 25mm</td>
<td>days</td>
<td>19</td>
<td>9</td>
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<td></td>
<td>Mean Annual Daily Maximum</td>
<td>mm</td>
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<td>86</td>
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<tr>
<td><strong>Extreme Heat</strong></td>
<td>Maximum Daily (in °C)</td>
<td>°C</td>
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<td>44</td>
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<tr>
<td></td>
<td>Number of Days with Temperature greater than 30°C</td>
<td>days</td>
<td>20</td>
<td>66</td>
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<tr>
<td></td>
<td>Number of Heat Waves (3 or more Consecutive Days with Temperatures greater than 32°C)</td>
<td>3-day events</td>
<td>0.57</td>
<td>2.53</td>
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</tbody>
</table>
Potential Implications of Study Projections … and Next Steps

Lawson J. Oates, MES
Director, Toronto Environment Office
Climate Adaptation & Infrastructure Management Approaches

Objectives

1. Cost effective pre-emptive adaptation measures

2. Minimize cost through adaptive design and construction

3. Build resilience and restoration capability into public infrastructure and services

4. Risk management analysis
Avoiding Future Climate Costs

- August 19, 2005 Storm impacted Finch Avenue
- at a Cost of $47 million to the City
- plus $600 million in Private Costs
City’s Adaptation Responsibilities

- Air Conditioning Peaks & Blackouts: Toronto Hydro
- Storms & Urban Flooding: Toronto Water
- Culverts & City Roads: Toronto Transportation
- Gardens & Trees: Toronto Parks & Recreation
- Storms: Toronto Region Conservation Authority
- People in Need: Shelter, Support & Housing
- Street Ventilation (re Smog etc): City Planning
WeatherWise Partnership Participants

BMO  TD  CIBC  Royal Bank
Brookfield Properties  Oxford
Telus  Rogers
Deloitte  Marsh  Civic Action
IBC  BAC  Insurance Bureau of Canada  Bureau d’assurance du Canada
ISSUE: Increased Summer Temperatures - A/C, Electricity Demand, Heat Vulnerability

Expected in 2040-2049: Almost “6 times” increase in A/C use during days with greater than 24°C
ADAPTATION: Options & Actions

- Cooling Centres, Shade
- Green Roofs
- Vulnerability Mapping

Clusters of Vulnerability to Heat
Composite, p < 0.05

Cluster type, by Toronto CTs
- Hot spot
- Cool spot
- Other
- Not significant
ISSUE: Increased Summer Temperatures – Impact Air Quality (SMOG)

Heat waves & smog events go hand in hand

More Heat means More Smog
ADAPTATION: Options & Actions

Site Development

Encourage Air Ventilation in Streets

Neighbourhood Development
Mainstreaming of Adaptation

Toronto to host Chief Planners Roundtable on Resilient Cities

Toronto’s Chief Planner told the Toronto Board of Trade:
• “Climate change could have significant planning implications in the years ahead”
• “Thinking about resiliency and how we’re going to adapt to changing weather patterns… needs to be injected into our conversation of city building”

ISSUE: Increased Summer Temperatures – Transportation Systems
ADAPTATION: Options & Actions – Low Tech Response

Learning from Others – Portland, Oregon
ADAPTATION: Options & Actions

- Mechanical components in traffic control systems have temperature thresholds
- Simple adaptation option, install fans to ensure continued operation
ISSUE: Increased Rainfall – Culverts, Roads and Drainage

Increase in Rainfall Intensity and Magnitude

- Basement Flooding
- Road Washouts
- Urban Flooding

Increased pressure on storm water systems & water treatment

Property Damage, Housing Habitability
ADAPTATION: Options & Actions

- Downspout Disconnection
- Underground Stormwater Storage Tank
- Stream and aquatic habitat restoration
- Finch Ave
- End of Pipe Facilities
Basement Flooding Protection Program - 34 Priority Study Areas

Enhanced Design Standards:
- May 2000 storm event for Sanitary Sewers.
- 100 Year design storm event for Storm Drainage systems.

Only a few cities undertake a similar risk assessment and mitigation approach.
Conclusions

- Toronto’s Future Weather Will Be Different with an increase in extreme weather events

- We Must Continue to Adapt to the Changes
  - City Divisions can now undertake individual Climate Change Risk Assessments (using City Risk Tool)

- Monitor Situation & Update Study as Required
Thank You

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