Attachment 1

STRATEGY FOR ASSESSING ICE STORM IMPACT ON CITY TREES: PRIORITIZING REQUIRED WORK AND IDENTIFICATION OF COST IMPLICATIONS

City of Toronto

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Prepared for: **City of Toronto**

Prepared by: **Davey Resource Group**
A Division of The Davey Tree Expert Company of Canada, Ltd.

Western Region Office
7627 Morro Rd
Atascadero, CA 93422

Canada Office
611 Tradewind Drive, Suite 500
Ancaster, Ontario L9G 4V5

The report reviews current urban forest management practices for the City of Toronto and provides recommendations and long-term management strategies for sustainable urban forestry assessment planning as a result of recent significant climatic events; including tree assessments, operational efficiencies and tree management software upgrades

DAVEY RESOURCE GROUP
A Division of The Davey Tree Expert Company

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Executive Summary

On December 21, 2013, a severe ice storm swept across the Greater Toronto Area (GTA) coating tree branches with heavy ice. By the following morning, Toronto's trees were badly damaged, with resulting limb and whole tree failures widespread throughout the city, as well as the surrounding GTA. This report is intended to provide an overview of Toronto's existing urban forestry program along with recommendations and cost estimations for assessing the structural integrity of the City's tree resource following the ice storm. This report can be used in Phase 3 recovery efforts to make informed decisions about immediate strategies for the identification of residual damages and for realigning long-term strategies and policies for managing and growing Toronto's urban forest.

Toronto contains approximately 17,000 to 18,000 hectares of urban forest canopy cover provided by approximately 10.2 million trees. Of these, an estimated 600,000 trees are City-owned street trees, 3.5 million trees are in City parks and natural areas, and over 6 million trees are growing on private lands. The *Occupiers' Liability Act* [1] establishes the standard of care that the City is obligated to provide to people on its property. With storm damage to the City's tree population, the City must act swiftly and take reasonable measures to mitigate risks to public safety.

Key policies and procedures have been developed to guide the City in managing their urban forest, parklands, and natural areas. The City established an Urban Forestry Branch and employs nearly 300 full-time and seasonal staff as well as outside contractors to proactively care for its urban forest. As part of the internal tracking capabilities, the City uses a work management tracking system, Toronto Maintenance Management System (TMMS) to update their Area Street Tree Maintenance (ASTM) and Core Services programs. In addition, the City engages in numerous sustainable planting programs, natural area restoration programs, and invasive species monitoring and eradication efforts. Also critical to the urban forestry program is the various partnerships with internal and external stakeholders including Toronto Hydro, Toronto Water, and Toronto & Region Conservation Authority, among many others.

Complicating the management of the City's trees has been the presence of invasive pests such as Emerald Ash Borer (EAB), Asian Long-horned Beetle (ALHB) and Gypsy Moth. Anecdotal information from urban forestry indicates that the ice storm caused more damage to ash trees where EAB was present, and it has complicated debris management (vector control) within ALHB regulated areas and throughout the City.

The ice storm has created an unacceptable level of uncertainty regarding the condition of the urban forest. Not only were hazardous conditions created due to limb and whole tree failures, but less obvious damage and invasive pests will likely contribute to a significant decline in the overall health and benefits provided from Toronto's trees. The most effective strategy for short-term management of tree hazards and long-term improvement to the health of the urban forest will come from a complete tree assessment of street trees and select parkland trees.

The findings of this report, supported by a review of current operations, site inspections (January and April), and consultation with similar cities, clearly indicate the need for an immediate inspection of the structural integrity of the urban forest to identify residual hazards and damage resulting from the storm. However, one key benefit to be gained from this event is that the ice storm may have created a galvanizing moment for the majority of Toronto's internal and external urban forestry stakeholders. These urban forestry partners indicated that more information sharing would advance the primary goals of the Urban Forestry Branch. Having a full assessment of all street trees and select parkland trees and incorporating critical data with these partners would greatly benefit all stakeholders for the betterment of the City.

Introduction

Known as a "city within a park," Toronto contains approximately 17,000 to 18,000 hectares of urban forest canopy cover provided by approximately 10.2 million trees[1]. Of these, an estimated 600,000 trees are City-owned street trees, 3.5 million trees are in City parks and natural areas, and over 6 million trees are growing on private lands. The urban forest provides a 26.6% - 28% overall canopy cover for the 2.8 million residents of Toronto.

Toronto's urban forest, parks, and open spaces are crucial to the urban environment. They contribute to water, soil, and air quality, provide wildlife habitat, and help people recreate and recuperate from everyday stress. The health and sustainability of these green spaces is therefore very important. However, considering severe weather events, the effects of climate change, site development impacts on trees, and the movement of pests and pathogens, these forested green spaces face new risks and stressors with each passing year. The encroachment of pests such as the Emerald Ash Borer (EAB) can result in large-scale removal of tree populations. Tree and canopy loss can occur quickly as a result of an introduced pest if proper planning is not in place to prevent the further distribution of the pest along with strategies for tree replacement.

On December 21, 2013, a severe ice storm swept across the Greater Toronto Area (GTA), coating branches of trees with heavy ice. By the following morning, Toronto's trees were badly damaged, with resulting limb and whole tree failures widespread throughout the city, as well as the surrounding GTA. Recent estimates place the cost of the damage in excess of $171 million dollars and increasing [2]. In response to the storm, a three (3)-phase approach was initiated. The initial phase (first response) minimized the risk to the public and mitigated further power interruptions by removing downed trees and limbs that affected power lines and blocked public access. The second phase of work (immediate clean-up, safety and preventive maintenance) is ongoing and focused on hazard abatement on the public right-of-ways and in parkland along park pathways and roadways and in high use areas. Work associated with this phase includes tree inspections, triage, scheduling, and implementation of required hazard elimination. The third phase of work, which is the subject of this report, will address hidden hazards and remedial work, including detailed inspections and assessments of the structural integrity of the City's tree resource.

Purpose and Use of this Report

Davey Resource Group (DRG) was commissioned by the City of Toronto to review current Urban Forestry policies and practices to help develop the best approach to assess the imminent and hidden hazards remaining from the ice storm to help ensure public safety. This report offers strategies in conducting a full assessment of Toronto's street trees and select parkland trees, prioritization of the required work and the cost implications of completing Phase 3 of the ice storm response.

This report is intended to provide an overview of Toronto's existing Urban Forestry programs and strategies and cost estimations for assessing the structural integrity of the City's tree resource following the December 2013 ice storm. As part of the Phase 3 response to the ice storm, this report can be used to make informed decisions about employing immediate and long-term sustainable practices as well as choosing the appropriate assessment tools to improve the urban forestry program.

[1] See Reference

Methods

The information and recommendations presented in this report are based on a comprehensive review of existing urban forestry policies established for the City of Toronto. Reviewed documents and maps provided by the City of Toronto, Parks, Forestry and Recreation Department, Urban Forestry Branch include:

- Toronto's Strategic Forest Management Plan
- Assessing Urban Forest Effects and Values: Toronto's Urban Forest [3]
- Every Tree Counts: A Portrait of Toronto's Urban Forest [4]
- Natural Environment Trail Strategy [5]
- Core Services Report [6]
- TMMS Codes List
- Sample Tree Inventory List
- Urban Forestry Organizational Chart
- Various Maps Including Maintenance Areas and Storm Response Service Requests

Site visits were conducted to observe the extent and nature of the damage to the tree resource from the ice storm. A survey of comparison cities was initiated to determine those efforts made regarding tree assessments in response to severe weather events. In addition, the process included consultation with the City of Toronto's Urban Forestry staff and review of industry best management practices relating to managing urban forests. Although the majority of the documentation reviewed was provided by the City, some external investigation was required to help formulate sound recommendations

Background

As a result of the December 2013 ice storm, the City's tree resource incurred a significant amount of damage. Emergency storm response priorities were focused on public safety and restoration of services for residents. Early estimates put the cost of the damage to the urban forest infrastructure at $106 million dollars with the long-term restoration costs still to be determined. Urban Forestry's recovery response included three phases of work.

Phase 1 Plan

The initial phase (first response) encompassed removal of trees and limbs that affected Toronto Hydro utility infrastructure, clearing trees blocking major intersections and roads, and the removal of imminent overhead hazards. These initial efforts helped to minimize risks to the public and prevent further power interruptions. A high volume of service requests were received throughout the Greater Toronto Area and mobilization efforts included utilizing a large number of outside contractors (Figure 1).

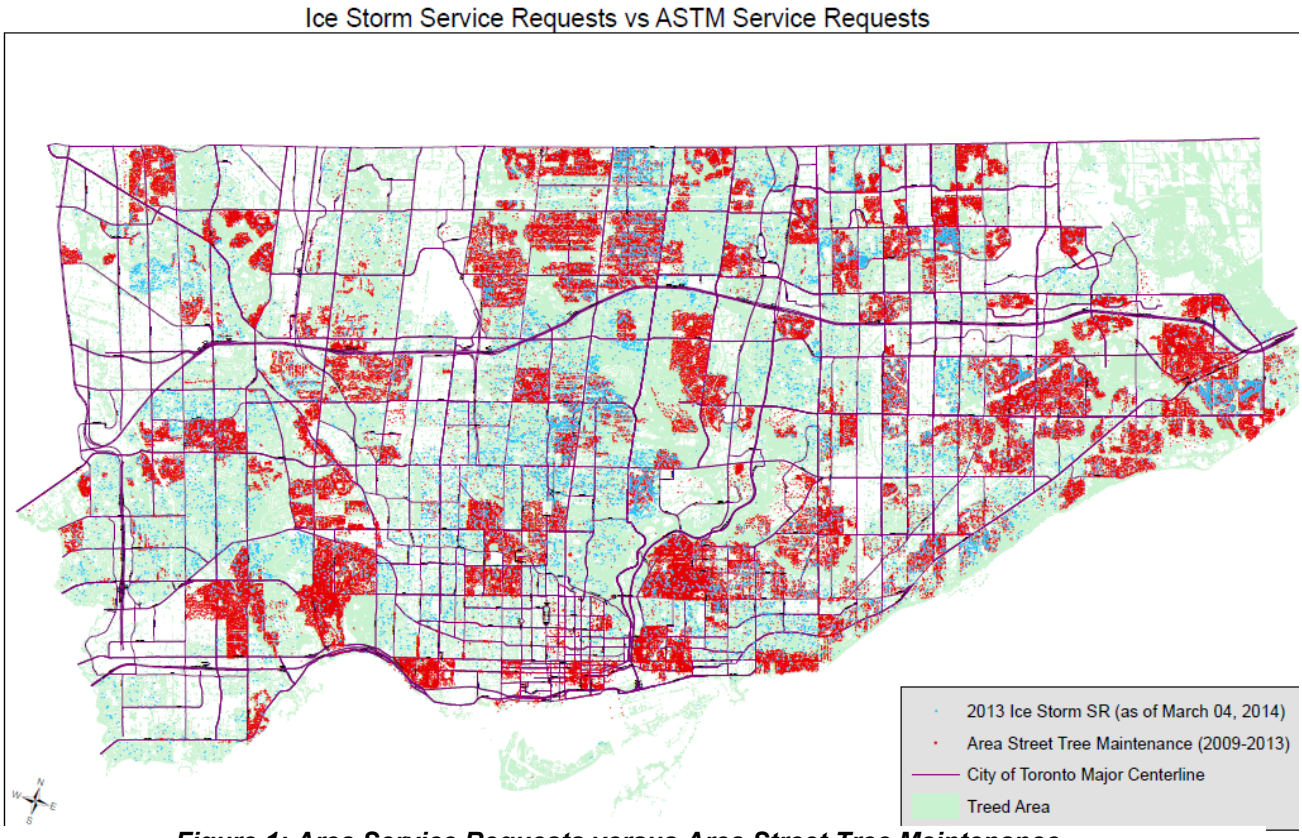

Figure 1: Area Service Requests versus Area Street Tree Maintenance

Phase 2 Plan

The second phase of the storm response is ongoing and focuses on hazard abatement on the public right-of-ways and in parkland along park pathways, roadways, in high use park areas, and in watercourses where tree debris jams may increase risk of flood damage to infrastructure and private property. This phase addresses obvious hazards, making trees safe by eliminating overhead hazards that pose an immediate risk of falling and causing personal injury or property damage. The work will mitigate liability as well as removing broken tree stems and branches in watercourses. The disposal of debris is a critical component of this phase with implications for the spread of invasive species and carbon deposition (Figure 2).

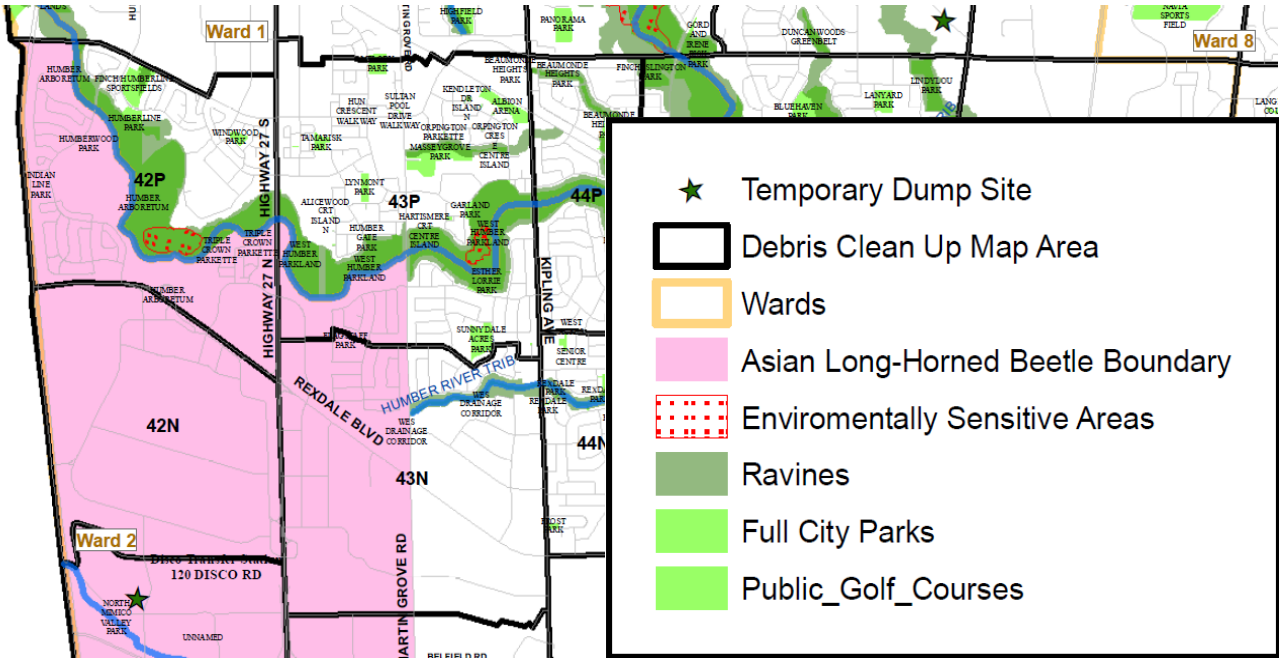

Figure 2: Example of Debris Cleanup Map

Phase 3 Plan

The third phase of work, the topic of this report, will be a detailed inspection and assessment of the structural integrity of City-owned street and select parkland trees to identify and prioritize necessary maintenance and replanting. This assessment is critical for setting priorities for addressing structurally compromised trees and developing an operational plan to address long-term restoration of the City's forest assets. As the recommendations offered in this report are administered, these actions will impart a better understanding of the storm's impact on the City's tree canopy.

Site Inspections of Storm Damaged Areas

In January, 2014, immediately following the ice storm DRG and City staff visited storm damaged areas to assess the initial impact on the urban forest. Follow-up site inspections began on April 16. The focus of these inspections was on species, tree structure, size of the failed part, areas hardest hit by the ice storm, implications to current programs and the required crew response complement. Below is a summary of the findings and conversations with City staff attending the site inspections. Please note that these are preliminary findings that will be further confirmed as individual assessments are conducted and data is analyzed. A complete review of the site inspections can be found in Appendix 3.

- Majority of damage was North of Eglinton Avenue with hardest hit areas in the northeast end of Toronto (North York/Scarborough region).
- Ravine areas exhibited more significant damage due to lower quality species and poorer structure.
- Some areas (e.g., East York) exhibited less damage due to smaller tree size and lower tree densities.
- Areas with more mature hardwood species (e.g., Forest Hill, Rosedale) did not exhibit as much widespread damage.

- Areas closer to Lake Ontario were typically not as badly damaged due to microclimatic effects from the lake.
- Degree of damage was dependent upon location, size, species, and structure. Species and structure were the greatest determinants.
- Siberian elm was the most damaged species.
- Ash trees that were not exhibiting visible signs of EAB infestation were not as badly damaged as trees with advanced infestation (independent of treated ash vs non-treated ash).
- In spite of proactive pruning practices like the ASTM program, the ice load was so severe that it damaged trees regardless of pruning.
- Softer wooded trees exhibited more damage than hardwood trees.
- Majority of damage due to whole tree failure.
- Observations indicate that significant residual risk remains throughout the city (Figure 3).

Besides lost canopy, trees with branch failures will tend to produce sucker growth over the next five to ten years. Sucker growth typically leads to multiple branch attachments/crowding and a weaker union with a higher likelihood of failure in the long term. To mitigate this effect, these trees will require restructuring, resulting in an additional long-term maintenance and financial impact from the ice storm.

Many ash were significantly damaged and were deemed hazardous (some of which were candidates for injection). Their subsequent removal will have a direct impact on the EAB management strategy long term as there will be fewer ideal candidates to inject and a greater need for new tree planting.

Lastly, there remains significant residual risk of varying degree throughout the entire city of Toronto. Some damage/breakage from the ice storm, while not yet evident, will be better observed in late spring and summer as emerging leaves increase the weight (and sail) on weakened branches.

Figure 3: Example of Residual Risk Following the Ice Storm

Toronto's Urban Forestry Program

The urban forest of Toronto includes all the trees within the City's boundaries. The trees in this forest provide a wide range of environmental, ecological, social, cultural, and economic benefits. The ecological benefits from air pollution filtration and energy alone have been valued at more than $28 million per year.

Currently, Toronto has approximately 17,000 to 18,000 hectares of urban forest canopy cover provided by approximately 10.2 million trees. This equates to a tree canopy cover between 26.6% and 28%. Of the 10.2 million trees, about 6% (600,000 trees) are City-owned street trees, 34% (3.5 million trees) are in City parks and natural areas, and 60% (6.1 million trees) are on private lands. The City's urban forest contains at least 116 different tree species, with a high proportion (68%) of young trees less than 15.2 cm in diameter (Table 1). Despite the many challenges of growing in an urban environment, 81% of Toronto's tree population is estimated to be in good condition.

Table 1: Summary of Toronto's Urban Forest Composition*

Characteristic	Quantity
Number Of Trees	10.2 Million
Canopy Cover	26.6%-28%
Canopy Cover Target	40%
Number Of Trees On Public Lands	4.1 Million (40%)
Number Of Trees On Private Lands	6.1 Million (60%)
Less Than 15.2 cm In Diameter	68%
Between 15.2 cm – 30.6 cm In Diameter	18%
Greater Than 30.6 cm In Diameter	14%
Predominance Of Native Species (64%)	64%
Structural Value Of The Urban Forest	$7.1 Billion
Annual Environmental Benefits	$28.2 Million
Annual Carbon Storage Value	$25 Million

**Derived from the 2013 Strategic Forest Management Plan*

To properly maintain their urban forests for the communities they serve, cities must initiate sound policies and defined procedures. Like most large forest populations, Toronto's tree resource faces many challenges in the urban environment. Threats to forest health, maintenance requirements and expectations, urbanization impacts, effects of climate change (including extreme weather events), recreational use pressures, and increasing public awareness and support all pose unique challenges to providing a sustainable urban forest and the benefits they offer. Through policies and programs developed by the City of Toronto, the city is well positioned to manage these challenges and successfully steward their urban forest.

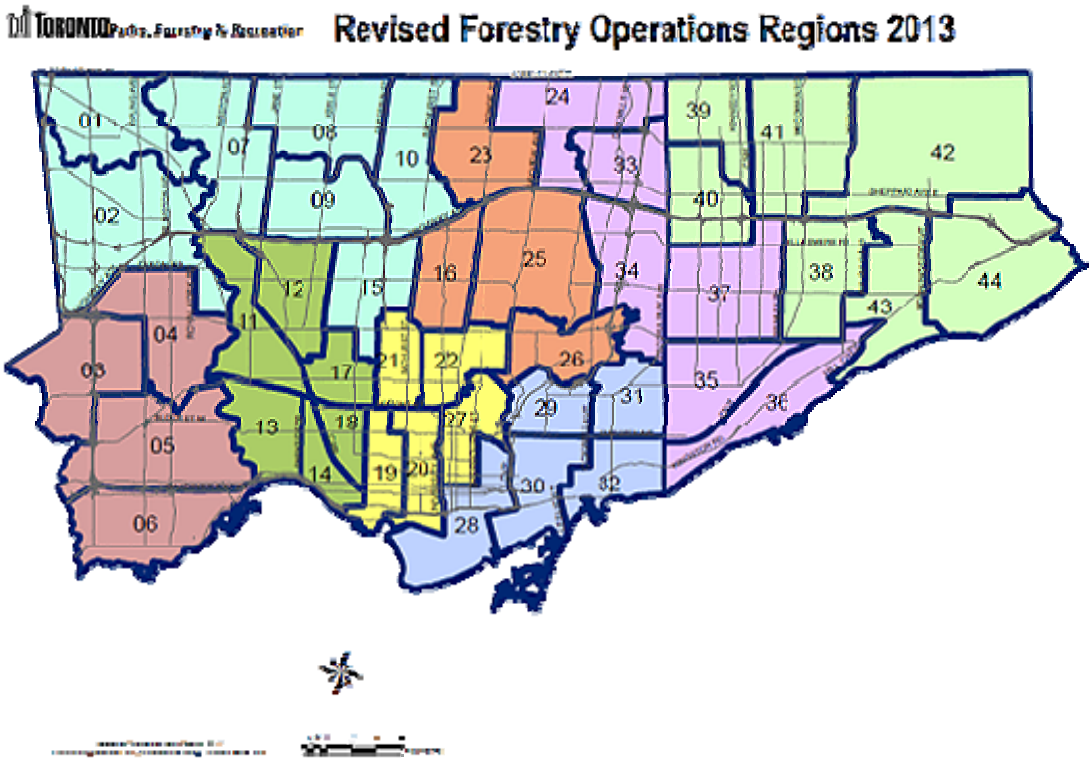

Figure 4: Toronto's Urban Forestry Operation Regions

Review of Current Urban Forestry Policies

Several key policies and documents were reviewed in the development of this report. The primary plan that helps guide Toronto's Urban Forestry Branch is the 2013 Strategic Forest Management Plan, which identifies six vital goals for sustaining the urban forest:

- **INCREASE CANOPY COVER** by protecting, maintaining and expanding the urban forest to achieve a healthy, sustainable forest with a canopy cover of 40%
- **ACHIEVE EQUITABLE DISTRIBUTION** of the urban forest and increasing canopy where it is most needed
- **INCREASE BIODIVERSITY** to improve urban forest resiliency and respond to climate change
- **INCREASE AWARENESS** by promoting better awareness of the value of trees, the natural environment, and the sensitivity of these resources
- **PROMOTE STEWARDSHIP** by improving stewardship and education of the multiple benefits of the urban forest and build collaborative partnerships for expanding the forest
- **IMPROVE MONITORING** by updating information management systems and enhance the ability to inventory, monitor and analyze the urban forest

Implementing the Strategic Forest Management Plan is primarily the responsibility of the Urban Forestry Branch, whose programs and functions are organized under four service pillars to help drive the program forward.

1. Maintenance of the Urban Forest
2. Protection of the Urban Forest and Natural Heritage
3. Planting to Expand the Urban Forest
4. Planning to Ensure Strategic Advancement of Forest Management Objectives

One of the pressures on the urban forest identified in the Strategic Management Plan was recreational use. A review of the Natural Environment Trail Strategy indicates a core principle of environmental protection. Included in this principle is the balance of risk management and environmental protection along the many trails throughout the city. The *Occupiers' Liability Act* [7] establishes the standard of care that the City is obligated to provide to people on its property. The Trail Strategy identifies Hazard Tree Abatement as an important part of that duty. In addition, new trail construction and/or repair must also consider both tree protection and risk reduction.

Another threat to Toronto's urban forest identified in the Strategic Forest Management Plan is invasive pests. The Core Services Review Report indicated the City's goal of increasing the urban forest canopy to 40% by the year 2050 was being hampered by reallocation of reserve funds toward combating EAB. This reallocation of resources has also affected efforts to move towards a routine proactive pruning cycle and continuing to grow tree canopy cover through new tree plantings across the city.

The ice storm has significantly affected and interrupted the advancement of some of the key elements in the Strategic Forest Management Plan. The document review clearly indicates that many of the goals and service pillars identified in the Strategic Forest Management Plan would benefit from the completion of a comprehensive assessment. As much needed funds are diverted for storm recovery, many established programs have been put on hold. This deferment of services will increase the backlog within these programs and ultimately require a significant increase in resources when the focus on these policies returns. In addition, specific key strategies within some plans, such as the hazard tree reduction in the Natural Environment Trails Strategy, will require increased focus and resources due to the new risks created from the ice storm.

Toronto's Current Urban Forestry Operations

Currently the City of Toronto's Urban Forestry staff includes more than 250 full time and approximately 40 temporary employees (Table 2). Field operations are divided into four districts (North, East, South and West) and eight regions (see Figure 4) and three sections oversee Urban Forest Renewal, Policy and Planning, and Tree Protection and Plan Review. The complete City of Toronto Urban Forestry organizational chart can be found in Appendix 1.

Urban Forestry employs outside contract crews to assist in various urban forestry operations and programs. Currently, approximately 80% of contract crews are working on Phase 2 ice storm response and 20% are focused on EAB, ALHB and district work.

Table 2: Summary of Toronto's Urban Forest Staffing Levels

	City Staff - Total Positions at 2013 Beginning Year				
	Permanent Full Time	**Permanent Part Time**	**Temp/ Seasonal/ Casual Full Time**	**Temp/ Seasonal/ Casual Part Time**	**Total**
Executive & Senior Management	-	-	-	-	-
Management with Direct Reports	22.0	-	1.3	-	23.3
Management Staff without Direct Reports	1.0	-	-	-	1.0
Exempt Professional, Technical & Clerical	-	-	-	-	-
Clerical/Technical/Professional	86.0	-	21.5	-	107.5
Hourly/Operations	142.0	-	18.0	-	160.0
Outside Trades	-	-	-	-	
Student/Recreation Workers	-	-	-	-	
Total City Staff	**251.0**	**-**	**40.8**	**-**	**291.8**

Core Program

The Urban Forestry Service Plan, adopted by City Council in 2008, outlines activities to efficiently and effectively manage, protect, and sustain Toronto's urban forest; creating conditions that maximize the return on investments in trees and allow them to produce optimum benefits [8]. The plan is focused on Urban Forestry's core services, characterized by the following four pillars:

- **Proactively Manage Forests and Maintain Trees**: Maximize tree canopy potential by ensuring healthier and long-lived trees through a proactive, systematic maintenance regime.
- **Improve Protection of Trees**: Maximize the canopy potential by ensuring healthier trees and avoiding unnecessary tree damage or removal.
- **Plant More Trees**: Increase long-term canopy potential by planting more trees.
- **Planning**: Develop policies, strategies, and tools to support the above programs.

The Core Program responds to work orders and service requests for the maintenance of public trees and encompasses all aspects of maintaining a healthy urban forest ecosystem, including protecting existing assets, increasing the value and benefits of the urban forest over time, and planting additional trees to meet canopy objectives.

Area Street Tree Maintenance Program

The Service Plan outlined a transition from reactive based tree maintenance to a proactive program with a target of achieving a 7-year average pruning cycle. The Area Street Tree Maintenance Program delivers planned and proactive maintenance on an area basis and is working to achieve this target through greater efficiencies in travel time, fuel costs, and productive working hours.

EAB Management Program

The EAB Management Plan, initiated in 2011, was developed in response to the expanding infestation and the City's requirement to remove trees that have died as well as to mitigate the impact on the urban forest canopy targets. The City estimates that Toronto will lose 860,000 ash trees over the next 4 to 5 years, including 32,000 street trees and 50,000 park trees.

The overall objectives of the EAB Management Plan are designed to mitigate the impact of EAB on the City of Toronto's urban forest. Components of the Plan include:

- Monitoring
- Education Plan
- Pesticide Treatments
- Removal of Infested Trees
- Tree Canopy Replacement

The EAB management strategy includes injecting healthy ash trees with TreeAzin™ to maintain their health and reduce the total number of trees that would otherwise die. In addition, injection can be used to slow the mortality of trees infested with EAB and spread the annual number of removals over a longer timeframe. The strategy also includes planting replacement trees for those that require removal in order to replace lost canopy as soon as possible [9, 10].

Structure of Urban Forest Renewal Programs

The Urban Forest Renewal Program (UFR) has four primary sections with a collaborative goal to maintain and restore trees and habitats in ravines, parks and natural areas:

- Natural Environment & Community Programs
- Forest Health Care
- Special Projects-Including ALHB and EAB
- Tree Nursery & Natural Resource Management

The goals of the UFR program include maintaining forest health, maintaining natural areas, stewardship of trails and natural areas, and developing and organizing community programs associated with tree plantings and renewal projects. Other tasks of the UFR program require cultivating capital projects in a variety of different categories. These include Ravine Forest Management, Natural Environment Trails, Park Asset Management Planning in Natural Environment Parks, Small Scale Environmental Initiatives (e.g., interpretive design features, brochures, private/public partnership projects), and Erosion Management.

Additional Urban Forestry Programs

Planting Programs

The City conducts a number of tree planting programs in support of the long-term tree canopy objectives. These include residential, commercial, and community planting programs as well as a Newly Planted Tree (NPT) maintenance program.

Toronto Water provides funding for storm water management plantings in parks and on road allowances. Their goal is to plant trees to help reduce storm water runoff, a direct benefit to Toronto Water. Funds from Toronto Water are incorporated directly into the operating budget to pay for planting trees aimed at storm water management and also for naturalization plans. Recent efforts have focused on ash replacement and forested natural areas where EAB management has effected overall populations.

Toronto Transportation provides funding for trees that are planted on streets where no transportation related construction work is planned to take place for a specified number of years. The estimated $750,000 is for larger stock planting to enhance roadways.

Tree Protection and Public Safety By-Laws

Toronto has tree by-laws that require trees on private and City owned property be protected from injury or removal unless a permit is obtained. In certain cases the City will take financial security deposits to guarantee that trees will be protected according to City specifications, when construction is occurring near trees.

The City will also inspect private trees where reports have been made that a private tree is dangerous. Orders can be issued to tree owners to remove a dangerous tree or branch. Tree owners can fulfill the order or failing that, the City can do the work and charge the costs to property taxes. As a result of the ice storm, the City currently has a backlog of these private tree inspection requests (~500) because of a focus on addressing hazards on streets and in the public domain.

Current Tracking Capabilities

Toronto's Urban Forestry program currently uses the Toronto Maintenance Management System (TMMS) to manage and track their data. TMMS is the internal maintenance management system that tracks urban forestry data and assets (trees), service requests (callsfrom Toronto 311 and internal requests), and work orders.

TMMS requires Oracle 11G to be installed on hardware (PC). Field inspectors access the system from tough book computers via the Citrix based environment to complete inspections and create associated work orders (Figure 5). Tough book computers are currently being used but are in the process of being replaced with both i-pads and HP 9470m laptops.

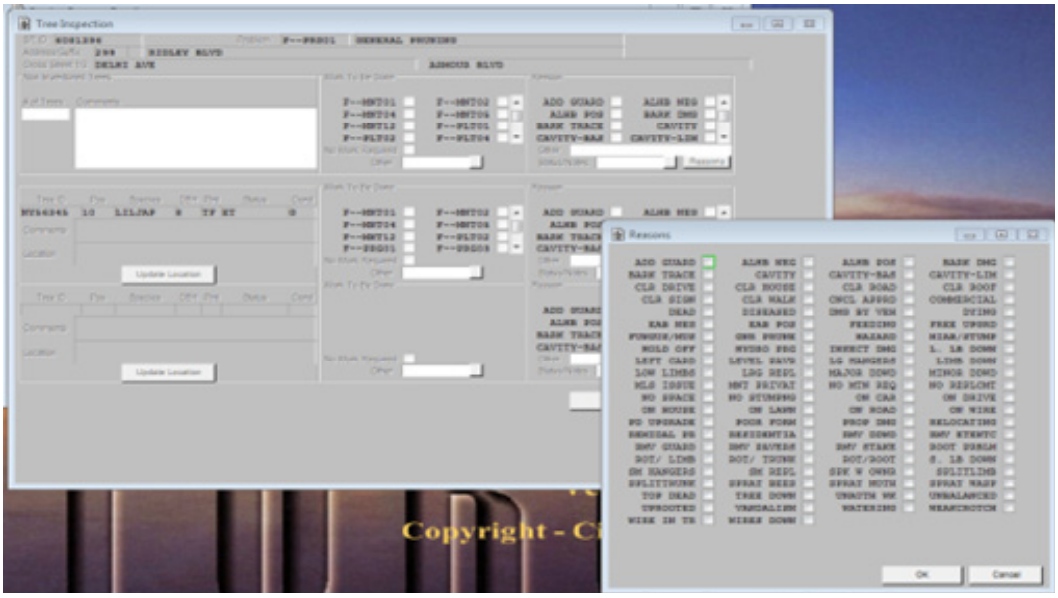

Figure 5: TMMS Tree Inspection Form

TMMS is used to track work planned and work completed (with a margin of error based on the amount of backlog entries) and provide a history of work completed for assets recorded in the Urban Forestry system. Other city divisions use TMMS to track costs, but currently Urban Forestry does not utilize this component.

When work is requested, the prescribed tree is recorded and inspected by assigning the specific assets of the tree to the service request and to the work order. After being assigned, operations staff can correlate the history of an asset and see what work has been completed. Trees without a direct address correlation (e.g., natural areas, centre boulevards) cannot be tracked or recorded and consequently no work or service request history can be reviewed. As a result, for areas where no specific inventory is captured, operations may have a work order that reports the number of trees worked, but no link to a specific asset or history in the system (Figure 6).

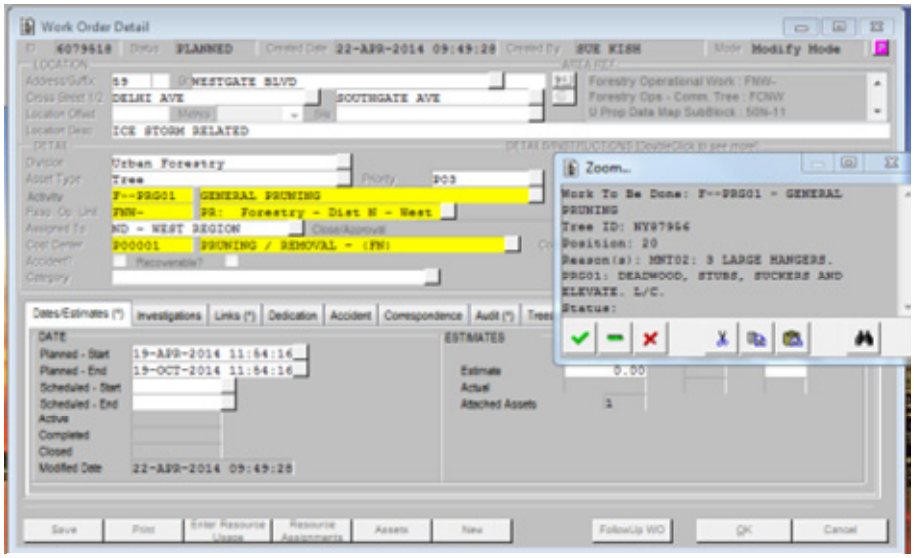

Figure 6: TMMS Work Order Form

RIVA is an asset management system and asset repository recently implemented by the Parks, Forestry and Recreation Division. It is planned that Urban Forestry assets (trees) will be added in late 2014/2015 in preparation for the deployment of a new Work Management System in 2015. Tabular data in RIVA is linked to geospatial data (geometry) in the City's spatial repository (ESRI). Currently, this system tracks approximately 17,000 assets in more than 1,400 parks and is also used to track capital projects related to assets such as pools, playgrounds, splash ponds, parks, and general park facilities (Figure 7). Table 4 compares both systems.

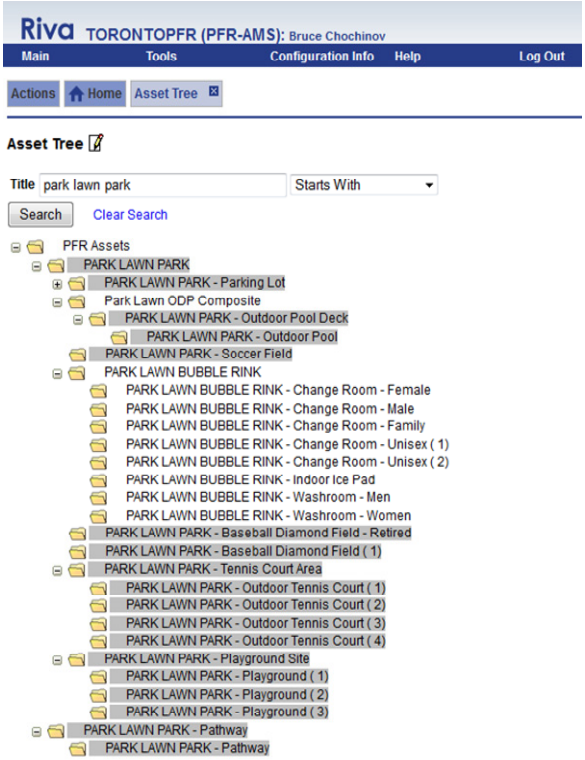

Figure 7: Screen Shot of RIVA Asset Tracking

Table 3: Comparison of Current Tracking Capabilities

	TMMS	Riva Modeling System
Data Delivery Requirements	• Assimilation of data is only achieved through front-end (Citrix) software. Back-end data delivery would involve a project setup, as no formal process currently exists to insert external data not captured within this system.	• Delivery of external data is achieved in Excel format.
Benefits (related to storm assessment):	• This method is currently used for generating and tracking work in urban forestry programs and will not require additional training.	• Delivery of storm data into Riva aligns with 2014/2015 goal of incorporating street tree data to prepare for integration with the future work management system.
Challenges	• Currently does not have any GIS or mapping component and all mapping is extracted to the coordinates of the associated address not to the actual location of the tree. • The system is not used to track actual costs and cannot easily identify outstanding work requirements. • Assimilating Data is only done through front-end (Citrix) software. • Assets in TMMS require a valid address to be added to the system. Trees without a direct address correlation (e.g., parks, medians) cannot be tracked or recorded and consequently no work history can be reviewed for a particular tree.	• The system will need to be updated to include subset and to tie archives of past work history and call center from TMMS. • Does not currently generate work requests. • Not a mobile application.

Toronto's Urban Forest Stakeholders

The City of Toronto's Urban Forestry Branch collaborates with many stakeholders both internally and externally. Some of these collaborative partners were interviewed to discuss the potential impacts and opportunities of the City's Phase 3 efforts. Specific questions were posed, including:

- Department's Primary Tasks and Goals
- Organization Chart
- Number of Employees
- Annual Budget (if available)
- How do partner operations parallel with UF operations?
- How did the storm affect the work within the department?
- How would an assessment of the trees affected by the storm benefit the department?
- What information would be useful from an assessment?
- Are there specific restoration/maintenance needs to consider when removing or pruning storm affected trees?
- How could collaborating with and/or contributing to this assessment benefit the Division?

Stakeholders were generally interested in collaboration; however each stakeholder identified specific additional information from an assessment that would be required for them to maximize the value.

Internal Stakeholders/Programs

Urban Forest Renewal

The effects of the storm on the Urban Forest Renewal (UFR) program were relatively significant, resulting in an increase in required work and community outreach. Community concerns for damage to natural parklands, including environmentally significant areas and ravines, required UFR to prepare and distribute information and guidelines for public outreach and critical communication. While some debris cleanup was necessary, UFR promoted outreach about the harm of unnecessary debris cleanup, educating the community about the importance of coarse woody debris on the forest floor, overhanging brush in smaller watercourses, and the increased sensitivity of plant communities to vehicular traffic when these debris are removed.

A complete tree assessment and the resulting updated inventory would benefit the UFR program with their forest health care and planting activities. Additionally, it would further aid in the planning of natural area management. Information about site and conditions would support their planning process. If the scope of the assessment was expanded to align with guidelines for watercourse management the UFR program would gain valuable information about where debris accumulation in watercourses and flooding is of concern. These watercourse guidelines are still being drafted however and may not be available for use with the assessment.

Another consideration identified by UFR is a need for information about heavily impacted ravines that could be mapped with data collected in the assessment process. The UFR's tree replacement program would also benefit from the identification of vacant sites by address and geospatial location.

There are other specific restoration and maintenance needs that should be considered in an assessment of ravines and natural areas. Generally, native species providing canopy and shade should be pruned rather than removed whenever possible. Non-native species should be removed rather than pruned and stumps should be treated to prevent re-sprouting. Furthermore, options for creating wildlife trees by retaining stems should be considered.

Debris management, work schedules, and other guidelines are also a concern for UFR. Woody debris management guidelines should be clearly communicated as to what can and should be left on site and what should be removed or chipped. Timelines need to be considered where access is sensitive, requires frozen conditions, or if the desired result is to effect native tree and shrub species. Developing contract specifications and training for a specialized work force to deliver watercourse maintenance in UFR areas is recommended.

Natural Areas Management

Natural areas are primarily managed by the **Tree Nursery and Natural Resource Management** section of Urban Forest Renewal. This section coordinates the removal of hazardous or invasive trees to facilitate restoration plans. In conjunction with this work, the Natural Environment and Community Programs section conducts restoration work and trail planning. This section anticipates providing additional natural areas maintenance resources in the future service plan. Besides the identification of hidden hazards, a comprehensive tree assessment would provide valuable information to help identify the location of maintained trails, assist with the building of new bike skills parks. In addition, this information may be critical to determining which unmaintained trails and bike skills parks should be closed to avoid unnecessary hazard tree management in vicinity.

Forest Health Care

Invasive species can be devastating to an urban forest as well as having a huge impact on neighborhoods that rely heavily on one or a few key tree species for shade and other benefits. Currently, through integrated pest management, Urban Forestry is managing a number of forest health threats, including:

EAB- UFR has established an Emerald Ash Borer Management Program that requires continuous communication with Forestry Operations. Results of surveys and monitoring inform operations of spread, assist with planning for projected tree mortality and budget requirements, aid with coordination of tree injection, and facilitate the marking of dead and dying trees in parks. UFR also provides information and support for communication with both the City Council and the public. Ash tree management in parks is implemented by Forestry Operations. UFR has managed logging operations to remove dead and dying ash. Since the beginning of 2014, UFR has removed 3,800 ash trees in five municipal parks.

ALHB-Asian Long-horned Beetle (ALHB) is an invasive pest that attacks and kills 12 different genera of deciduous trees (primarily maples). The management of the ALHB Special Project is currently conducted under the Forest Health Care Section within the Urban Forestry Branch under contract by the Canadian Food Inspection Agency. Specific roles include:

- Survey operations: 2 City inspectors are currently inspecting trees for the presence of ALHB.
- Tree Removal: The project has been tasked with the removal of 4 key genera (maple, willow, birch, poplar) within a radius of 800 m from an original point of identification. Approximately 7,000 public and privately owned trees have been removed within that zone. This component of the project is nearing completion. While the management component has been administered by City staff, contract crews have performed the operational component.

- Waste Management: All woody material is being processed at the Disco Transfer Station, located within the regulated area. Special provisions have been developed by the City of Toronto's Solid Waste Management Division to bypass the collection and disposal of woody material out of the ALHB regulated area in the Disco Transfer Station. Additionally, pick up of material within the regulated areas is being disposed of solely at the Disco Transfer station.

Gypsy Moth- European Gypsy Moth is a serious threat to Toronto's urban forest. At outbreak levels, this invasive insect can cause severe defoliation of trees. Parts of the city of Toronto experienced outbreaks in 2007, 2008, and 2013. An Integrated Pest Management control program was implemented in these years to prevent significant canopy loss in the affected areas. During fall 2013, Urban Forestry staff conducted multiple surveys to assess the population of surviving insects in different areas of the city. The results of these surveys indicate that large remnant populations still persist in some locations within the city.

Toronto Water

The City's Toronto Water division delivers safe drinking water, collects and treats wastewater, and provides stormwater management services. They recognize that trees can play a vital role in reducing stormwater run-off and improving water quality. A tree assessment would benefit Toronto Water because it would help prioritize tree planting opportunities.

External Stakeholders

CFIA – ALHB

On December 3rd 2013, the Canadian Food Inspection Agency (CFIA) confirmed the presence of ALHB in an industrial area near Pearson International Airport. As a result, the CFIA has established a regulated area in parts of Mississauga and Toronto to prevent the spread of the pest. The Infested Place Order now prohibits the transportation of woody plant material out of or through the regulated area. This order will remain in effect for a period of at least five years without further detection of the beetle.

One of the profound challenges of the ice storm was dealing with the resulting debris. In the aftermath, a priority concern was educating residents within the ALHB regulated area. Consequently, regulated material needed to go to a specific transfer station.

In the coming years, inspectors will continue to survey host trees, looking for signs of ALHB as required under contract by the CFIA. Having additional personnel adequately trained to identify signs and symptoms of ALHB would enhance the monitoring capacity of this special project currently administered by the City of Toronto. In collaboration with a comprehensive tree assessment, the survey protocol developed by the CFIA could be communicated to qualified tree assessors to facilitate ALHB monitoring. Relatively little specialized equipment would be required to complement the ALHB project beyond the use of binoculars.

Toronto Hydro

A great number of public and private trees in the urban forest are routinely pruned or removed by Toronto Hydro to mitigate conflicts between trees and power-lines. During the ice storm, a priority focus was on public safety and restoring power. Trees were pruned or removed as quickly as possible from Toronto Hydro infrastructure. A comprehensive assessment of residual risks adjacent to power-lines would be of most value in a partnership project with Toronto Urban Forestry. Details about species and growth rates would facilitate targeted tree trimming and likelihood of failure would also have some value to assess risk. Toronto Hydro strives for a 3-year management cycle of trees adjacent to its facilities. In support of

this management strategy, identification of trees that have a high risk of falling into high-voltage conductors within the next 3 years would be very beneficial.

Toronto and Region Conservation Authority

The Toronto and Region Conservation Authority (TRCA) works with the City's Urban Forestry staff and other divisions, including Planning, to implement habitat restoration and other improvement projects in natural areas throughout the city. Budgets are limited and resources are allocated based on priorities and current projects. The locations of rare habitats and species (identified through the Environmentally Significant Areas in the City of Toronto report, June 2012) are used to identify critical areas for continued management. Since storm damaged trees could have impacts to watershed health and flooding, TRCA would benefit from assessment data on watercourses within these critical areas.

Review of Other Municipalities' Similar Strategies/Approaches

To gain a broader understanding of the impact of the ice storm and the status of recovery efforts, DRG reached out to five municipalities in the region to learn more about their experiences, successes, and challenges in responding to the December 2013 ice storm. None of these five municipalities were as large as Toronto in terms of their urban forestry program scale. However they do provide additional context to illustrate how the Urban Forestry's response from the ice storm was substantially more complex in scope and scale. Of the five municipalities consulted, all of them have a tree inventory and most have a routine pruning cycle, with Richmond Hill having the longest cycle interval (12 years). Inventories allowed for rapid and accurate accounting of damaged trees and pruning cycles may have helped reduce the extent of tree damage. Of note was that the majority of damaged trees in most cities were ash and poorly structured trees. This indicates that EAB programs and early tree care pruning can help reduce infrastructure damage to the urban forest.

Overall, cities reported that the majority of damage occurred to trees that were not structurally pruned and ash trees weakened by EAB. In woodlots, damages occurred most frequently to trees on the outer, exposed edges and along trails. The municipalities reported losing between 0.3% and 2% of their inventoried trees, an overall average of 0.9% of the combined resources. The following is a summary of the losses, recovery efforts, and lessons learned:

Ajax

The Town of Ajax lost 500 trees as a result of the ice storm, approximately 1% of their street and park tree inventory (45,000 trees). The majority of trees lost (90%) were ash already impacted by EAB. To identify the remaining damage and potential hazards, tree crews will inspect and prune (where necessary) every tree by the end of the year. The work is being completed by a combination of in-house (40%) and contracted staff (60%).

Ajax prunes their street and park trees on a 5 to 7-year cycle. They report that pruned trees suffered less damages than those that had not been pruned. They also noted that ash trees that are being treated for EAB suffered less damage than those not treated. The Town estimates that storm recovery will cost $3.5 million including canopy loss.

Burlington

The City of Burlington lost 150 trees, approximately 0.3% of their right-of-way inventory (50,000 trees). Inspections for damages and hazards were completed in house by dividing the city into winter control sectors (28). In each sector, a supervisor was responsible for the inspection of roads and hydro. Pruning and removals were completed with a combination of in-house (~40%) and contracted staff (~60%). To date, the storm response has cost the City approximately $2 million.

The City reports that their 7-year rotational maintenance program helped to significantly reduce damage to public trees, noting that most damage occurred to ash, trees with observable defects, and private trees that had not been structurally pruned. They credit a large part of their successful storm response to having a great rapport with contractors and being able to rely on highly skilled sub trades and employees.

In response to the ice storm, Burlington will explore opportunities to increase the diversity of their urban forest and reduce reliance on ash. One of the bigger challenges for the ice storm response was cleaning up private trees that failed into the City right-of-way. To reduce this impact on future storm response, they

would like to explore provisions for the mitigation of hazards on private trees adjacent to City right-of-ways through property standards.

Oakville

The City of Oakville lost 700-750 trees, approximately 0.5% of their inventory of active park and roadway trees (~140,000). Another 8,136 trees (5.8%) required some level of pruning to repair structure and/or mitigate risk. Following the initial emergency response, 12 inspectors (6 in house and 6 contracted) looked at every tree on roadways and in parks via windshield survey to spot remaining hazards. Based on these inspections, the identified work is being completed with a combination of contracted staff (~83%) and City crews (~17%). To date, Oakville has been able to complete storm clean up on all roadways and active parks (~300 parks) at a cost of approximately $5.2 million.

Oakville does not currently have a regular pruning/maintenance cycle for their active tree inventory. However, they do have approximately 10,000 trees in the inventory that are routinely pruned for line clearance on a 3-year cycle. Observing that these trees, which represent approximately 7% of the active inventory, sustained only 3% of the storm damage, they are hoping to justify a rotational maintenance program going forward.

Richmond Hill

The Town of Richmond Hill lost 1,400 street and park trees, approximately 2% of their inventory (70,000 trees). To identify residual damages and hazards inspectors walked parks and performed a windshield survey on street trees. Where damage was identified, the inspectors collected a complete inventory update on the tree. Recovery efforts were completed with a combination of contract staff (70%), in-house staff (21%), and 6 inspectors on loan from the City of Ottawa (9%). The cost of recovery is estimated to be approximately $1.5 million.

Richmond Hill took advantage of this year's above normal snow pack and used track machines (versus wheeled) to cleanup trees in parks. This improvisation allowed them to clean up more quickly and with less destruction than would have occurred in a typical winter with a normal freeze thaw cycle.

Based on their recovery experience, foresters are recommending that the Town adopt a 5-year pruning cycle (currently 12-years). They are also focused on developing stronger relationships with utilities and regional entities in the interest of sharing resources and developing regional standards and best management practices.

Watertown, NY

The City of Watertown, New York lost 30 trees, approximately 0.5% of their inventory (~5,500 trees). This is comparatively less than was lost in the North American ice storm of 1998 when the City lost approximately 400 large, mature trees. This difference is attributed to the younger age of existing trees (most planted since 1995) and the City's dedication to structural pruning as a result of lessons learned in previous storms (1991 ice storm, 1995 microburst). Reinforcing this lesson, the City observed that ash trees planted as street trees on private property (behind sidewalks) suffered extensive damage in the December 2013 ice storm in comparison to ash trees planted as street trees in the public right-of-way (between curb and sidewalk). All of the ash trees were planted at the same time, but the trees in the public right-of-way had been structurally pruned while those on private property had not. In general, most of the damage from this ice storm occurred on private property and the City was able to use in-house staff to complete inspections and tree work.

Best Management Practices (BMP) for Risk and Assessment

Ideally, long-term management objectives for Toronto's urban forest should include achieving a routine, seven (7) year maintenance cycle consistent with the Strategic Forest Management Plan. This also implies that on average, any particular tree would be inspected at least every seven years during the pruning cycle. The City has essentially adopted this as a best practice to manage their liabilities and practice due diligence obligations on behalf of the City's residents and as part of the Strategic Forest Management Plan. However, since the ice storm, the risks and liabilities associated with the City's trees are uncertain and presumed to be very high. For this reason, an accelerated assessment cycle is warranted. Risk assessment following a storm is not uncommon, and best practices for risk management and assessment have emerged from international organizations such as the International Standards Organization (ISO) and the International Society of Arboriculture (ISA).

ISO 31000:2009 is built around a three-pillar structure: risk management principles; risk management framework, and risk management process. Within the management process established through ISO is the domain of risk assessment. The ISA has applied these risk assessment standards along with other industry practices to develop their BMP for Tree Risk Assessment [11]. This BMP (Best Management Practices) guide suggests a standardized approach to identify, analyze and evaluate the risks associated with trees. With each level of assessment, the scope of inspection increases in detail and sophistication. The three (3) levels of a tree risk assessment are as follows:

- Level 1: Limited Visual
- Level 2: Basic
- Level 3: Advanced

With a visual assessment (level 1) approach, limited information is gained about the urban forest very quickly. It can identify and prioritize the most immediate hazards, but the limited scope results in data that has limited utility for long-term management. For the sake of expediency, lower priority and less obvious hazards are often ignored. As more detailed information about a tree is collected, the information becomes a basic assessment (level 2). The basic assessment is by far the most desirable tree assessment level for urban forest management as tree hazards can often be assigned to moderate and lower risk categories. With the identification of moderate and low risk categories, trees can be scheduled for long-term (or lower priority) maintenance solutions that become cyclical routine management. In some cases, trees can be of such significant importance to the landscape or community that an advanced assessment is needed (level 3) to accommodate the tree owners risk tolerance. Although this is a very important level of assessment, the associated time and expense makes it less common in large-scale urban forestry applications.

Each of these levels provide urban forest managers with a risk management framework that can help prioritize the assessment of large populations of trees when budget and/or staff resources are limited. In all cases, the assessment of multiple trees (a set of trees), becomes a part of the fundamental set of information that constitutes a tree inventory. Besides being a tool for risk management following a storm, when the right information is collected a tree inventory is vital to work planning, tracking long term management strategies, and vegetation management in utility corridors.

Knowing what information will meet the City's needs for the short-term recovery of storm-damaged trees and the long-term management of the urban forest is essential for setting up the appropriate level of detail for the inventory assessment. According to the ISA BMP for Tree Inventories [12], an urban forest inventory can help a city realize the following benefits:

- Increased efficiency in operations
- Accountability from documented actions
- Improved community relations
- Enhanced emergency preparedness
- Improved budget justification

Identifying a clear budget commitment will provide a foundation for defining the scope of the assessment. To realize the most benefits from an assessment, the scope will also require a commitment of staff (either in-house or contracted) that can leverage the right tools and software to manage the assessment data while being collected. Once the assessment is complete, the City should be prepared with the GIS compatibility requirements and tree management software needed to maintain the database of information going forward.

Recommendations for Assessment and Work Prioritization Strategies

The recommendations presented here are based on review of Toronto's existing urban forestry policies, current operations, and site observations directly related to the December 2013 ice storm, as well as industry best management practices. While there are a number of options for assessing the overall structural integrity of a given tree population, following a catastrophic event such as this ice storm the only practical method for identifying the residual risk is an individual assessment of every street and significant park tree (e.g., in proximity to trails or other facilities). As a result, it is important for the City of Toronto to focus on a priority-based method for effectively identifying trees with residual risks and prioritizing mitigation.

The ice storm caused extensive damage to Toronto's urban forest, resulting in the complete failure of thousands of trees. In phase I of the emergency response, the City of Toronto identified these failures and cleaned up the resulting debris. However, significant damage has occurred on many other trees that while less obvious, provides a considerable residual risk of tree failure in the future. Ice damage can often compromise the structural integrity of a tree, leading to increased susceptibility to pests, disease, and wood decay, and increasing the likelihood of branch and total tree failure over time. To mitigate this ever-increasing hazard to the public and threat to the City's urban forest, a complete assessment is recommended.

Prioritizing Tree Assessment

The most comprehensive strategy for identifying residual risk is complete assessment of all City trees. However, with over 600,000 street trees and an uncertain number of significant trees (based on proximity to trails, structures, and other amenities) in critical locations in City parks and along high traffic trails in natural areas a complete inventory of all City trees will take time. Therefore, DRG recommends that the City commence a prioritized assessment to identify risks and hazardous conditions created by the storm by collecting tree data in areas of the City that were most heavily impacted by the storm.

Beginning in districts north of Eglinton Avenue and in the Scarborough area, assessments should systematically proceed through areas identified by the City as suffering the greatest damage. Within each district the City should further prioritize assessment efforts along streets since street trees are most likely to be in proximity to a target (e.g., vehicle, pedestrian, etc.). At the same time, the City should focus on park trees in high traffic areas, and high use trails in natural areas in those priority districts.

As these prioritized areas still define very large boundaries, additional consideration should be given to locations with other special conditions to further identify trees for initial inspection, including:

- **High Traffic and Emergency Access Routes**
- **Presence of Hydro Lines**
- **Neighborhood with Mature Trees**
- **Park Usage and Function**

With priority areas and hazard criteria identified, trained inspection teams can proceed systematically across the city, performing an assessment of specific risks for each tree.

In ravine, wetland, and waterway areas where storm damaged trees are not likely to pose hazards to public safety there remains a concern that tree failures could create flooding issues. These wetland and waterway areas should receive the equivalent of a limited (Level 1) tree assessment. The City should focus on areas that are flood prone or where flooding could result in property damage. Qualified personnel should inspect and assess these watercourse locations for trees that have either fallen or have imminent failure concerns that may affect stream flow or drainage. Locations of concern should be monitored annually unless, or until, the hazardous condition can be mitigated. This information can be summarized by watercourse to assess the overall risk within individual watercourses and to prioritize mitigation efforts. Any mitigation should include consideration of remediation; planting suitable trees that are appropriate for a watercourse or to maintain slope stability.

Where the City has secured a financial security deposit for the protection of City-owned trees near construction sites, trees should be inspected as soon as possible to update condition, document any damage or loss from the ice storm, and verify that a security deposit is still warranted.

Work Completion Estimations

To devlop costs and work completion estimations, DRG used the following methodology:

The City of Toronto estimates that the urban forest includes 600,000 street trees and 3.5 millon park trees. The estimated trees in each priority area are based on the total number of street trees divided by 44 (the number of total wards), multiplied by the number of wards within each area. Park trees are estimated based on the proportion of wards identified in the city and 10% of the estimated total population of park trees. Duration of months was estimated based on a 50 hour work week.

Table 4: Estimated Cost Implications of Recommended Assessment Stages

Priority Area - # of Wards	Wards	Estimated Street Trees*	Park Trees**	Total Estimated Trees	Estimated Duration (Hours)	Estimated Staffing	Estimated Duration (Months) ***	Estimated Complete by Date/Trees			Estimated Cost
								May 17-June 22	June 23 – Sept.1	Sept.1-Dec.31	
Scarborough Wards-10	29,30,31,32,35,36,37,38, 43,44	136,364	79,545	215,909	13,494	25	2.7	159,933	55,976	-	$1,012,074
Wards North of Eglinton Avenue-25	1,2,3,4,7,8,9,10,11,12, 15,16,17,21,22,23,24,25, 26,33,34,39,40,41,42	340,909	198,864	539,773	33,736	40	4.2	-	321,293	218,479	$2,249,053
Wards South of Eglinton Avenue-9	5,6,13,14,18,19,20,27, 28	122,727	71,591	194,318	12,145	35	1.7	-		194,318	$910,866
	Totals	**600,000**	**350,000**	**950,000**	**59,375**			**159,933**	**377,270**	**412,798**	**$3,958,333**

*The number of Street Trees is estimated based on the proportion of the wards identified in the city and of the estimated total population of 600,000.

**The number of Park Trees is estimated based on the proportion of the wards identified in the city and 10% of the estimated total population of park trees (3.5 Million).

***Duration of Months is based on 50 hour work weeks.

Collection Criteria

In addition to prioritizing streets in areas with the most damage, the City will need to define specific criteria, or a set of conditions, to capture and prioritize trees posing a hazard. Using a more detailed set of attributes will allow the City to strengthen their partnership with the various stakeholders who are vested in the urban forestry program. The City should consider collecting the following data set from the ISA BMP's as a foundation:

- Date of inspection
- GPS Location
- Location (street number and street name, park, etc.)
- Species
- Priority
- Diameter at breast height (DBH)
- Overall Condition – A summary condition assessment that includes Structure and Crown
    - Structure – assessment of the above ground woody components
    - Crown- assessment of the above ground leafing components,
- Storm Related Defects- observations including:
    - Identification of dead trees
    - Structural defects
    - Split stems/branches
    - Broken/cracked limbs
    - Noticeable degree of lean and direction of lean
    - Hollow stems/limbs
    - Frost cracks
- Further inspection Requested– to alert City staff to trees requiring a higher level of assessment and/or prompt action, if desired by the City
- Vacant Planting Sites

Further Recommendations

Software & Hardware Upgrades

Information should be collected in the field using computers with GPS capabilities. Data should be uploaded regularly to a Management Information Software (MIS) system for delivery to Urban Forestry staff for work prioritizing and tracking. Data can be delivered in almost any platform required by the City's existing data management system (TMMS). The City will need to integrate newly collected data in to existing systems while collections are in progress. Specific Tree Management Software should be utilized to assure that all tree inventory and work information is captured accurately for proper tree management. Software systems should be flexible enough to support the user in how their trees are managed (the City in this case), rather than the software dictating the procedures of the municipality. Software should be fully customizable to meet the needs of the users. Minimal software needs include:

- Species lists
- Maintenance Records – tracked both by internal work and contractor

- Customizable Work Areas (Neighborhoods, districts, etc.)
- Customizable/Robust Reporting Capabilities
- Customizable Data Fields
- Work Order Generation
- GIS Component
- Tree Valuation (both through 9th Edition Tree Appraisal Guide and i-Tree Tools)
- Tree Sites can be connected to Photos, Arborist Reports or other documents
- Web-based (for ability to access from anywhere) or loaded on a network system
- ESRI compatible
- Ability to modify and/or edit tree data in GIS mode
- Google Street View of specific addresses (where available)

In addition, software systems are changing so that many can be utilized in the field on a "SmartPhone" or pad-type device. Those types of systems support quick field updates, and require less expensive equipment.

Replanting

Comprehensive assessment and collected inventory data will determine the overall tree loss from the ice storm and should identify existing planting sites. This information can be used by the City to revisit existing planting plans, develop a storm recovery planting strategy, and realign annual tree planting goals with Toronto's tree canopy goals.

Wood Biomass Disposal

Coordination with EAB and ALHB programs is required in order to identify and track boundaries that govern the movement of wood and the disposal of wood biomass resulting from ice storm recovery.

Future Emergency Response Planning

An important step in the storm recovery process is an evaluation of the Emergency Response Plan. This process should include a complete review of emergency response procedures and the application of the Plan in response to the ice storm. A debriefing of responders (City staff and contractors) can identify areas of success as well as challenges faced so that the Emergency Response Plan can be adjusted and improved for the future.

Assumptions and Limitations

The information reviewed in this report and the recommendations provided are assumed to be based on the most current available data and documentation provided by the City of Toronto's Urban Forestry Branch. Cost estimations and workforce expectations are based on the most current market values and do not represent a formal proposal in any way. Costs do not include initial mobilization efforts, software set up, or other startup expenses. Estimates should only be used as a benchmark for budget forecasting purposes and are not a predictor of future economic conditions. The delivery of inventory data and hazard abatement recommendations assumes compatibility with existing systems.

Conclusion

The City of Toronto's Urban Forestry Branch manages one of the largest and most diverse tree populations in North America. The Branch has been moving towards a proactive approach to managing their tree resource by initiating sound policies, such as their Strategic Forest Management Plan, and developing strong partnerships with both internal and external stakeholders. Gains have been made in increased canopy cover, urban forest renewal, and invasive pest management.

The December ice storm was so severe that it affected the entire City of Toronto in some way. Depending upon species, structure, location, and tree size, various levels of damage occurred throughout the urban forest. Impacts of the storm will have direct implications on existing management plans including EAB and ASTM. If left unattended, these impacts will have long-term financial implications. Unidentified residual risk remains throughout the City, which should be addressed as quickly as possible in the coming months. In addition, the storm required the diversion of valuable resources from all operations to assist in Phase 1 and Phase 2 recovery efforts.

The findings of this report, supported by review of existing operations, site inspections, and consultation with similar cities, clearly indicate the need for an immediate inspection of the structural integrity of the urban forest to identify residual hazards and damage resulting from the storm. To facilitate the identification and mitigation of highest risk, DRG recommends a comprehensive assessment of City trees on streets, in parks, and on natural area trails. This strategy will support the City in addressing urgent and residual hazards that remain. Comprehensive data and improved technology will better align the tree database with current and future information management systems. Most importantly, a tree assessment allows the City to meet key goals set forth in adopted policies to increase canopy cover, perform effective ongoing monitoring of the urban forest and increase operational efficiencies.

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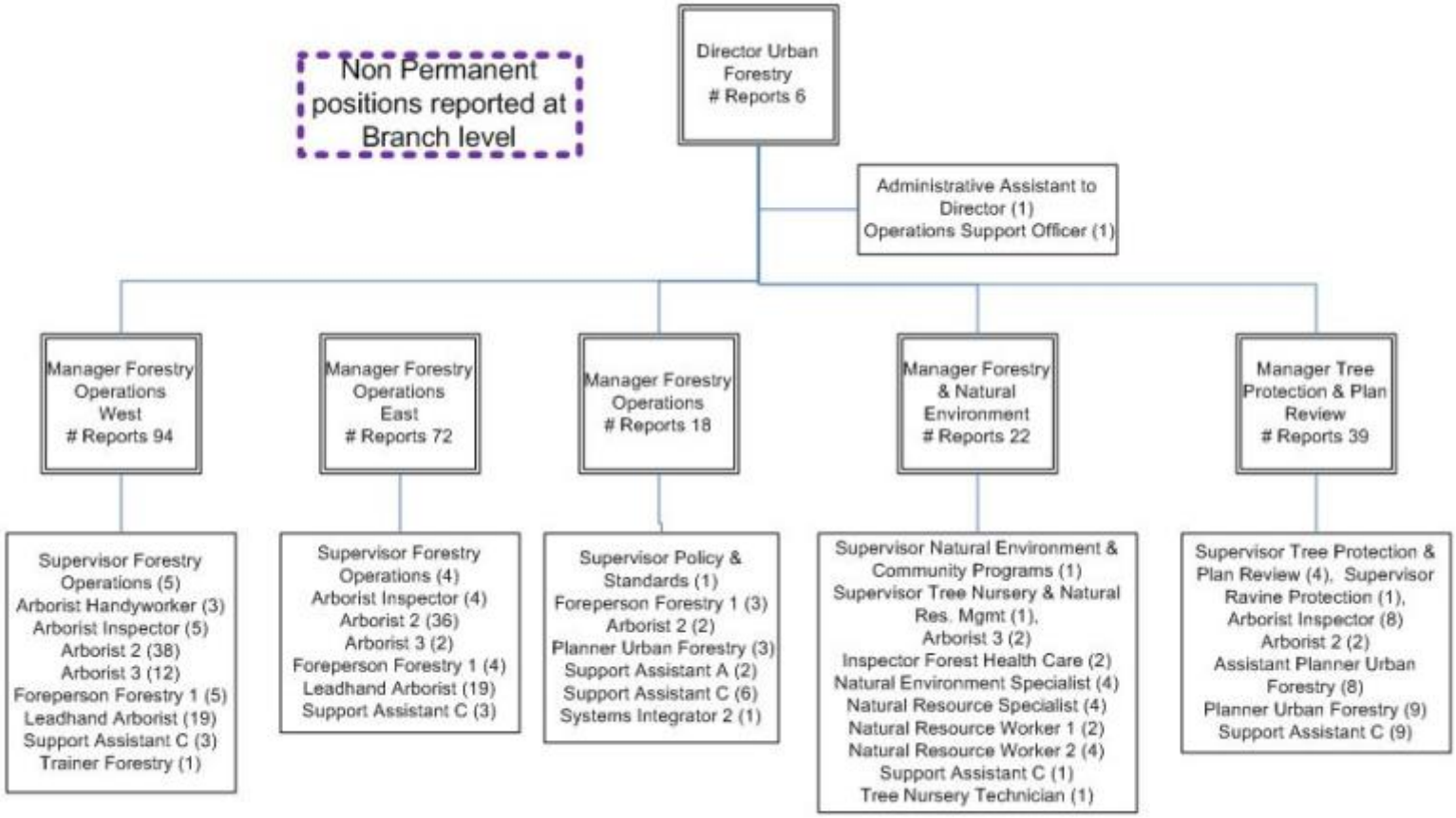
Appendix 1: Toronto's Urban Forestry Organizational Chart*

(Current as of April 22, 2014)



**Note that the Manager Forestry & Natural Environment position is now referred to as Urban Forestry Renewal and the Manager Forestry Operations with "# Reports 18" is now referred to as Manager, Forest Policy and Planning.*

Appendix 2: Comparison of Urban Forestry Programs

Table 5: Summary of Comparison Cities

City	Population	Total # of City owned trees	Inventory	Storm Cleanup Services Contracted vs. In House	Cost (to date)	Ongoing management programs	Pruning Cycle	Type of damage?	Existing programs that played a role in storm damages	Emergency Response Plan (and status)	Methods used to identify remainder of damages after initial "emergency" response	Long Term Impacts and Lessons Learned	Other Notes
Ajax	110,000	45,000	Yes	60% contract, 40% in house	~$3.5 million anticipated	EAB management, rotational maintenance program	5-7 year (contract)	90% of failed trees were ash, there were smaller limb failures in general.	Rotational maintenance and EAB. Anything that was maintained as far as pruning was far better off than ones not touched. With regard to ash trees: those that were injected were not damaged very much. Trees not injected were very brittle and dry	**PHASE 1**: All in house response for primary access routes and ensuring access for emergency personnel. Streets and driveways were first. **PHASE 2:** Inspection and cleanup & removal . Determined which was hazardous. Still in clean up now. **PHASE 3**: Each street is to be inspected by end of year. 2 Bucket trucks to drive each street and inspect for damage. If found, bucket truck will complete the work and continue inspecting. Further, the on staff Urban forest tech is looking at assigning priority to the hardest hit streets and looking also at the extent of damage within parks and woodlots.	See Emergency Response Plan	EAB impact. Many of the trees removed were ash, and will no longer be treated. 40% canopy increase is going to be delayed. 2050 goal is still achievable but not firm. Important to build on processes and improve on what you have. The goal will be back on track by 2015.	Aside from ash, Norway maples were hardest hit (split apart). Some crown failure in lindens. Proposed planting to replace every tree removed with one new tree by end of 2015.
Burlington	175,000	50,000 ROW trees, woodlots are unknown	Yes	~60% contract, 40% in house	~$2 million	EAB management plan (treat anything >20 cm. DBH)	7-year	150 trees removed, number of trees pruned is unknown as it was treated like a block prune to remove hangers and make safe, pruning large stubs, but leaving smaller ones for next rotational maintenance.	Rotational maintenance helped significantly. The majority of trees lost were ash, and those with noticeable structural defects (included bark, co-dominant stems, etc.). Observing private homes, many more trees were damaged from the storm because they were never	Have one, but it was not implemented for this event. Emergency response for the ice storm included a **Phase I** response to open all major roads and provided adequate access for EMS response. Utility lines were restored. **Phase II** involved clearing secondary roads and residential roads, addressing aerial hazards, etc.	Called in all supervisors and staff/ divided the city into winter control sectors - 28 divisions. Each supervisor was given a sector to inspect roads and hydro. This component of the response was completed concurrently with phase 1. 6 supervisors were tasked with inspections.	This storm will have implications to the EAB management strategy, rotational maintenance and planting. Many ash were removed. (150 trees removed south of Dundas). The Urban Forestry management plan should include provisions for the removal/mitigation of hazards to privately owned trees adjacent to city ROW with the ability to back charge from property	No gingko, or London plane tree fell down. Large part of the success of work was having a great rapport with contractors. Were able to rely on highly skilled subtrades/ employees.

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									pruned (silver maples and poplar spp.).			standards. Mostly trees damaged were privately owned. Would like to see less of a reliance on ash, and more of a larger of variety of trees.	
Oakville	182,520	Including natural natural areas, >1 million; 140,000 active park and roadway trees	Yes	Inspections: 50%/50% Tree work: ~80% contracted, 20% City crews	~$5.2 million	75% of Ash canopy (~5,300 trees) in active inventory are being treated for ALHB. Line clearance is completed on a 3-year cycle for ~10,000 trees (7.1% of overall active inventory)	N/A	700-750 trees fell over. 8,136 damaged trees requiring some level of pruning to restore.	Line clearance of ~10,000 trees on 3-year cycle. These trees make up 7.1% of the inventory, but sustained only ~3% of the damages.	Referred to Emergency Manual for Public Officials. **Phase I** "Debris clearance." Clear priority traffic lanes and culverts, push debris to the side, clear at least one lane on arterials, highways and secondary roadways, and open major walkways. **Status: Complete** **Phase II**, "Debris removal and disposal." Use established routes and methods for clearing tree debris. **Status: Complete** **Remaining "make safe"** work estimated to complete by July 1. Complete cleanup estimated to be complete by Fall with existing crews. ~300 active parks of ~600 parks are completed (make safe and cleanup) and open now **Status: Ongoing**	Windshield survey (3X), Phase I, Phase II, and current	Hoping to justify a rotational maintenance program based on demonstrated reduction of damage to line clearance inventory.	N/A
Richmond Hill	185,541	70,000	Yes	70% contracted, 21% City staff, and 9% borrowed staff (Ottawa)	~1.5 million	EAB strategy	12-year	~1,400 trees removed (~700 street/~700 park)	N/A	ERP was in place and initiated successfully	Walkthrough in parks, windshield survey on streets. Trees needing inspection were updated completely	Hoping to justify a 5-year pruning cycle. Planning to develop and maintain a database of contractor resources. Greater involvement with regional entities to collaborate on regional standards and BMPs.	Took advantage of track machines (versus wheeled) because of snow pack and were able to clean up more quickly and with less destruction because of the weather. Would have been harder in a typical winter with a freeze thaw cycle.
Waterto wn	27,000	5.500 street and park trees	Yes	~100% In House	N/A	N/A	3-Year	30 fell over/removed	Structural/Training pruning	Yes	Windshield surveys and follow up inspections where needed	Structural/Training pruning reduces the extent of damage to trees in an ice storm.	N/A

Appendix 3: Summary of Site Survey

Table 6: Summary of Site Survey

Region	Staff Contact	Typical tree species damaged by ice storm	Avg Ht of trees (m)	Size of damage (0-10 cm, 11-50 cm, 50+ cm)	Tolerance for risk/Defect removal	Areas hardest hit	Implications to EAB management	Implications to ASTM program	Potential Barriers to Success	Crew Breakdown during storm	Gen. Comments
East Region	**Mike O'Hara**	ash spp., Norway maple, silver maple, **elm (mostly Siberian),** honeylocust, willow.	8 m (25'). South of Eglinton, trees get larger in size.	Species dependent. Most damage 10-50 cm ranging from tops of trees damaged (elm) to large scaffold failure (ash, willow, maple).	Anything over 1" diameter was removed	Tam O'Shanter G.C.; Ravines	Significant ash damage. Size was typically between 10 and 20 cm branches.	Some areas blocked pruned and sustained damage, but potentially not as much	Insufficient personnel with required skill sets	20 contract crews, 5 city crews, 1 construction crew	L'Amoreaux Park was north dump site; 2 years of remedial work anticipated based on conversation with Ottawa staff.
East West Region	**David Black**	white pine, **elm,** silver maple, linden, willow	20 m (60')	0-10 cm typically. Softer wood was damaged more. 10-50 cm damage in some maple spp.	Anything over 1.5-2" diameter was considered a hazard.	**East Don Parkland (ravine) due to species composition (Manitoba maple, willow spp.)**	More ash tree removals will be required. Further assessment to determine structure important	Indiscriminate damage to trees. Some areas block pruned several weeks earlier sustained just as much damage.		10 contract crews, 2 city	4 inspectors were generating w/o in the field. Over 700 w/o at one time
North East Region	**Richard Arsenault**	**elm,** large willow, large silver maple, all soft wooded trees. Birch failure high	mature trees 20 m+ (60')	10-20 cm defects. Large Norway maples, some were heavily damaged, some not at all		Leaside		ASTM wouldn't have helped; damage/weight was too severe	Coordination with other intergovernmental agencies		**Need to complete remedial pruning**
North West Region	**George Melissis**	softer wooded trees were damaged more; linden, ash, honeylocust, Norway maple.	10 m ht (30 '). **Previous ALHB quarantine zone**. Many larger trees removed	typically 0-10 cm.		not as hard hit as east end; ravines	More ash tree removals will be required. Further assessment to determine structure important	Indiscriminate damage to trees. Some areas block pruned several weeks earlier sustained just as much damage.		30 contract crews, 2 city	Remedial work has started (1 wk in)
Southwest & Southeast regions	**Mike Noordover**	**mostly Siberian and Chinese elm**; Manitoba, honeylocust	mature trees 20 m+ (60') East York has lower tree densities and smaller tree size	0-10 cm typically. Softer wood was damaged more. 10-50 cm damage in some maple spp.		**Real damage starts north of Bloor/Eglinton area.** Rosedale hit hard; Chorley Park; David A. Balfour Park; Ravines; Beltline Trail	Not as many ash in the region;	Indiscriminate damage to trees. Some areas block pruned several weeks earlier sustained just as much damage.	Insufficient personnel with required skill sets; Coordination with other intergovernmental agencies; **Wait times for Toronto hydro hold offs slowed crews down**	3 city crews; 20+ contract. 30+ park staff dealing with debris	**There will be long-term financial implications as proactive corrective pruning may not be afforded leading to poor growth structure.**

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West Region	**Al Thomas/Fred Kremer**	**elm,** willow, Manitoba maple	Wide range 20 m trees by the lake, northern Etobicoke have more juvenile trees. Lower densities.	wide range based on tree location and species; failures typically from poorer structures	Anything over 4" was considered a hazard. Clear 10 - 15 m from banks and paths.	West Dean Park; Mimico Creek. 427 to Martingrove; Eglinton to Rathburn significant damage. Everything north of Eglinton		Indiscriminate damage to trees. Some areas block pruned several weeks earlier sustained just as much damage.	Insufficient personnel with required skill sets	2-3 city crews; 10 contract crews	3 crews with 2 mini ex, hi-hoe, skid steers and trucks worked for 3 weeks at Mimico creek. **In future: inspectors should be used initially for triage. After first sweep, w/o should be written up by inspectors and crews dispatched via grid.**
West East Region	**Joe Gutterres**	**elm,** willow, ash; Manitoba maple.	Street trees 10 m; Ravine trees 10 - 20 m. Less dense than other areas	Ranged from small limb failure to whole tree failure in ravines.	directive to prune all branches in contact with energized conductors, including service lines.	Ravines; Not as hard hit as other regions. **Climbing crews were dispatched to North Park and pruned according to ANSI standards. Debris cleanup done by super crews. Led to less residual risk and less remedial work required.**	**Ash candidates were not pruned as much intention to leave adequate canopy for injection treatment. Led to greater ash damage from storm.**	Indiscriminate damage to trees. Some areas block pruned several weeks earlier sustained just as much damage.	Coordination with other intergovernmental agencies; Toronto hydro hold offs slowed crews down. Inaccurate/out of date information on TMMS.	**3 inspectors immediately deployed. Crews deployed based on priority of work (power, primary access route clearing)**	Success was based on staff availability & organization. TMMS is a very powerful tool, but you need to know how to use it. TMMS requires updating.