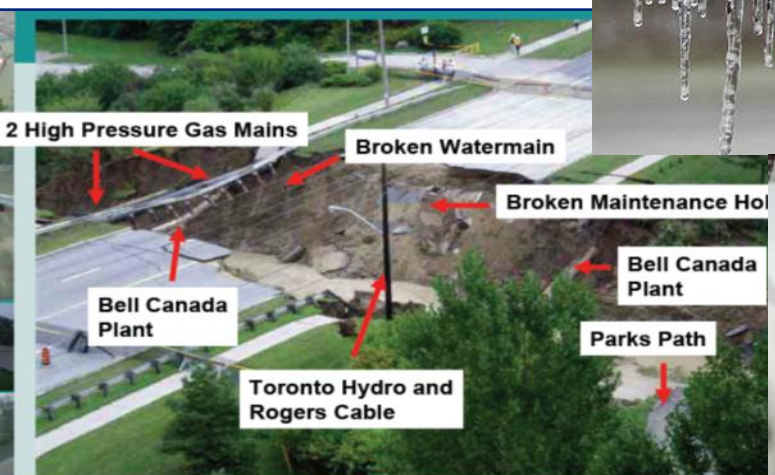
TORONTO

Beyond the Storm:

Risk-Based Process & Tool to Enable Better Understanding and Management of Climate Change Risks

A webinar in support of the
Municipal Adaptation & Resilience Service (MARS),
a program of the Great Lakes St. Lawrence Cities Initiative

February 20, 2014




Flooding of Roads
Loss of Mobility
Increase in Insurance Claims
Rail Tracks Undermined
Power Outage
Loss of Traffic Signal Control
Heat Wave
Washout of Roads
Increase in WSIB Claims
Rutting of Roads
Infrastructure Degradation
Louisiana or Toronto?
Collapse of Catchbasins
Loss of Communication

Toronto Climate Study Projections (SENES)

City of Toronto undertook localized modelling of future extremes

- **Longer & Hotter Heat Waves**
  - ***Average annual temperatures increase by 4.4ºC***
- **Less Snow and More Rain in Winter**
  - ***140 centimetres less snowfall in parts of Toronto***
- **More Intense Thunderstorms**
  - ***Less Snow & More Rain in Winter***
  - ***More Rain in July (80%) & August (50%)***
  - ***Same Number of Storms in Summer BUT these are much more intense Storms !!***

What is Environmental Risk Management

- Environmental risk management is a systematic approach to assessing, mitigating, monitoring, and reporting on risks associated with an organization's interaction with, and impact upon the natural environment

- Environmental risk should be viewed as any other kind of organizational risk, e.g.:
  - ***Financial costs***

  - ***Organizational/employee liability***

  - ***Damage to critical assets/infrastructure***

  - ***Reputation risk***

Importance of Due Diligence & Personal Liability

Environmental due diligence:

- Employees must *"take all reasonable steps"*
- Employees must *adhere* to laws & regulations
- Employees must *anticipate* risks

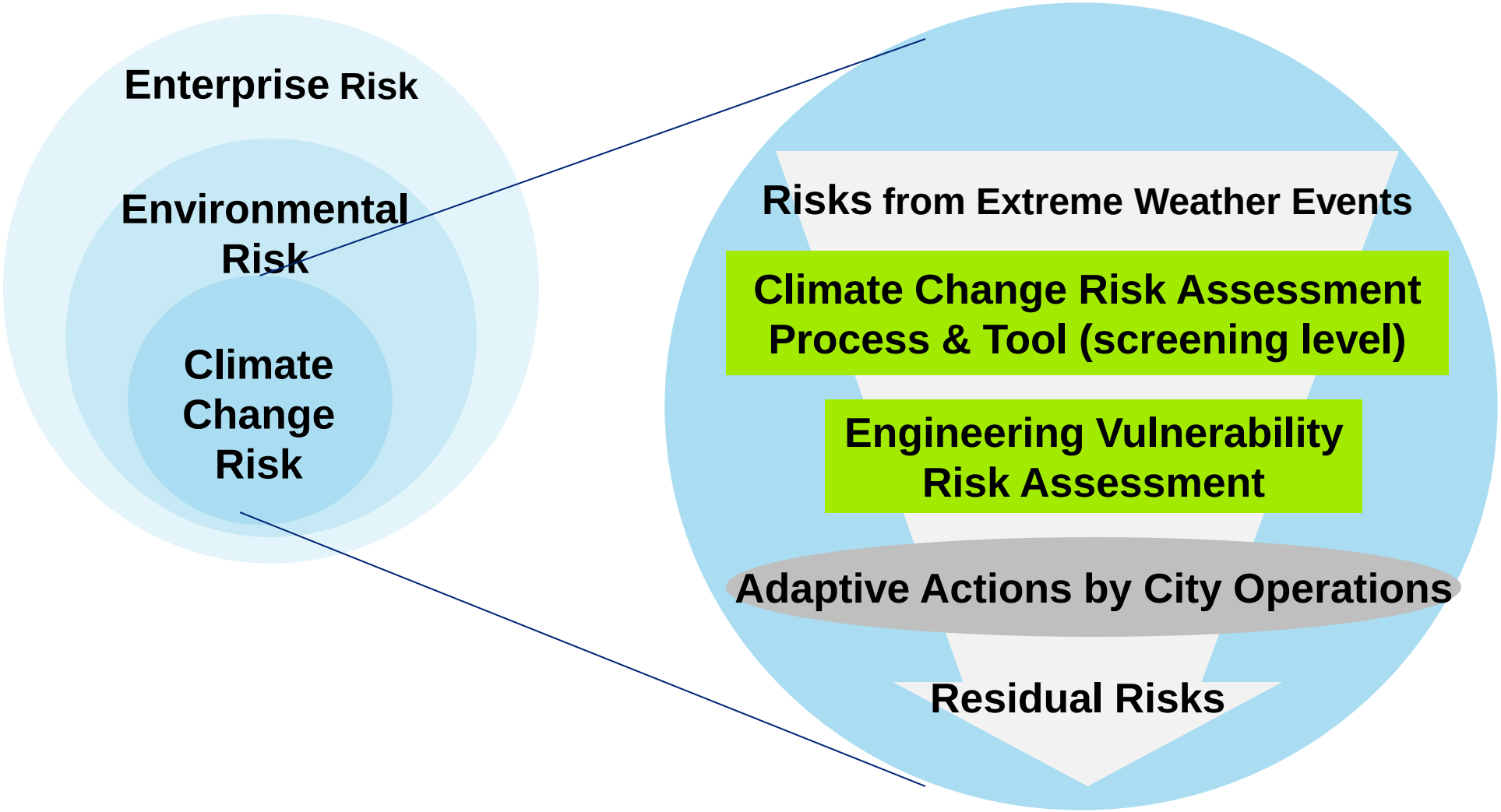
Applicable standard of care:

- Having proper management systems
- Having effective operations
- Consider leading practices:
  - City practice
  - Other cities / comparable organizations
  - Emerging technology

Information courtesy of Graham Rempe, Environmental Lawyer, City of Toronto

Project Scope and Objective

Scope - Climate change risk is a subset of environmental risk

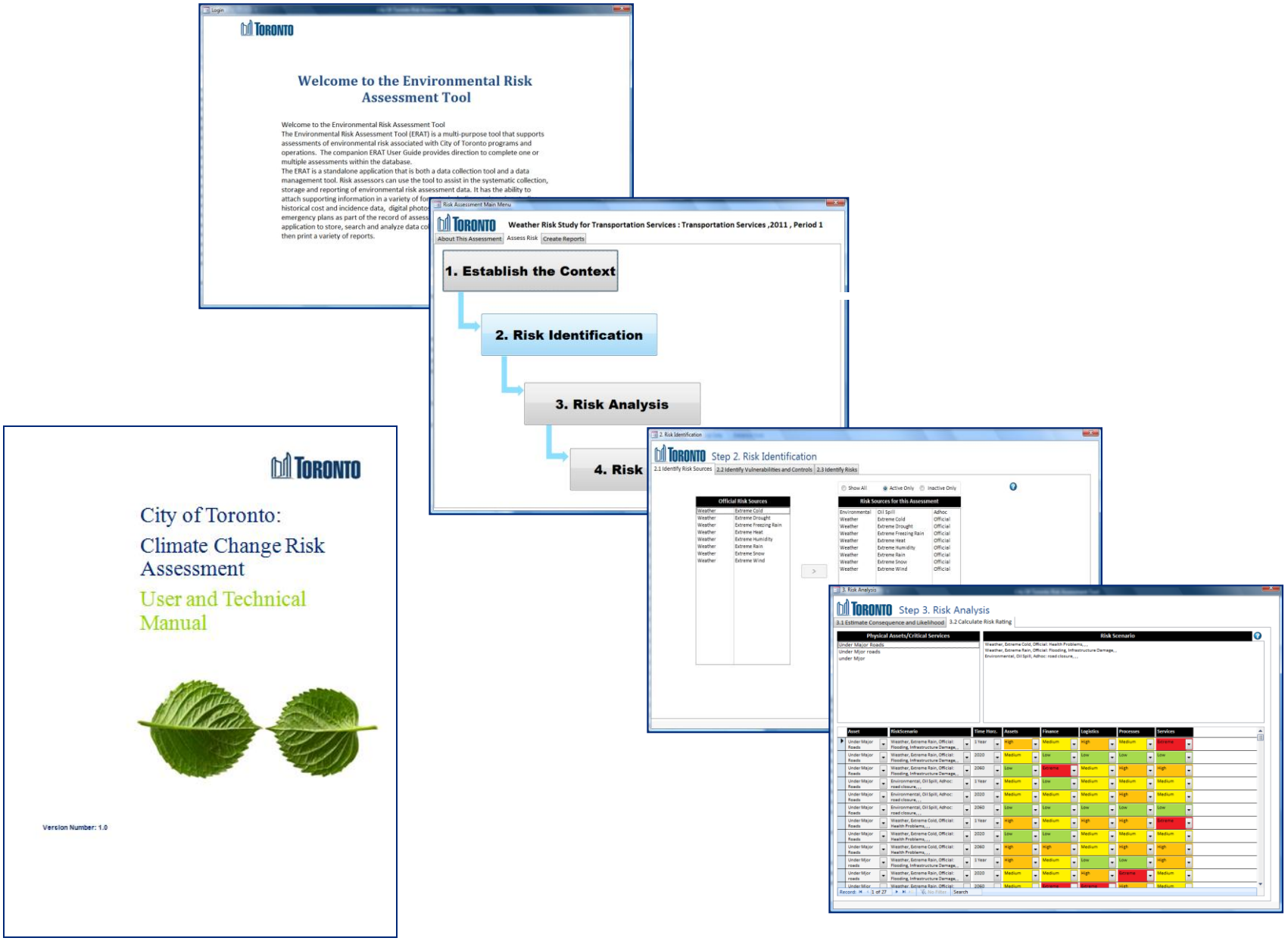


Purpose of project - develop a process and tool for screening & prioritizing all environmental risks - first application climate change risks

Why Manage Climate Change Risk

Drivers	Challenges
Economic Development	**Outdated climate info**, codes & standards & procurement policies
Safety: avoid harm to residents, staff and customers	• **Aging infrastructure** • **Cost and time** required for infrastructure upgrades • Increasing **concentration of built assets**
Customer service	**Structural damage, system degradation and loss of function**
Cost avoidance: • damage from extreme weather • credit & insurance risk rating of City & taxpayers	**Identify sectoral interdependencies & synergistic risk**
Legal liability of organizations & individuals	Disruption of **operations and emergency response capability**
Evidence of **due diligence**	Need for **enhanced coordination** among departments, agencies, sectors and governments

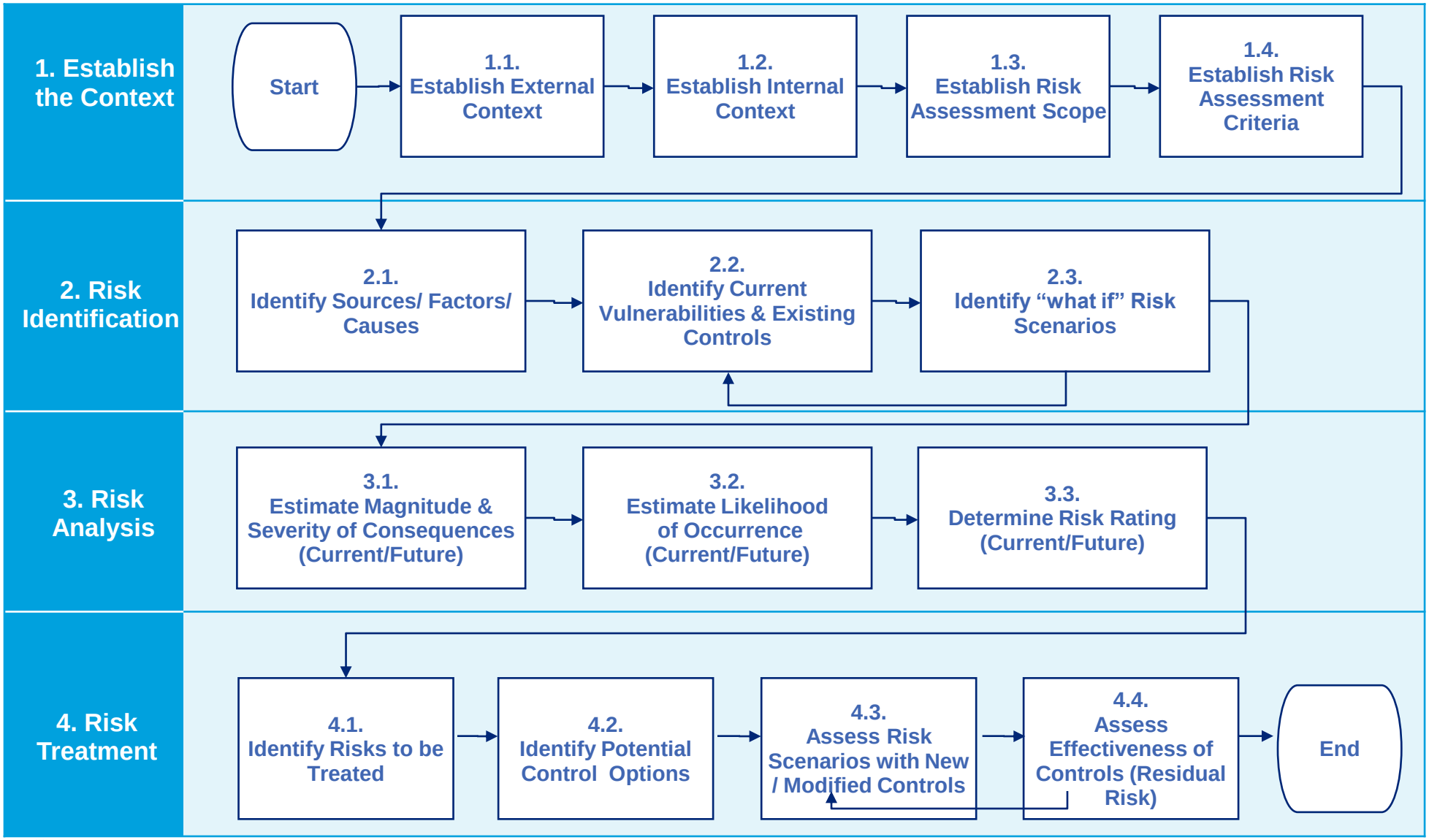
MS-ACCESS Enabled Risk Tool



City of Toronto's Climate Change Risk Assessment

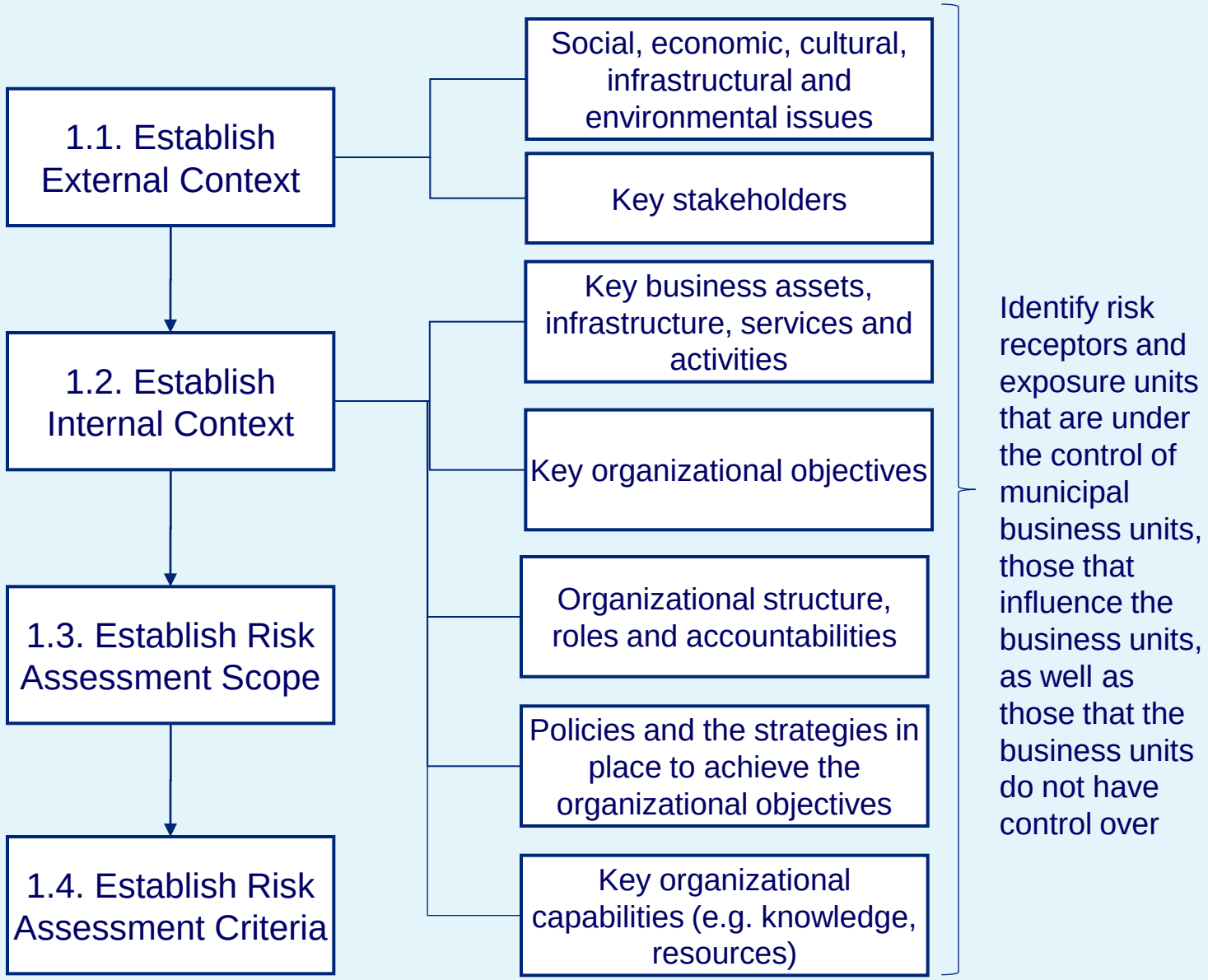
The process comprises four (4) steps, each consisting of component sub-steps

The process is linear but also iterative for flexibility



Step 1. Establish the Context

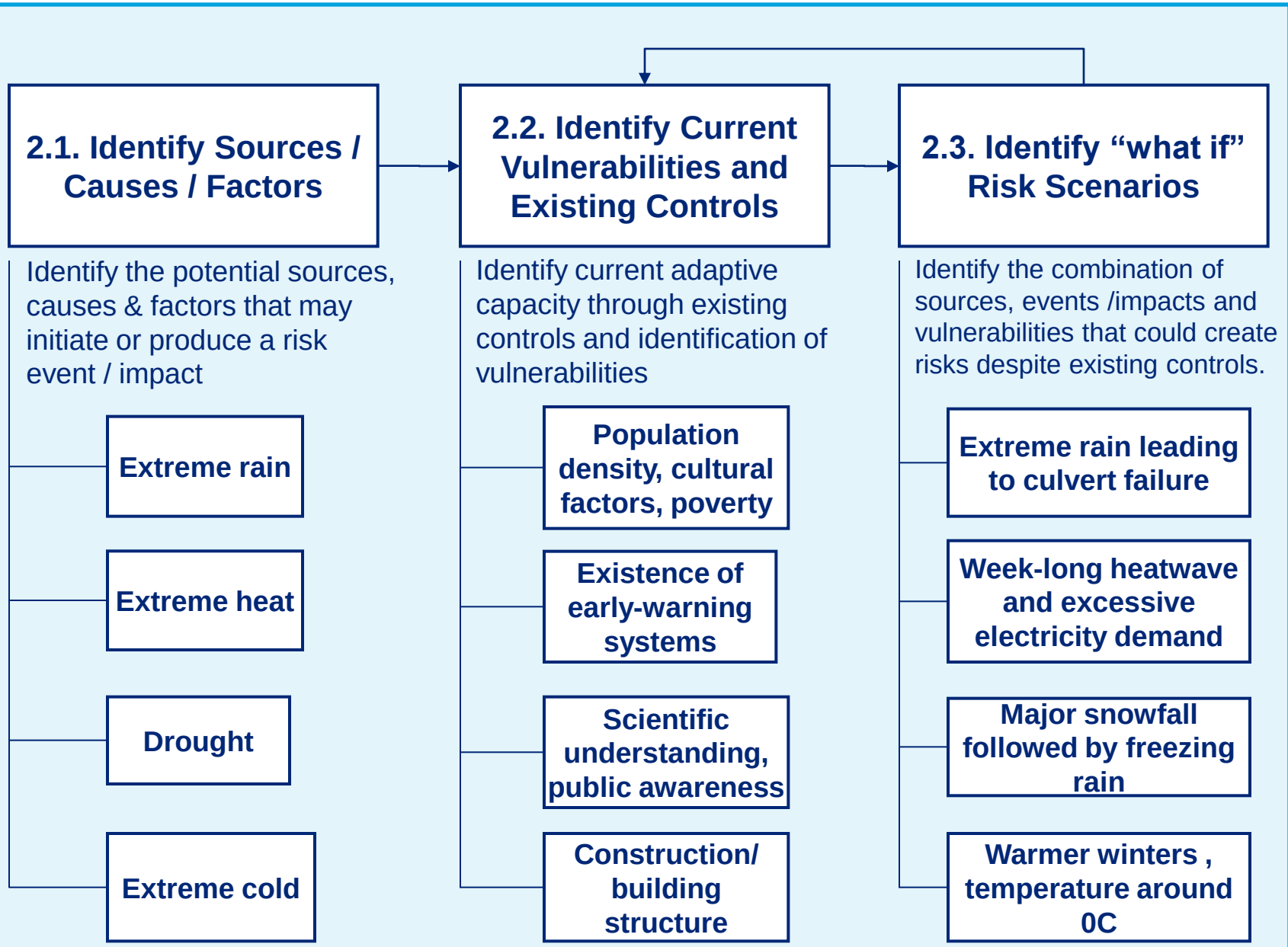
1. Establish the Context



Step 2. Identify Risks

2. Identify risks

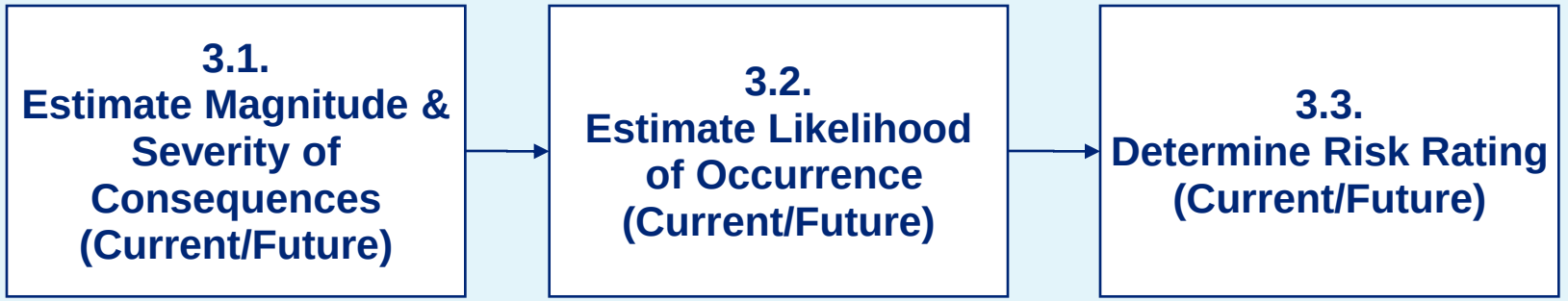
Identify the potential sources and factors of risk, where current vulnerabilities exist and the controls that are currently in place, and the potential risk scenarios that may occur.



Step 3. Risk Analysis

3. Risk Analysis

Risk is defined as a combination of the consequences of a risk scenario (including changes in circumstances) and the associated likelihood of occurrence.



Step 3.1 Estimate Magnitude & Severity of Consequences

Draft, subject to change - not for quotation

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

Sample Definitions

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

Moderate (3)

Cost / Time (including Reputation)

- Moderate costs / damages incurred representing 5-10% capital / operating budget variance
- Localized community/ interest group/ stakeholder concern and moderate media attention

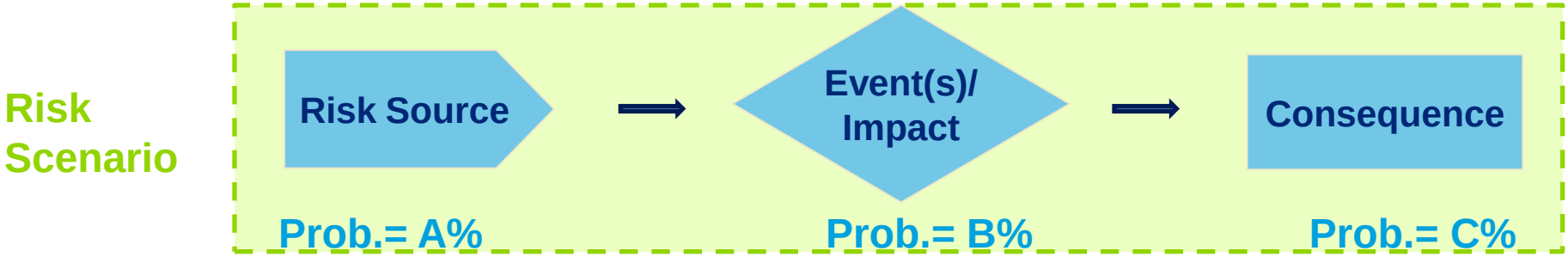
Insignificant (1)

Corporate Processes and Functions, and Service Delivery

- No or very minor disruption in delivery of essential services, projects or processes
- No increase in demand for services

Step 3.2. Estimate Likelihood

	Qualitative Probability Estimate	Quantitative Probability Estimate	Recurrence Interval
5	**Almost Certain** – the risk will occur	**90-100% probability**	**1/1 year event**
4	**Very Likely** – the risk will probably occur	**55-90% probability**	**1/5 year event**
3	**Likely** – the risk could occur	**30-55% probability**	**1/25 year event**
2	**Unlikely** – the risk may occur	**5-30% probability**	**1/100 year event**
1	**Rare** – the risk will occur only in exceptional circumstances	**<5% probability**	**1/500 year event**



Prob. of Risk Scenario, D% = A% x B% x 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.

Likelihood	Consequence					
		Insignificant	Minor	Moderate	Major	Catastrophic
	Almost Certain	M	M	H	E	E
	Likely	L	M	H	H	E
	Possible	L	M	M	H	H
	Unlikely	L	L	M	M	M
	Rare	L	L	L	L	M

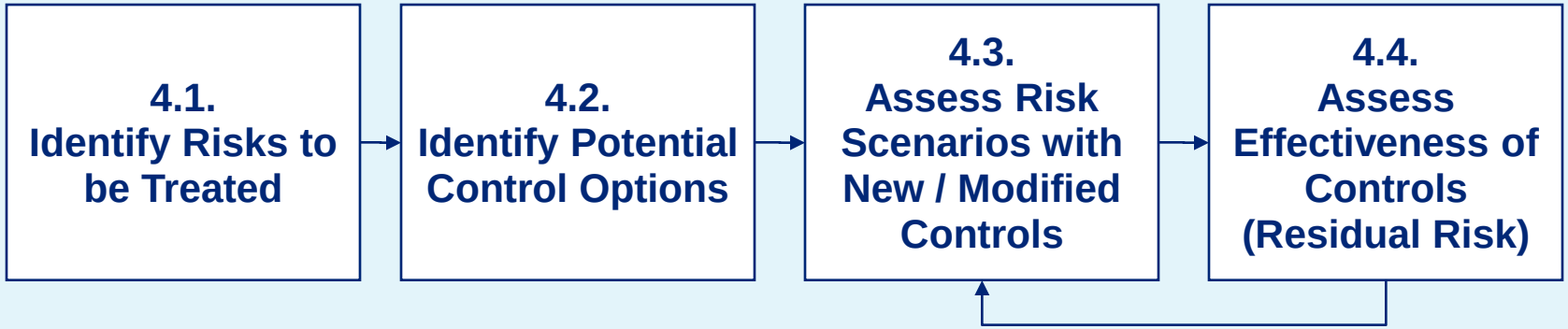
Sample Risk Tolerance Definitions

Risk Level	Description
Extreme	Primary or critical risks require immediate attention. They may have a high or low likelihood of occurrence, but their potential consequences are such that they must be treated as a high priority. Deputy City Manager involvement is essential. DCM to follow City protocol for notification of City Manager, Mayor or Council.
High	These risks are classed as significant. They may have high or low likelihood of occurrence, but their potential consequences are sufficiently serious to warrant appropriate consideration. Senior management involvement (e.g. Division / Organization Head) is essential. The Deputy City Manager should be informed.
Medium	These risks are less significant, but may cause upset and inconvenience in the short-term. Operations Management should ensure that preventive controls and mitigation plans are established and maintained, and risks are re-assessed at appropriate intervals. The Division / Organization Head should be informed.
Low	These risks are both unlikely to occur and not significant in their impact. Risks should be managed by routine procedures. Employees and contractors should be made aware of risks.

Step 4 – Risk Treatment

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.



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

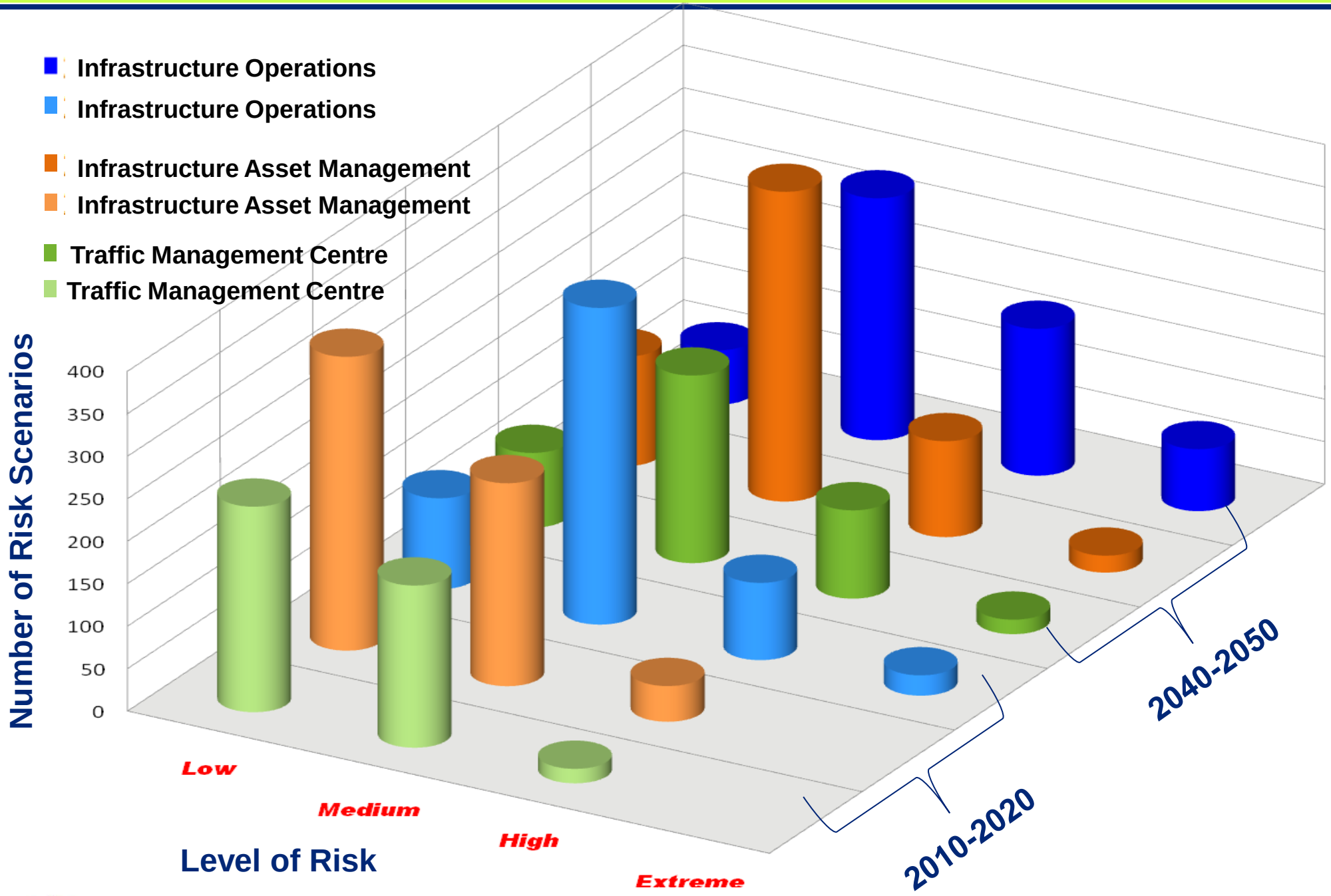
Traffic Controls Signals, RESCU Operation; Traffic Control Systems; Business Continuity Plan

Road Operation: Equipment; Staff Health and Safety; Winter Maintenance; Road Repairs; Street Sweeping Service; Inspections and Patrolling; Investigations

Transportation Services - Accomplishments

- Over **95** high priority ASSETS & critical SERVICES
- Over **1600** RISK SCENARIOS for each of the time periods **2010-2020** & **2040-2050**
- **15** half day RISK ASSESSMENT sessions
  3 half day RISK TREATMENT session
- Determined the CAUSE and EFFECT relationship between extreme weather events & cascading failures
- **100** FUTURE CONTROLS for mitigating risk
  60 CURRENT CONTROLS already in place
- Established the RIGHT MIND SET

Transportation Services
Overall Climate Change Risks Results



Traffic Control Signal Controllers - Extreme Heat

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

Transportation Impacts - Short Term Adaptation

Flooding

- Blockages/danger from washouts, flooded facilities

Wind Damage

- Blockages/danger from downed trees, power lines

Ice Storms

- Traction loss, switch malfunction and danger from ice formation

Heat Waves

- Expansion buckling of rails, pavement (e.g. rutting, shoving)

- Drainage remediation, additional run-off facilities
- Monitoring, flooding/washout/wind warnings and emergency response
- Ice warnings, sanding/salting, traffic restrictions
- Strengthening of structures
- Road/rail damage prevention/remediation

Transportation Impacts - Long Term Adaptation

- **Transportation System**: new design, materials, monitoring, construction, management, communications, maintenance and rehabilitation standards/actions
- **Flooding:** larger culverts, stronger/higher bridges
- **Wind damage:** stronger sign supports, wind shelters
- **Ice:** stronger overhead supports
- **Heat:** wider road/rail runway expansion gaps, more use of concrete, higher PGAC-value asphalt
- **Urban Form:** more sustainable development, ecology
- **Walkable cities:** mixed use mobility hubs, modal choice
- **Stormwater retention:** ponds, wetlands, green corridors, reforestation, permeable pavement

Benefits of the CCRA

- Identifies nature & severity of risks to assets and services
- Identifies most obvious vulnerabilities plus short & long term adaptation measures that are practical & achievable
- Identifies areas requiring detailed engineering vulnerability analysis (e.g. PIEVC)
- Identifies need for new designs, retrofitting & rehab
- Operationalizes climate change
- Assists in development of an Adaptation Strategy
- Ensures consistency & accountability – **due diligence** through a structured, documented approach
- Provides a mechanism for communicating climate change risk

Communicating about risk is important!

Benefits:

- Shared understanding, goals & better decisions
- Builds trust & reduces misconceptions
- Public Education & Awareness

Not communicating about risk can lead to:

- Inappropriate allocation of funds/resources
- Ineffective management of risks across the organization
- Staff legal liability
- Loss of management credibility
- Diversion of management attention from important to less important problems
- Conflicts with stakeholders

Emergency Response & Business Continuity Plan

System based approach

- Infrastructure failure and loss of service **both spatially &temporarily** -- **effective preparedness and emergency response and business continuity plans**
- **Prevention and mitigation measures** that minimize the **response & recovery**
- **Interdependencies** and **synergistic risks** which enhance **emergency response deployment** & **communication protocols**
- Develop **public education** & **awareness** for both **business** and the **community** at large

Asset Management: Culvert Management System

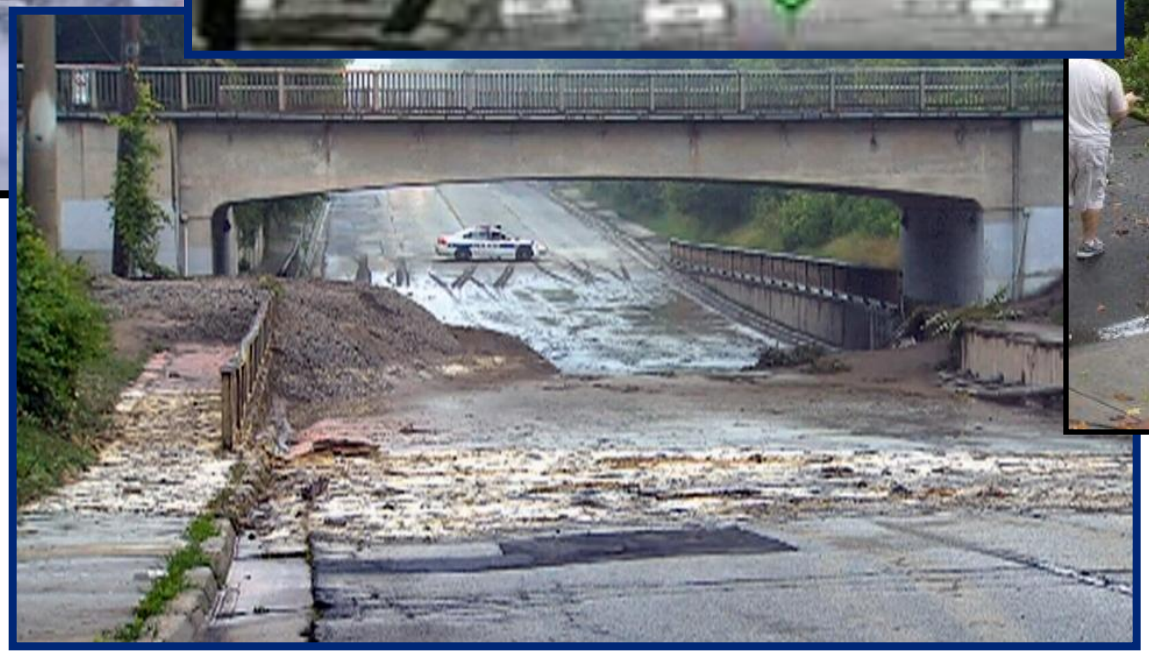
Interdependencies


Focus on the Positive!
2006 7 27

Asset Management: More Low Lying Fruit

- Installation of environmental controls (heaters and cooling fans)
- Concrete bus bays & stops
- Higher temperature resilient asphalt

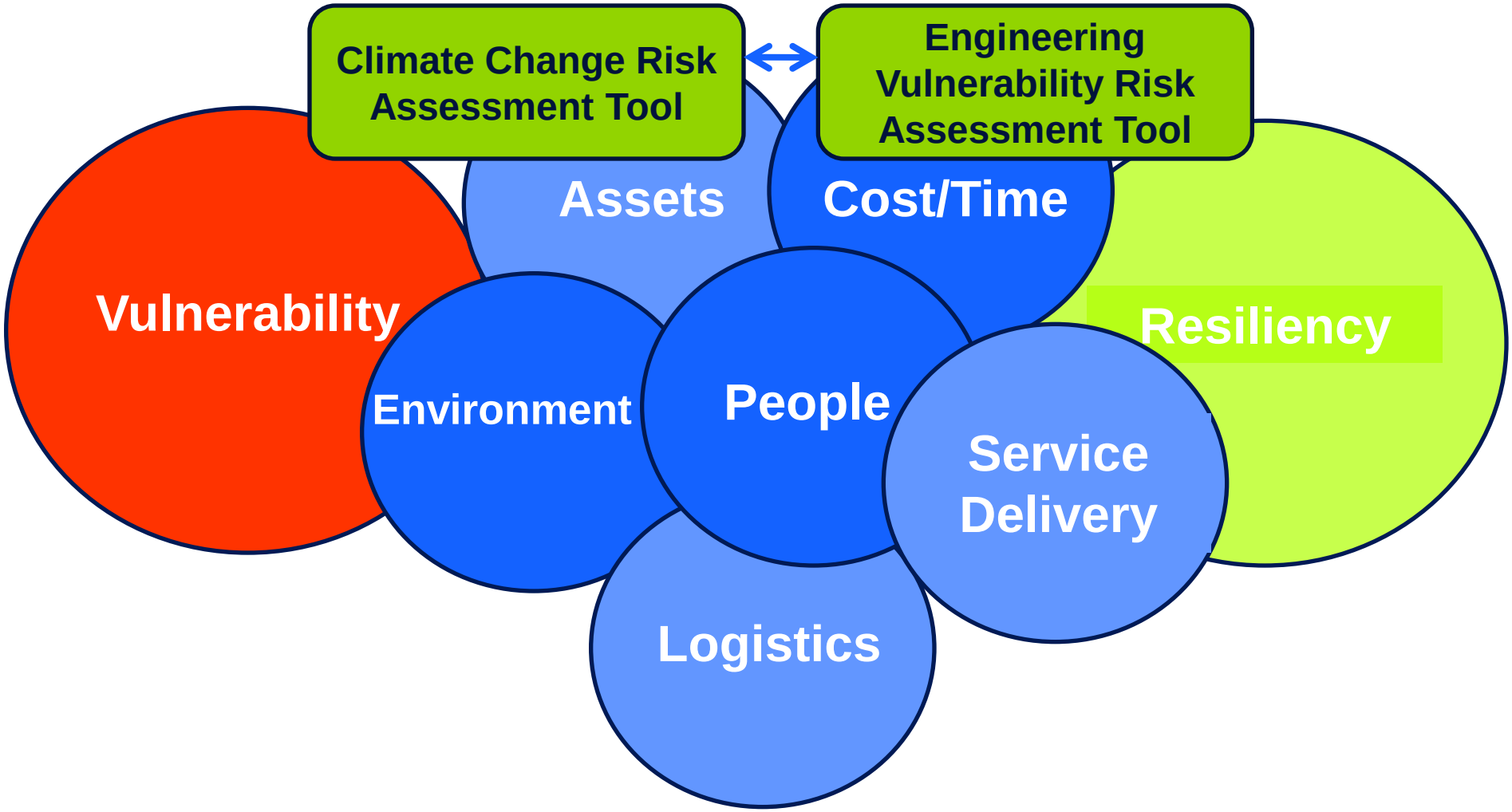
Validation of Climate Change Risk Assessment



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** & **synergistic risks**
- Select **risk assessor and train within each of the functional groups**
- Risk assessment process captures **existing adaptation controls** that provides evidence of due diligence

Beyond the Storm - Adaptation Course



Action & Awareness

- **Toronto's Climate Change Adaptation Strategy (2008), Risk Assessment Tool (2010)** & **Culvert Management Program** are ahead of the curve

- **Transportation Association of Canada (TAC)** recognizes need for climate/extreme weather adaptation in its **Canadian Guide for Green Roads (2012)** & is considering developing a **Risk Assessment Tool** for use by municipalities across Canada, drawing on Toronto's pioneering work

- Transport Canada and Natural Resources Canada co-leading an **Assessment of Climate Change Impacts & Adaptation for the Canadian Transportation Sector**

Questions

Contact Info

Vesna Stevanovic-Briatico

Transportation Coordinator
Transportation Services
vstevan@toronto.ca

David MacLeod

Senior Environmental Specialist
Environment & Energy Division
dmacleo2@toronto.ca

Reliance upon information in this presentation is at the discretion of the user. The City of Toronto accepts no liability for reliance on this information. It is request that if this information is used then appropriate citation be indicated.