



Annual State of Public Safety Report – Full  
Report  
2013/2014 Edition

# ***Technical Standards and Safety Authority***

## ***Annual State of Public Safety Report – State of Public Safety Full Report***

2013/2014 Edition



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## Glossary of Terms

|                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|---------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Code Adoption Document (CAD)</b>         | The default regulatory instrument for mandatory requirements of general application, such as the adoption of codes and standards. This instrument is used to change or modify TSSA-specific requirements.                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>Compliance Rate</b>                      | The percentage of inspections conducted by TSSA inspectors wherein no non-compliances (hazards) with the <i>Technical Standards and Safety Act, 2000</i> (the Act) and associated regulations are found.                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Director's Order</b>                     | <p>A regulatory decision made by a Statutory Director under the powers given to him/her as per the Act.</p> <p><b>Director's Order, Limited Use (s. 27)</b><br/>Places limits on the operation of a thing that is found to be defective or to not comply with the conditions of its authorization after the thing is fabricated or installed.</p> <p><b>Director's Order, Public Safety (s. 31)</b><br/>Used only where there is or may be a demonstrable threat to public safety and the subject matter has not otherwise been provided for in the Act or regulations. It can require regulation, use or disuse of specified things.</p> |
| <b>Disability-Adjusted Life Year (DALY)</b> | A DALY of 1.0 is the loss of one year of healthy life of a single person due to an injury. Please see Appendix C for a full description.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>External Factors</b>                     | Safety impact related to failures associated with factors outside the direct control of the safety system (e.g. behaviour of users/consumers of technologies and devices in lieu of their intended use, environmental/weather conditions, utility failures).                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Fatality-Equivalent</b>                  | A unit of measure obtained by integrating quantified health impacts into a single count of equivalent fatalities for benchmarking and decision-making purposes. Injury burden and Risk of Injury or Fatality are expressed in terms of Fatality-Equivalents.                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Health Impact</b>                        | Refers qualitatively to injuries and fatalities sustained by the public exposed to TSSA regulated devices/ technologies. A health impact could be one of fatal, permanent or non-permanent injuries                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>Injury Burden</b>                        | Quantified health impact determined by integrating injuries and fatalities observed across the population exposed to TSSA regulated devices/ technologies over a period of time. The Disability-Adjusted Life-Year metric is used to combine injuries and fatalities. The injury burden is expressed in the units of fatality-equivalents per exposed population per year.                                                                                                                                                                                                                                                                |
| <b>Potential Gaps in Regulatory System</b>  | Safety impact associated with gaps in the regulatory system or where no regulatory control exists.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Inspection</b>                           | An official examination of a device, system or procedure conducted by an inspector under the Act in accordance with Section 17 of the Act.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |



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|--------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Inspection Order</b>                          | <p>The authority to issue an order comes from Section 21 of the Act and is served by an inspector to one who contravenes and/or who corrects a contravention to the Act or associated regulations. Under this section, an inspector may also seal any thing with respect to amusement devices, boilers and pressure vessels, elevating devices, fuels, operating engineers and upholstered or stuffed articles, as referred to in the regulations. Where there is or may be a demonstrable threat to public safety, whether or not the thing is subject to an authorization, an inspection order includes the specific nature of identified contravention, the conditions and actions to be taken to correct the contravention and the allowable time to comply for each identified contravention</p> <p><b>High Risk Inspection Order</b><br/>Issued where non-compliance is identified and warrants an inspection order for immediate action within 0 to 10 days, for time to compliance to regulatory requirements.</p> <p><b>Medium Risk Inspection Order</b><br/>Issued where non-compliance is identified and warrants an inspection order for action within 11 to 60 days, for time to compliance to regulatory requirements.</p> <p><b>Low Risk Inspection Order</b><br/>Issued where a non-compliance is identified and warrants an inspection order for action within 90 days, for time to compliance to regulatory requirements.</p> |
| <b>Non-Compliance with the Regulatory System</b> | <p>Safety impact associated with the violation of established regulatory controls.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>Non-Permanent Injury</b>                      | <p>The consequence of an incident occurrence wherein there was an observed health impact that was estimated to be non-permanent based on the nature of the injury and its associated severity using a methodology developed by the World Health Organization (WHO). A non-permanent injury has no significant impact on the individual's life expectancy at the time of injury.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>Occurrence</b>                                | <p>The realisation of a hazard which results in, or has the potential to result in, a consequence to people or property.</p> <p><b>Incident</b><br/>An occurrence involving a system/device/component under TSSA's jurisdiction, whereby a hazard is exposed resulting in a consequence to people or property</p> <p><b>Near-miss</b><br/>An occurrence involving a system/device/component under TSSA's jurisdiction, whereby a hazard is exposed demonstrating an instance of elevated exposure to risk, while in this particular instance resulting in no consequence to people or property.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>Operational Risk</b>                          | <p>Potential risk of injury or fatality associated with the operation and maintenance of things or class of things regulated under the Act and does not account for sources of risks manifested during the design and installation stages.</p> <p>Operational Risk considers only those risks that can be observed during an inspection and can be addressed through the issuance of inspection orders.</p> <p><b>High, Medium, Low Operational Risk</b><br/>Potential risk of injury or fatality associated with operation and maintenance of things or class of things that may reach unacceptable levels within timeframes defined by the Statutory Director of each regulated program.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |



# Annual State of Public Safety Report – Full Report

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|                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|-----------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Periodic Inspection</b>        | An inspection conducted at such intervals as may be determined by the Statutory Director or required by code or regulation for the purpose of ensuring the safe operation of the device/facility.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Permanent Injury</b>           | An injury sustained by an individual that partially or permanently impairs the normal abilities of that individual for the rest of his/her expected remaining life.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Prediction Interval</b>        | A prediction interval is an estimate of an interval into which a new observation will fall, with a certain probability, given what has already been observed. In this report, the prediction interval covers between the 5 and 95 percentiles of the measured data. Observations for those indicators lying outside the prediction intervals are made with a 95% confidence level.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>Risk</b>                       | <p>The combination of the probability of occurrence of harm from a thing or a class of things under Section 2 of the Act and the severity of that harm.</p> <p>ISO/IEC. Guide 51:2014 “Guidelines for inclusion of safety aspects in standards.” Beuth, Berlin.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Risk of Injury or Fatality</b> | <p>The injury burden predicted using a simulation model to combine the probability of occurrence of harm (estimated as occurrence rates) to someone interacting or exposed to TSSA-regulated devices/ technologies and severity of that harm. The Risk of Injury or Fatality metric is expressed in fatality-equivalents per exposed population per year.</p> <p>This measure of risk accounts for historic occurrences while taking into consideration the uncertainties and variability inherent in the involved parameters such as the occurrence rate, number of victims, age of each victim and types of injuries sustained.</p> <p><b>Composite Risk of Injury or Fatality</b><br/>A single quantified measure of risk of injury or fatality across TSSA-regulated sectors in Ontario. The estimate is only for reporting purposes and may be used for benchmarking.</p> |
| <b>Safety Order</b>               | <p>A regulatory decision made by a Statutory Director under the powers given to him/her as per Section 14 of the Act.</p> <p><b>Director’s Safety Order (s. 14)</b><br/>Issued to specific persons or classes of persons, to require that specified things not be used or only used in a particular way. The order can also authorize inspectors to address any imminent hazard.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>Root Cause</b>                 | The most basic reason (underlying cause) for an occurrence that can be reasonably identified.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| <b>Trend</b>                      | A statistically representative measure for the noticeable tendency or movement toward or in a particular direction over a measured period of time (e.g. positive trend, negative trend and no significant quarterly trend).                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |



## I. Introduction

Statutory Directors appointed by TSSA have regulatory powers and obligations to effectively administer the Technical Standards and Safety Act (the Act) [1] and its associated regulations to ensure the safety of Ontarians. TSSA's Risk-Informed Decision-Making (RIDM) framework is an objective, evidence-based scientific assessment and decision-making approach that assists the Statutory Directors to discharge their regulatory responsibilities. The framework also supports TSSA to implement prevention and educational strategies to reduce risk to Ontarians. The Chief Advisor, Public Safety Risk Management is responsible for providing strategic advice and information to the Statutory Directors for them to make risk-informed decisions to reduce the risk of injury or fatality to Ontarians.

The *Annual State of Public Safety report* (ASPR) is a key component of the RIDM framework and acts as a primary source of knowledge on the safety of Ontarians resulting from TSSA-regulated technologies and its management, and also provides a forum for the Statutory Directors and those responsible for preventative and educational tools to publicly express the current and future safety strategies made across various safety programs to enhance safety and reduce risk of injury or fatality to Ontarians.

TSSA's report on the state of safety continues to be based on a continually enhanced and improved use of its unique safety indicator, "risk of injury or fatality", to help quantify observed health impacts resulting from occurrences and specifically, a prediction model that estimates the risk of injury or fatality to Ontarians. This approach was validated through a peer reviewed process and was published in a leading academic journal during the course of the year.

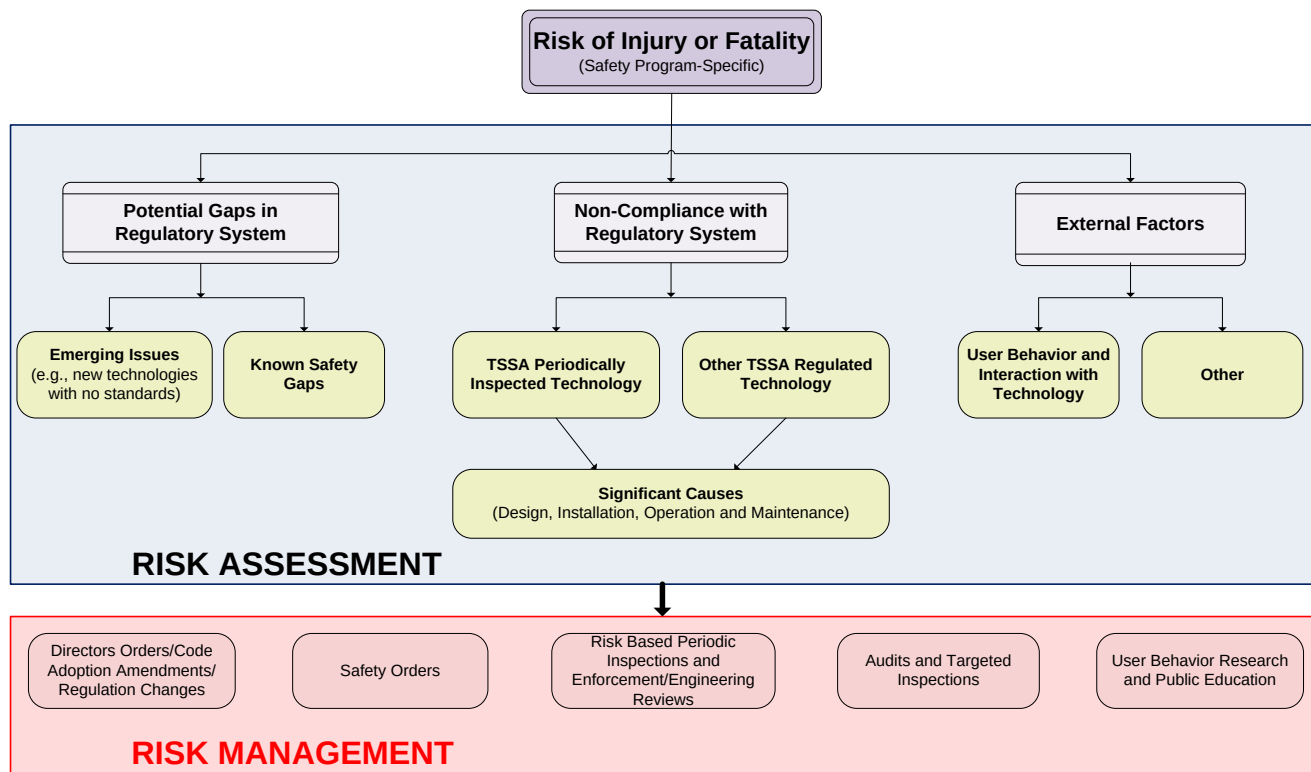
This year's version of the ASPR, while presenting the current state of safety for a seven-year period ending April 30, 2014, focuses on providing a deeper understanding of the causes and behaviours contributing to the overall level of risk. This year's report is aptly themed as "Reducing Public Safety Risks – Understanding and Managing Causes and Behaviours".

### I.1 Reducing Risk of Injury or Fatality – Understanding and Managing Causes and Behaviours

Risk of injury or fatality to Ontarians across the different TSSA-regulated sectors is estimated primarily using information gathered through reported and investigated occurrences (incidents and near-misses), and complemented with information collected through TSSA inspections and other regulatory oversight tools. The information collected allows TSSA to analyze the primary causes associated with the risk that helps Statutory Directors establish and implement strategies aimed at reducing risk.

This two stage process of assessing and managing risk depicts the public safety risk management framework that can best be illustrated using Figure 1 shown below:

Figure 1: Public Safety Risk Management Framework.



As shown in Figure 1 above, the three primary causal categories (as defined in Appendix D), leading to public safety risk include the following.

### I.1.1 Potential Gaps in Regulatory System

Emerging technologies lacking any proactive regulatory oversight including, codes and standards, form one aspect of this category. Risks in such cases are typically unknown or may not be estimated due to limited data availability. However, the potential hazards with such technologies may be known or ascertained.

Another subset of this category involves known safety gaps that are inadequately addressed by the current regulatory system. Examples include technologies designed to older codes and standards that may be prone to fail over time.

In both above-mentioned cases, TSSA may be able to address the gaps through interim tools such as Director's Orders. In certain instances, TSSA may recommend the need to effect changes to regulations.

### I.1.2 Non-Compliance with Regulatory System

This category of occurrences involve failures resulting from non-compliance with the regulatory requirements by those statutorily responsible for design, manufacture, installation, operation and/or maintenance of TSSA regulated technologies and devices. The level of understanding, education, required skills and training of these regulated stakeholders or responsible parties such as owners of technologies, installation and maintenance technicians, along with their intent to comply, affect this category of risks.

The level and type of TSSA regulatory oversight of these activities varies from program to program. In most instances, the regulatory expectations of TSSA are specified in the Act [1] and its associated regulations. A key oversight function involves TSSA initial and periodic inspections of devices before and during their operation.



Risks falling in this category are identified and reduced through introduction and/or enhancement to TSSA's existing regulatory oversight tools. Increasing levels of risk in this category may require introduction, expansion or modification to existing TSSA regulatory oversight powers such as inspections and audits. Another important regulatory tool to manage significant risks involves the use of Directors' Orders and in certain instances, regulatory changes may also be recommended.

### **I.1.3 External Factors**

Occurrences take place despite the presence of an adequate regulatory management system. Risks in this category are typically caused due to use of technologies and devices by users, such as members of the general public in lieu of their intended purpose. Examples include improper maintenance of residential heating equipment, such as furnaces due to poor or inadequate understanding of the risks which contribute significantly to risks in this category. A comprehensive understanding of user behaviour helps TSSA set up appropriate public education tools to reduce risk in this category. A detailed description of TSSA's innovative approach to understanding and modifying user behaviour is provided in Appendix A of this section of the ASPR.

Other reasons under this category may include environmental factors such as weather, deliberate intent or sabotage, occurrences involving TSSA-regulated technologies but due to factors outside of TSSA's jurisdiction etc. Typically in such cases, other regulatory agencies may take on primary investigation and management of the risks with TSSA's technical support and expertise. In rare circumstances, changes may be made to TSSA's regulatory tools to address the risk.

## **Revisions to the Annual State of Public Safety Report**

In line with its commitment to continuous improvement and based on feedback from stakeholders, TSSA has made several structural changes to the report. Based on new information and data, TSSA also enhances its processes and methodologies in analysis and reporting. Significant changes to this year's ASPR affecting the results of analysis are discussed herewith. Structural changes are not identified as they are considered as enhancements to the readability of the report and do not impact the analysis.

TSSA's estimate of risk of injury or fatality is based on a mathematical model that uses various sources of data, including historic occurrence rates, types, and extent of injuries sustained by victims in the past, and the number of injured victims. TSSA has enhanced its model and methodology to account for new data for these variables while continuing to duly account for uncertainty. However, comparisons continue to be with historical results as reported in the previous versions of the report and based on previous versions of the model. Details of the enhanced methodology and the specific changes are included in Appendix C.

TSSA's rolling five-year period for measurement and reporting of compliance information for this version of the report is actually based on 4.75 years. In order to ensure reasonable data integrity, TSSA has used data only from the current TSSA information database, which was implemented in July 2009. In previous versions of the report, TSSA combined data from two information databases.

TSSA has expanded the flexibility of its business intelligence tools and, as such, is now able to attribute occurrence information to perceived actual dates rather than relying on dates based on internal processing times. Effectively, this change has resulted in few variations, but allows TSSA to communicate occurrence and health impact trends more accurately.

Some structural changes have been made to ensure consistency, appropriately reflect information availability, and enhance the readability of the report. Primarily, these changes affect the means by which information on the Upholstered and Stuffed Articles (USA) program is included. The USA program does not currently have any regulatory requirements for reporting of incidents and near-misses. As such, information on the potential risk of injury or death is not available and cannot be ascertained. TSSA is currently using its standard inspection order



initiative to help collect relevant information on the level of compliance in the USA program as a means to understand the level of safety. Currently available information is not adequate to make comments on the state of compliance. No specific information is therefore included in the Summary Report. However, basic statistics available have been included in the Full Report.

## Assumptions and Sources of Uncertainty

It is important to note that analysis on compliance trends will be provided over a rolling five-year period, in alignment with TSSA's strategic planning process, which typically sets safety strategies within a five-year horizon. This allows for appropriate measurement and reporting on the effectiveness of these strategies. Trend analysis on occurrences will be based on an indefinite period, limited by the nature and quality of information available in TSSA's database. This will help in better understanding the changing risk profile over extended periods of time.

In producing this report, TSSA makes every effort to ensure a high level of data integrity and continuously works toward improving the integrity of all data collected for the purposes of reporting. To this effect, TSSA takes every precaution to ensure the accuracy and quality of data presented in the *Annual State of Public Safety Report*. As such, TSSA has implemented a Quality Management System (QMS) to ensure accurate presentation of public safety information. The QMS is based on ISO 9001:2008 principles and requirements to assure transparency, data integrity and quality of the information in the report. Occasionally, it is necessary to make restatements to results reported in previous years, typically a result of timeframe factors such as information received subsequent to the issuance of the report, localized reporting lags for periodic data, and other issues.

Analysis involving prediction of health impacts and those conducted as part of safety risk assessments have identified and quantitatively accounted for additional sources of uncertainties. Explicitly stated predictions in this report typically represent expected values after accounting for such known sources of uncertainties. In line with its commitment to transparency, TSSA also began reporting on the range of expected values associated with these measures to give readers a better idea on the uncertainty surrounding these estimates.

Analysis involving reported and inspected occurrences may be significantly impacted by reporting biases, defined in Appendix C. Due to the varied nature of reporting across the different regulated sectors, TSSA is currently unable to quantify the level of reporting bias and is therefore not currently in a position to account for this uncertainty.

## Acknowledgement

TSSA would like to express gratitude to its inspectors and engineers for collecting and documenting valuable pieces of information and data through their inspections and investigations that has been used to develop this report. Thanks also to its Research and Education team for providing information on the activities and outcomes related to their User Behaviour research, and its Information Services team for providing the tools and advice for extracting data.

TSSA would like to especially acknowledge Public Safety Performance Analysts Supraja Sridharan, Kavitha Ravindran and Robert Wiersma, Public Safety Risk Advisors Arun Veeramany and Dwight Reid, and Decision Analysis Advisor Lency Abraham for leading the analysis and development of this report. TSSA would like to thank Project Coordinator Christine Ho for conducting quality assurance on the analysis and wording in the report.



## II. Full Report

### II.1 Composite Level of Risk of Injury or Fatality to Ontarians – Period Ending April 30, 2014

The risk of injury or fatality experienced by Ontarians exposed to technologies regulated by TSSA over the past seven years remains below the internationally recognized and used threshold [2, 3] of 1 fatality/million people/year. Additionally, the component of the risk of injury or fatality caused by non-compliances with regulatory requirements across all technologies periodically inspected by TSSA continues to remain a small proportion of overall risk and lower as compared to last year. Factors beyond current regulatory controls, including maintenance and use of technologies within private dwellings, continue to be the largest contributors to the risk of injury or fatality.

Over the past seven years and as a result of the fatalities and injuries shown in Table 1, Ontario has experienced an average injury burden of approximately 0.5 fatality equivalents/million people/year involving TSSA-regulated technologies and devices. Additionally, and during the same period, over 20,000 incidents and near-misses have taken place, fortunately not causing any injuries. Using a predictive approach [4] that combines these incidents and near-misses with the observed injuries, TSSA estimates that the composite risk of injury or fatality to Ontarians is approximately 0.91<sup>1</sup> fatality-equivalent/million people/year. While the total number of occurrences and fatalities do not demonstrate any significant quarterly trends, permanent injuries show a decreasing trend at 13% fewer injuries per year. Tables 1 and 2 provide information on these statistics, and Figures 2 and 3 below represent these observations graphically.

Readers are cautioned that composite risk of injury or fatality has been established for reporting and benchmarking purposes only. Readers are advised to review the risk assessment sections provided for the individual safety programs for gaining an understanding of the significant causes, more importantly, strategies for monitoring and managing risk to Ontarians.

**Table 1: Overall state of safety measures for the period  
2007/2008 – 2013/2014.**

| Measure                                                                            | Year          |               |               |               |               |               |               |
|------------------------------------------------------------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
|                                                                                    | 2007/<br>2008 | 2008/<br>2009 | 2009/<br>2010 | 2010/<br>2011 | 2011/<br>2012 | 2012/<br>2013 | 2013/<br>2014 |
| Fatalities                                                                         | 7             | 14            | 2             | 4             | 4             | 4             | 8             |
| Permanent Injuries                                                                 | 41            | 40            | 42            | 19            | 31            | 29            | 20            |
| Non-Permanent Injuries                                                             | 724           | 685           | 606           | 651           | 890           | 932           | 599           |
| Occurrences<br>(Incidents and Near-Misses)                                         | 4,022         | 4,122         | 3,998         | 4,009         | 3,994         | 4,157         | 3,751         |
| Composite Risk of Injury or Fatality<br>(fatality-equivalents/million people/year) | Not reported  |               |               |               | 0.90          | 0.83          | 0.91          |

<sup>1</sup> Represents expected estimate of a simulated distribution, 5th and 95th percentiles are 0.51 and 1.37 fatality-equivalents per million people per year respectively.



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**Table 2: Trends as of 2013/2014 for TSSA regulated sectors.**

| Measure                                    | Results and Trends (end of 2013/2014) |
|--------------------------------------------|---------------------------------------|
| Fatalities                                 | No significant quarterly trend        |
| Permanent Injuries                         | Decreasing trend                      |
| Non-Permanent Injuries                     | No significant quarterly trend        |
| Occurrences<br>(Incidents and Near-Misses) | No significant quarterly trend        |

**Figure 2: Occurrences involving all regulated program areas over the last seven years.**

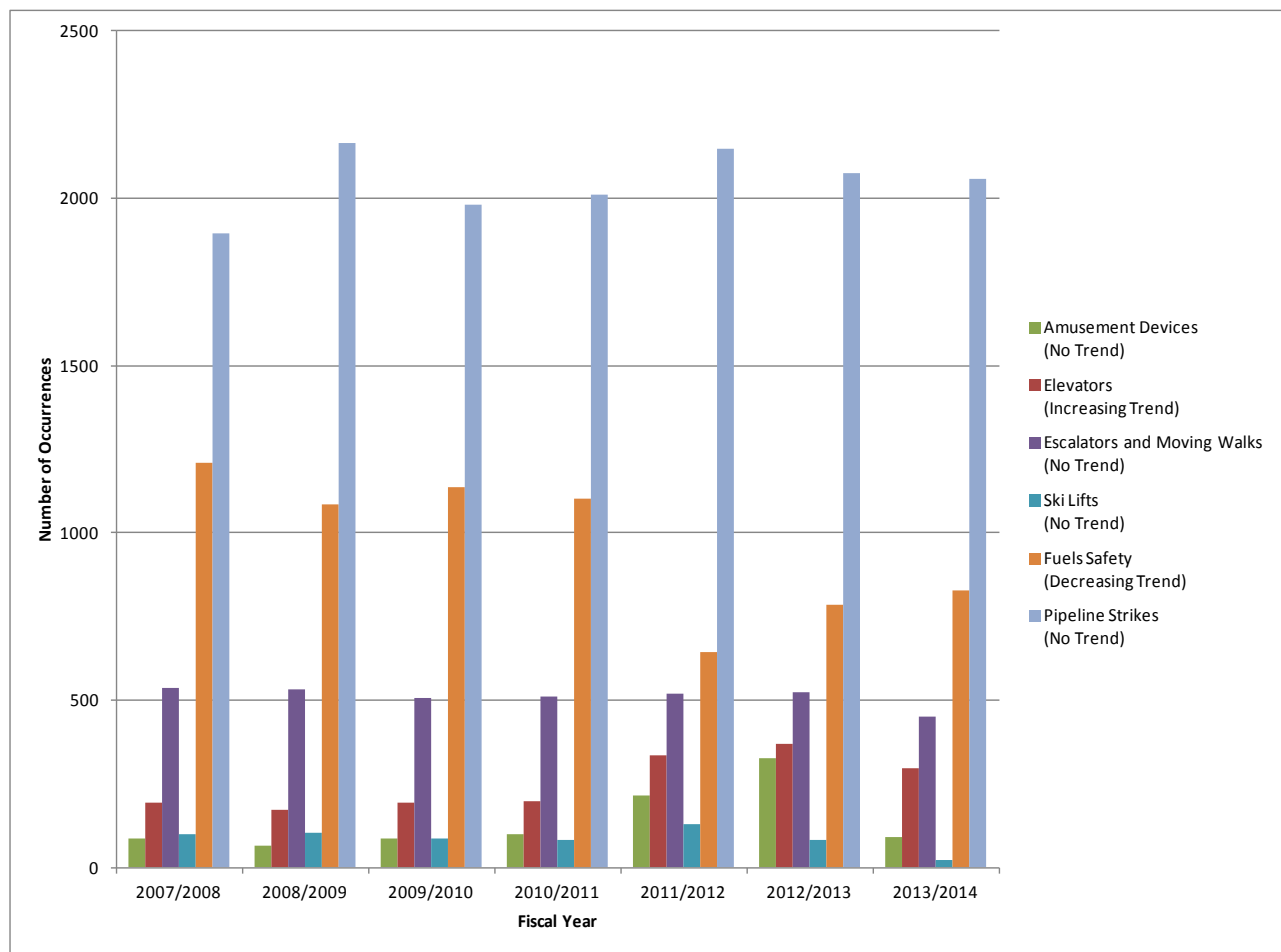
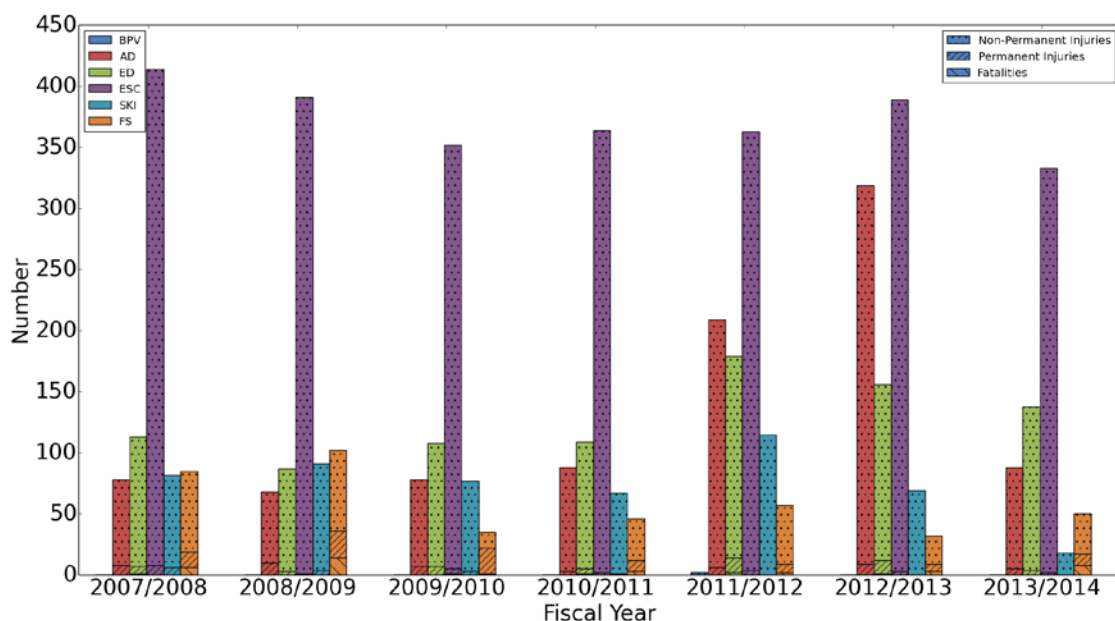




**Figure 3: Injuries involving all regulated program areas over the last seven years.**



## II.2 State of Safety Highlights

This section provides specific highlights on the areas seeing a risk reduction and those areas that are of potential concern. This has been determined based on a comprehensive analysis of available data across the regulated safety programs.

### II.2.1 Key areas of public safety risk showing a reduction over this period include the following:

#### A. Reduction in Public Safety Risks across Amusement Rides, Escalators and Passenger Ropeways (Ski Lifts)

Risk of injury or fatality measured on total Ontario population basis and across amusement rides, escalators and passenger ropeways continue to remain low and declining compared to last year. In the absence of reliable information on the actual number of riders, it is difficult to estimate the risk normalized to the actual exposed population. Risk due to non-compliance with the regulatory system continue to be low and has reduced from last year.

#### B. Reduction in Public Safety Risks at Fuels Storage and Dispensing Licensed Sites

Risk of injury or fatality to Ontarians at fuels storage and dispensing sites has reduced as compared to last year. TSSA inspects these locations on a periodic basis based on frequencies set either in regulation or through Statutory Director policies. Additionally, the compliance rate at propane storage and dispensing sites is 69%, representing an increase of 9% compared to last year, and continues to show an increasing quarterly trend.



## **II.2.2 Key areas of public safety risk that are at unacceptable levels and/or posing a concern include:**

### **A. Risk of Injury or Fatality at Private and Multi-Residential Dwellings**

Risk of injury or fatality at private and multi-residential dwellings due to occurrences resulting from heating appliances has increased by 7% since last year. Nearly 60% of all occurrences, involving regulated fuels and approximately 70% of the observed health impact, are related to these locations. The risk of injury or fatality due to carbon monoxide poisoning at private and multi-residential dwellings has increased by nearly 15% since last year. These occurrences continued to be caused primarily due to inadequate maintenance of heating appliances including boilers, furnaces and water heaters.

### **B. Risk of Injury or Fatality at Institutions and Commercial Establishments**

Risk of injury or fatality caused by heating equipment at institutions with vulnerable populations (hospitals, schools, nursing homes, etc.) has increased by 2% since the last year. These risks are mainly due to non-compliant installation and maintenance practices of heating equipment and associated accessories. Occurrences involving carbon monoxide poisoning alone are increasing by nearly 15% per year. The acceptability threshold at these locations<sup>2</sup> [5] is understandably much lower than normal locations [2, 3] of exposure.

The risk of injury or fatality at commercial establishments has increased by 5% since the last year. Poor maintenance practices of appliances, such as stoves and burners at food service locations like bakeries and restaurants posed the most risk while occurrences resulting from damage to gas supply lines (risers, meters, regulators etc.), into these locations are most frequent.

### **C. Risk of Injury or Fatality on Passenger Elevators**

Risk of injury or fatality on passenger elevators has increased by approximately 4% from last year. There has been a 9% increase in the risk due to external factors largely related to unsafe use by riders. Elevators at residential locations, primarily involving rental and condominium units, account for nearly 40% of occurrences caused by unsafe rider use.

However, the portion of the risk due to non-compliance with the regulatory system has decreased by 6% since the last year. Occurrences due to this causal category involved less than 1% of the nearly 52,000 elevators in the province. TSSA's model for risk-based inspection scheduling model [6] indicates that the majority of these elevators represent "low operational risk" as verified by TSSA inspections.

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<sup>2</sup>  $0.3 \times 10^{-6}$  according to the PSM Division, CScHE. Major Industrial Accidents Council of Canada (MIACC) Criteria for land-use planning (2008).



### III Program-Specific State of Safety and Compliance and TSSA Strategies

#### III.1 Boilers and Pressure Vessels

The Boilers and Pressure Vessels and Operating Engineers Safety Program operates within a strong regulatory and standards infrastructure, which provides effective protection for the public from any incidents involving pressure vessels. TSSA is involved in all aspects of the lifecycle of pressure vessels: from design, to manufacture, to installation, to operation and maintenance, to decommissioning – plus the certification of operators.

Boilers and pressure vessels include equipment that produces and distributes hot water, steam, compressed air, and other compressed liquids and gases used in commerce and industry. TSSA is responsible for regulating all pressure retaining components manufactured or used in Ontario, with a commitment to ensuring the safety of boilers, pressure vessels and piping systems. TSSA conducts periodic inspections on uninsured boilers and pressure vessels in Ontario. The remaining insured boilers and pressure vessels are inspected by insurance companies licensed to underwrite boiler and machinery insurance. TSSA is responsible for the certification of the inspectors employed by the insurance companies.

Incidents involving this type of equipment and associated piping are infrequent. Nevertheless, cracked and corroded vessels or piping can leak or rupture, producing a variety of safety problems, including poisonings, suffocations, fires or explosions. Ruptures can be catastrophic and may immediately threaten life and property. The safe design, installation, operation, and maintenance of pressure vessels, in accordance with appropriate codes and standards, are essential to public safety. TSSA's activities help ensure that safeguards are in place for the lifecycle of this type of equipment.

##### III.1.1 Risk Assessment

There have been seven occurrences attributed to regulated boilers, pressure vessels and piping systems in the province over the last seven years. Due to limited data, estimates of risk or trends associated with occurrences cannot be currently established.

Table BPV-1 provides statistics on past occurrences and associated trends.

**Table BPV-1: State of safety measures for boilers and pressure vessels for the period 2007/2008 – 2013/2014.**

| Measure                                                               | Seven Year Quarterly Trend     | Year          |               |               |               |               |               |               |
|-----------------------------------------------------------------------|--------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
|                                                                       |                                | 2007/<br>2008 | 2008/<br>2009 | 2009/<br>2010 | 2010/<br>2011 | 2011/<br>2012 | 2012/<br>2013 | 2013/<br>2014 |
| Fatalities                                                            | No significant quarterly trend | 0             | 0             | 0             | 0             | 0             | 0             | 0             |
| Permanent Injuries                                                    | No significant quarterly trend | 0             | 0             | 0             | 0             | 2             | 0             | 0             |
| Non-Permanent Injuries                                                | No significant quarterly trend | 0             | 0             | 0             | 0             | 0             | 0             | 0             |
| Occurrences (Incidents and Near-Misses)                               | No significant quarterly trend | 0             | 0             | 5             | 1             | 1             | 0             | 0             |
| Risk of Injury or Fatality (fatality-equivalents/million people/year) | Insufficient data              |               |               |               |               |               |               |               |



### III.1.2 Risk Management

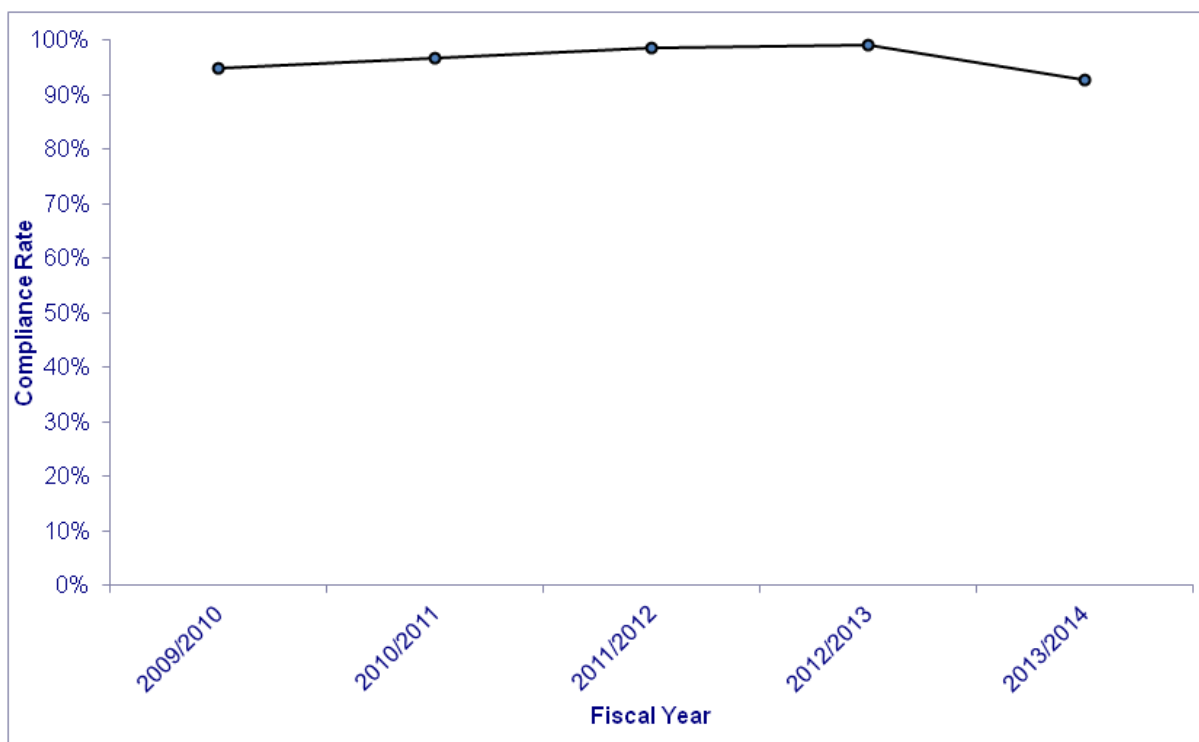
TSSA conducts periodic inspections of uninsured boilers and pressure vessels to determine the level of compliance in the province of Ontario. The frequency of those inspections is specified in the Code Adoption Document associated with the Ontario Regulation 220/01 (Boilers and Pressure Vessels). TSSA deals with non-compliance by requiring the owners/operators to address observed failures within an appropriate timeframe through the issuance of inspection orders. This periodic inspection process contributes to the preventative management of risk associated with boilers and pressure vessels.

Table BPV-2 provides information on key indicators associated with the results of the periodic inspections. Over the last five years, 2,017 periodic inspections were conducted for uninsured vessels. The compliance rate measured over the last five years is 97% and does not demonstrate any significant quarterly trend. Figure BPV-1 illustrates these observations graphically. Information on inspection orders issued for non-compliant inspections is currently not available.

**Table BPV-2: State of compliance for uninsured boilers and pressure vessels  
as of 2013/2014.**

| Measure                           | Measured over Five-Year Period |
|-----------------------------------|--------------------------------|
| Compliance Rate <sup>3</sup>      | 97% <sup>4</sup>               |
| Observed Trend in Compliance Rate | No significant quarterly trend |

**Figure BPV-1: Compliance rate for periodic inspections conducted on boilers and pressure vessels  
over the last five years.**



<sup>3</sup> Median of quarterly compliance rates over five years.

<sup>4</sup> Median value for a prediction interval of 92% to 100%.



The compliance rate for the Boilers and Pressure Vessel Safety Program area remains very high for the uninsured boilers and pressure vessels. This is corroborated by statistics from North America, which shows a similar compliance rate of 90.9% (based on the latest National Board report, Summer 2014 edition, which covers 642,607 periodic inspections over a period of 12 months). As evidenced by historical and current incident data, TSSA will continue to work with industry and boiler insurers to maintain positive safety outcomes.

The number of compliant and non-compliant inspections, as well as the number of orders issued, is shown in Figure BPV-2.

**Figure BPV-2: Number of orders and compliant and non-compliant periodic inspections conducted on boilers and pressure vessels over the last five years.**



TSSA continues to work with the insurance industry to develop a mutually beneficial process by which the status of all insured pressure retaining components in Ontario is known and appropriate actions are taken to assure public safety. The current action plan has TSSA continuing to fulfill its responsibility of inspecting uninsured pressure vessels while continuing quantitative reviews of existing TSSA and insurer data sets and data retrieval processes to assess gaps and develop plans for delivering the above-mentioned mutually beneficial process.

Another initiative that is being developed is the standardization of orders to facilitate analysis. Once implemented within TSSA, these standardized orders will then be shared with our insurer partners.



## III.2 Operating Engineers

Operating engineers, also known as power engineers in jurisdictions outside Ontario, are certified professional power plant managers and operators who oversee the provision of energy, climate control, electric power or other utilities for thermal-electric generating stations, industrial processes and facilities. They manage, operate and maintain boilers, steam turbines and engines, gas compression plants, refrigeration plants, and associated mechanical and electrical systems in power generation, industrial processes and environmental system plants.

Depending upon the size of a specific facility, operating engineers may also manage, operate and maintain all physical facility operations. Large power plants have several operating engineers for each shift, designated as shift engineers and assistant shift engineers. In all cases, a chief operating engineer is responsible for the entire plant management, operation and maintenance. The Operating Engineers Safety Program is responsible for registering, inspecting and regulating the safety of approximately 2,900 plants in Ontario, as well as examining and certifying over 12,700 operating engineers and operators to confirm their qualifications. These activities ensure that all operating engineers and operators in Ontario have the skills and knowledge to safely manage, operate and maintain registered power plants.

### III.2.1 Risk Assessment

No fatalities or permanent injuries were reported over the last seven years and four occurrences were reported during the same period. Due to limited data, estimates of risk of injury or fatality or trends based on past occurrences cannot be currently established involving registered operating plants.

### III.2.2 Risk Management

TSSA conducts periodic inspections of nearly 2,900 registered operating plants in Ontario. These periodic inspections assist in maintaining a low to negligible risk of injury or fatality to Ontarians that may result from non-compliance with the regulatory requirements. TSSA uses a risk-based inspection scheduling process [6] to determine the frequency of inspections of all registered plants. Data collected through these inspections helps prioritize frequency of inspections and to proactively manage risk of injury or fatality.

Using a risk-based approach, the entire inventory is inspected at least once over a two-year period. TSSA deals with observed non-compliances by issuing inspection orders to the owner/operator to address these non-compliances within an appropriate timeframe. This periodic inspection process contributes to the preventative management of risk of injury or fatality associated with operating plants.

Table OE-1 provides information on key indicators associated with the results of the periodic inspections. 11,550 periodic inspections have been completed over the five-year period. The compliance rate measured over the last five years is 42% and does not demonstrate any significant quarterly trend. Figure OE-1 illustrates these observations graphically.

**Table OE-1: State of compliance for operating plants as of 2013/2014.**

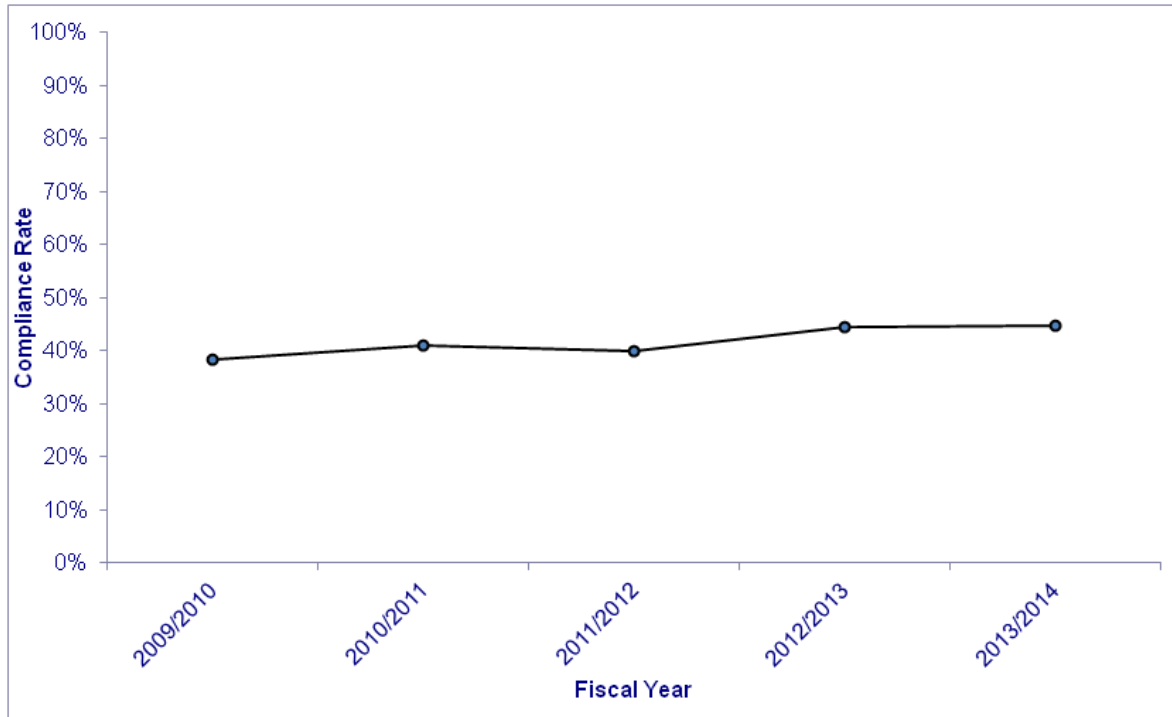
| Measure                                   | Measured over Five-Year Period |
|-------------------------------------------|--------------------------------|
| Compliance Rate <sup>5</sup>              | 42% <sup>6</sup>               |
| Observed Trend in Compliance Rate         | No significant quarterly trend |
| Percentage of High Risk Inspection Orders | 42%                            |
| High Risk Inspection Orders Trend         | Decreasing trend               |
| Percentage of Low Risk Inspection Orders  | 42%                            |
| Low Risk Inspection Orders Trend          | Increasing trend               |

<sup>5</sup> Median of quarterly compliance rates over five years.

<sup>6</sup> Median value for prediction interval of 30% to 52%.

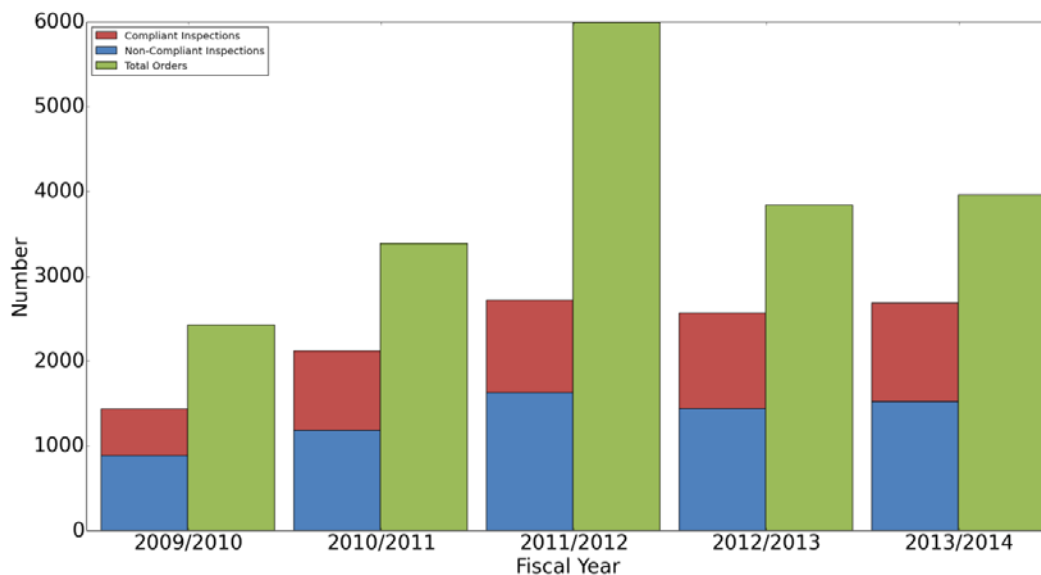


**Figure OE-1: Compliance rate for periodic inspections conducted on operating plants over the last five years.**



The number of compliant and non-compliant inspections, as well as the number of orders issued is shown in Figure OE-2.

**Figure OE-2: Number of orders and compliant and non-compliant periodic inspections conducted on operating plants over the last five years.**





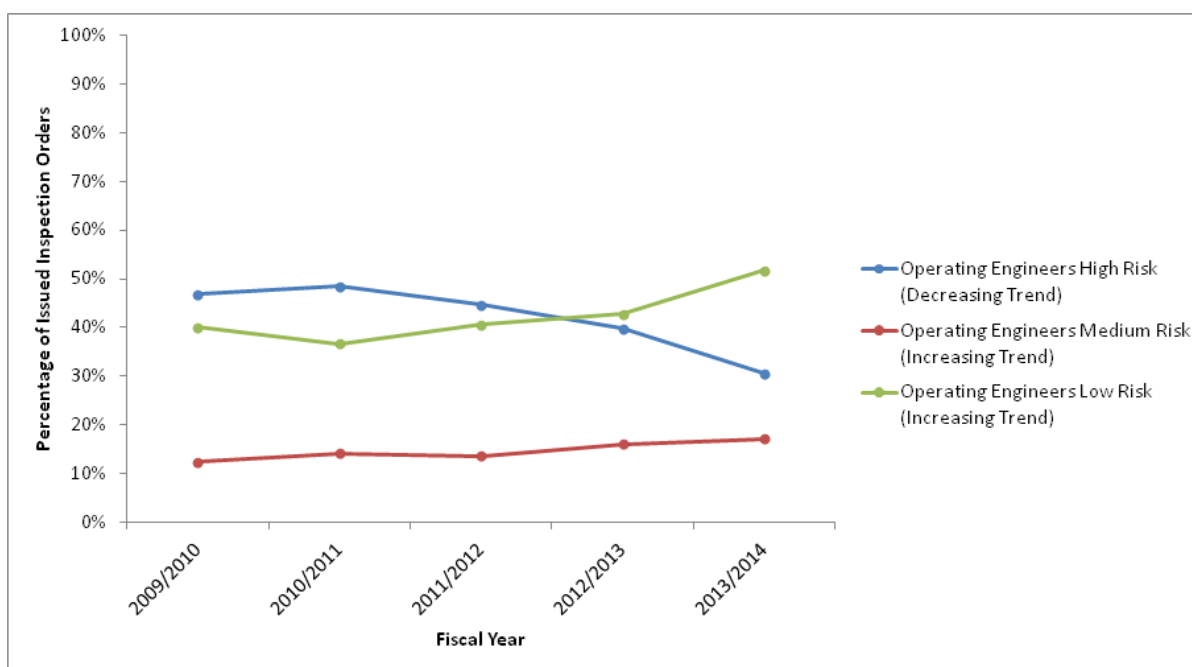
During this period, 19,628 inspection orders were issued with the non-compliant inspections. Of these, 42% were high risk inspection orders and demonstrate a decreasing trend. Table OE-2 and Figure OE-3 illustrate these observations graphically. Examples of high risk inspection orders include: addressing improper identification, lack of testing and servicing of pressure relief and safety limiting devices, in accordance with requirements.

42% of the inspection orders are low risk and demonstrate an increasing trend. Examples of low risk inspection orders include those associated with tagging of refrigeration detectors, re-registration requirements to reflect change in power ratings, and documentation.

**Table OE-2: Distribution of issued orders at operating plants for the period 2009/2010 - 2013/2014.**

| Order Risk | Year          |               |               |               |               |
|------------|---------------|---------------|---------------|---------------|---------------|
|            | 2009/<br>2010 | 2010/<br>2011 | 2011/<br>2012 | 2012/<br>2013 | 2013/<br>2014 |
| High       | 47%           | 48%           | 45%           | 40%           | 31%           |
| Medium     | 12%           | 14%           | 14%           | 16%           | 17%           |
| Low        | 40%           | 37%           | 41%           | 43%           | 52%           |

**Figure OE-3: Risk of issued orders at operating plants over the last five years.**

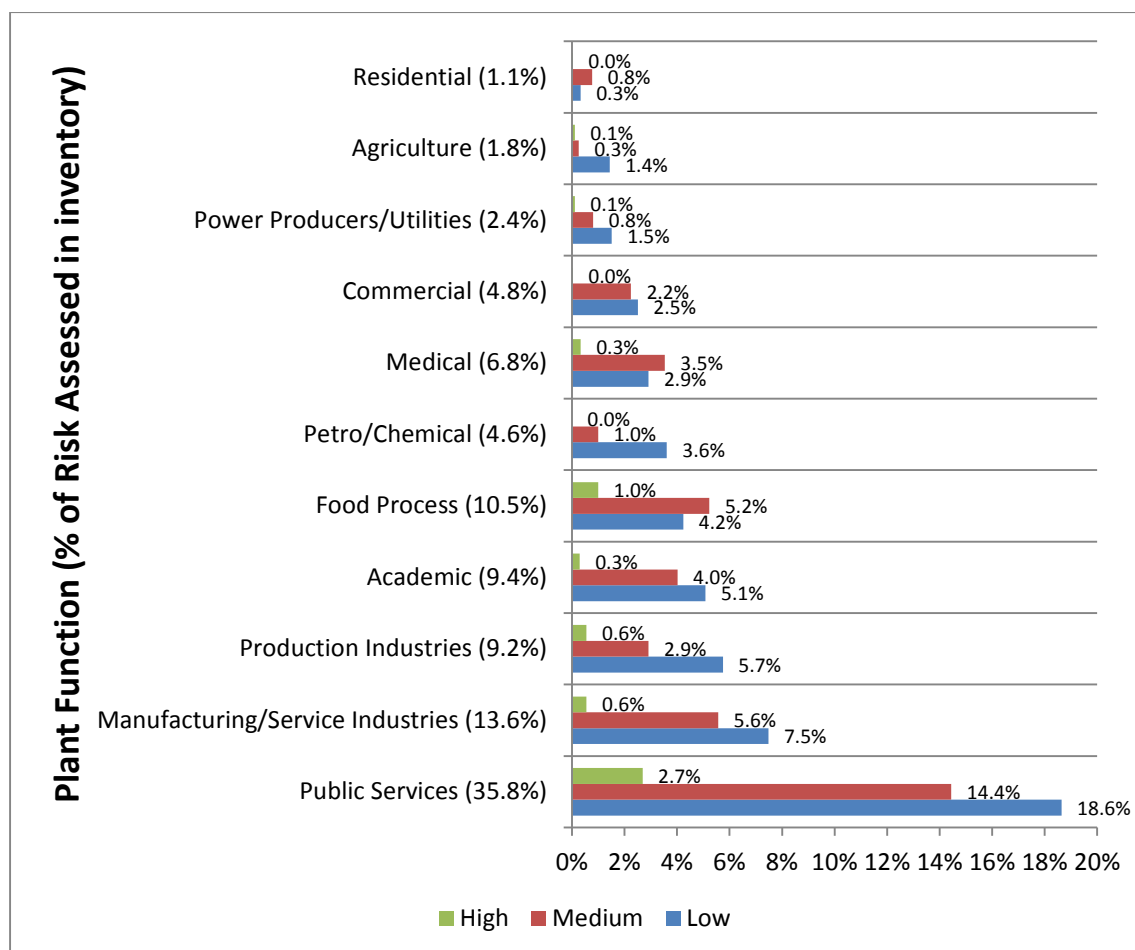


According to the current results of the risk-based model, approximately 6% of all registered plants have been identified as high operational risk and are inspected every six months. Specifically, 45% of registered plants located at public services represent high operational risk. Plants at public service locations form nearly 36% of all registered plants, of which 90% are unattended.

Approximately 41% of registered plants are medium operational risk with an inspection frequency of every year while 54% of plants are low operational risk with an inspection frequency of once every two years. Figure OE-4 illustrates these observations graphically.



**Figure OE-4: Percentage distribution of the risk profile for operating plants across all plant functions determined through the Risk-Based Scheduling Model.**



The Operating Engineers Safety Program area continues to benefit from the application of RIDM in scheduling periodic inspections.

One factor that contributes to improving compliance for operating plants is TSSA's continuing efforts to refine the risk-informed inspection process by further validating the risk formulae and identifying discrepancies between assigned and required risk assignments. The new work processes implemented last year have greatly clarified the activities undertaken to provide Operating Engineer safety services, and now clearly show seasonal plants, customer shut-down plants, and sealed plants. As well, standardized orders have also been deployed, which now contribute to more accurate analyses, thereby improving the risk assessment of each plant; hence its required inspection frequency.

A number of years ago, TSSA identified a possible shortage of skilled operating engineers. In this regard, TSSA is continuing to work with operators and training organizations to address the future of operating engineers in Ontario. Options being considered range from increasing the availability and visibility of training programs through college, to modernizing the Operating Engineers Regulation to ease requirements for training, plant certification and experience. Dialogue with the Institute of Power Engineers (IPE) as well as convening an advisory council risk reduction group is ongoing in this regard. One success story in this area is the creation of a promotional video that highlights operating engineering as a very attractive career choice for those looking for career options. Premiered at the IPE Annual General Meeting in September 2013, this video has been distributed across North America and has earned rave reviews by all. It remains a very active download from the TSSA YouTube channel, with over 3,000 views to date.



### III.3 Amusement Devices

TSSA regulates approximately 2,000 permitted amusement devices in Ontario by ensuring all rides conform to the Act and applicable regulations, codes and standards. TSSA reviews and registers rides, issues permits for each ride in the current operating season, licenses operators, conducts inspections and incident investigations, and delivers public awareness campaigns throughout the province. Amusement devices under TSSA's jurisdiction include: roller coasters, Ferris wheels, merry-go-rounds (and other circular motion rides), water slides, flume rides, dry slides, go-karts, bumper carts, inflatables (inflatable bouncers), bungee devices, bungee-assisted bounces, zip lines (track and cable rides), and other generic spinning and whirling rides.

The trend analysis presented in this section should be considered in the predominantly seasonal nature of the operation of these devices. The trend analysis confirmed and took into account seasonality while establishing historical patterns of safety and compliance performance.

#### III.3.1 Risk Assessment

Based on actual injuries and fatalities over the past seven years, the average rate of injury is approximately 10 injuries/million people/year. No fatalities have been reported during this period. Using TSSA's approach to estimating the total injury burden, the observed injury burden corresponds to approximately 0.03 fatality equivalents/million people/year. Additionally, 58 occurrences were reported during the same period where no injuries resulted.

Table AD-1 provides statistics on past occurrences and associated trends. Figures AD-1 and AD-2 illustrate these observations graphically. TSSA's model [4] estimates that the risk of injury or fatality to Ontarians riding amusement devices is 0.08<sup>7</sup> fatality-equivalents/million people/year, which continues to decrease from last year. This estimate assumes the entire population of Ontario (approximately 13 million) would ride an amusement device at least once over the course of a year. A more realistic prediction of risk of injury or fatality may be estimated by obtaining reliable information on ridership. TSSA is working with the amusement ride operators to obtain such an estimate.

**Table AD-1: State of safety measures for amusement devices for the period  
2007/2008 – 2013/2014.**

| Measure                                                               | Seven Year Quarterly Trend     | Year          |               |               |               |               |               |               |
|-----------------------------------------------------------------------|--------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
|                                                                       |                                | 2007/<br>2008 | 2008/<br>2009 | 2009/<br>2010 | 2010/<br>2011 | 2011/<br>2012 | 2012/<br>2013 | 2013/<br>2014 |
| Fatalities                                                            | No significant quarterly trend | 0             | 0             | 0             | 0             | 0             | 0             | 0             |
| Permanent Injuries                                                    | No significant quarterly trend | 8             | 10            | 7             | 3             | 6             | 9             | 5             |
| Non-Permanent Injuries                                                | No significant quarterly trend | 70            | 58            | 71            | 85            | 203           | 310           | 83            |
| Occurrences (Incidents and Near-Misses)                               | No significant quarterly trend | 89            | 64            | 87            | 99            | 214           | 326           | 92            |
| Risk of Injury or Fatality (fatality-equivalents/million people/year) | Not applicable                 | Not reported  |               |               |               | 0.11          | 0.11          | 0.08          |

<sup>7</sup> Represents expected estimate of a simulated distribution; 5th and 95th percentiles are 0.01 and 0.21 fatality-equivalents per million people per year respectively.



**Figure AD-1: Occurrences involving amusement devices  
over the last seven years.**

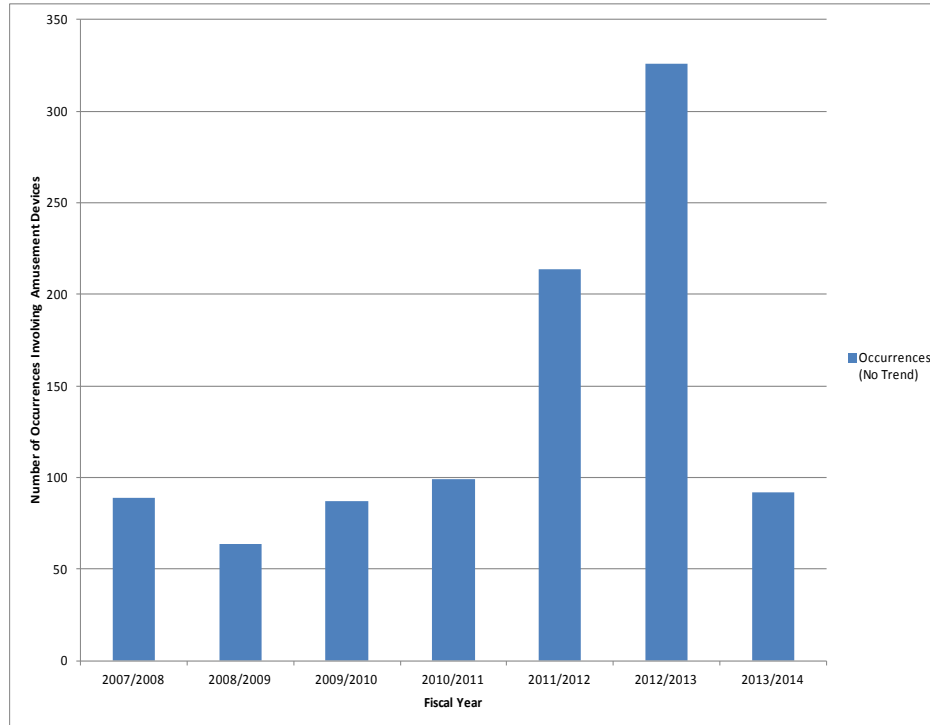


**Figure AD-2: Injuries involving amusement devices  
over the last seven years.**

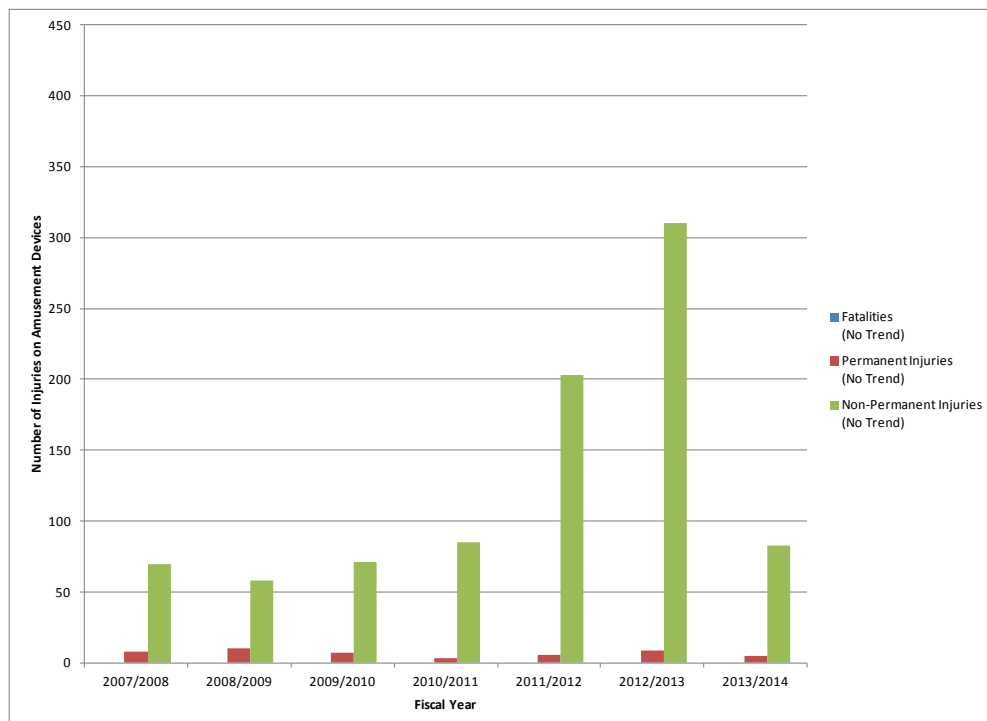
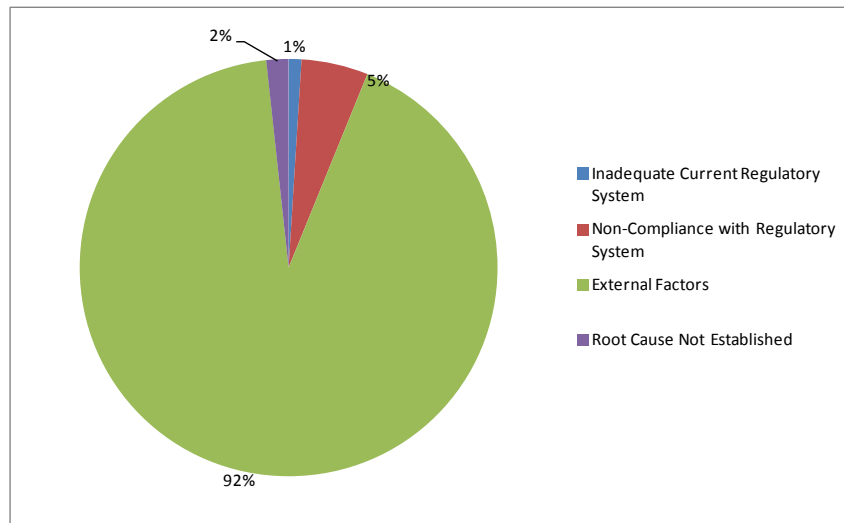




Figure AD-3 shows the distribution of the risk of injury or fatality across the three causal categories.

**Figure AD-3: Risk of Injury or Fatality in amusement devices by cause  
(based on period ending 2013/2014).**



#### **Risk of Injury or Fatality due to Potential Gaps in Regulatory System**

Approximately 1% of the risk caused over the past seven years is due to an inadequate regulatory system. Nine incidents, involving flume rides, inflated rides and waterslides, contributed to this risk. No potential safety issues or gaps requiring action were identified. One of the waterslides involving an occurrence has been dismantled.

#### **Risk of Injury or Fatality due to Non-Compliance with Regulatory System**

5% of the risk is as a result of non-compliance with the regulatory system. This represents a decrease compared to last year. Waterslides contribute to 33% of occurrences. Failure to follow operating procedures is identified as the primary root cause with these occurrences. Waterslides form 7% of the total inventory of amusement rides in the province. Non-compliance related to waterslides is also a leading cause of risk of injury or fatality compared to all other amusement devices.

TSSA inspects all active amusement rides on an annual basis.

#### **Risk of Injury or Fatality due to External Factors**

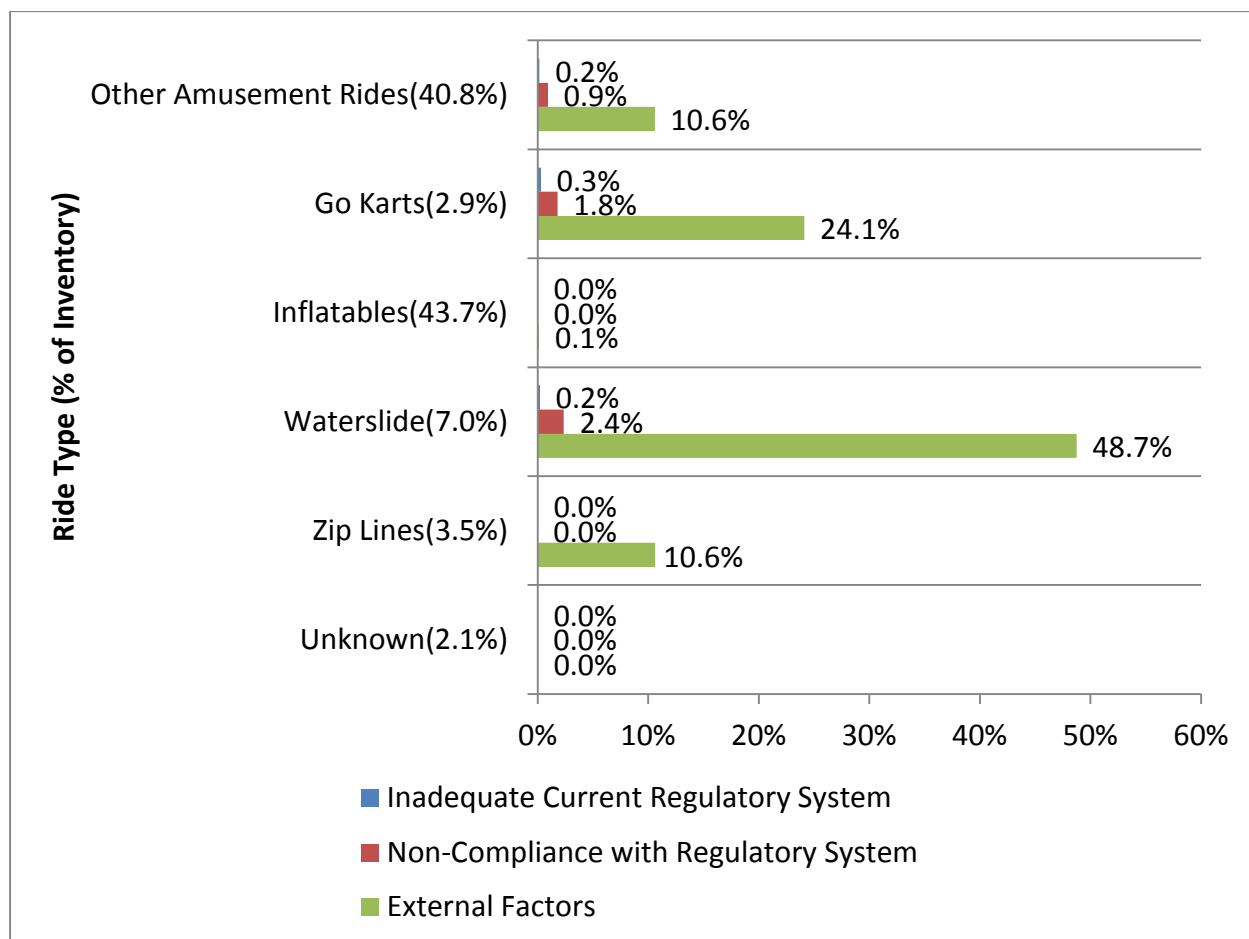
Nearly 92% of the risk is attributed to factors external to the regulatory requirements including rider behaviour and actions on rides, and represents a reduction from last year. Occurrences involving water slides account for 42% of these types of occurrences and are related to nearly 60% of all injury burden. Circular rides and Zip Lines account for over 20% of these types of occurrences. Examples of occurrences include slips and falls due to distracted riders not paying attention while entering and exiting rides.

Waterslides account for 7% of the inventory, but contribute towards 50% of risk of injury or fatality due to external factors outside the regulatory system. A collective group of amusement rides, such as bungee, cable ride, fun house, boat ride, etc, form 40% of the inventory and pose a risk of 12% across all causal categories.

Figure AD-4 shows the percentage distribution of risk across the different ride types and by the three causal categories.



**Figure AD-4: Risk of Injury or Fatality for amusement devices classified by rides and causal categories.**



### II.3.2 Risk Management

#### Managing Risks due to Potential Gaps in Regulatory System

No potential safety issues or gaps requiring action were identified.

#### Managing Risks due to Non-Compliance in Regulatory System

TSSA conducts periodic inspections of all amusement devices annually to oversee and manage the state of compliance across approximately 2,000 permitted amusement devices in the province of Ontario. Amusement device operations are generally seasonal in nature with a few devices operating all year round. TSSA deals with non-compliances by requiring the owner/operator to address observed failures within an appropriate timeframe through the issuance of inspection orders. This periodic inspection process contributes to the preventative management of risk associated with amusement devices.

Table AD-2 provides information on key indicators associated with the results of the periodic inspections. Over the past five years, 7,174 periodic inspections were conducted on amusement rides. The compliance rate measured over the last five years is 64% and demonstrates no significant quarterly trend. Figure AD-5 illustrates these observations graphically.



# Annual State of Public Safety Report – Full Report

2013/2014 Edition

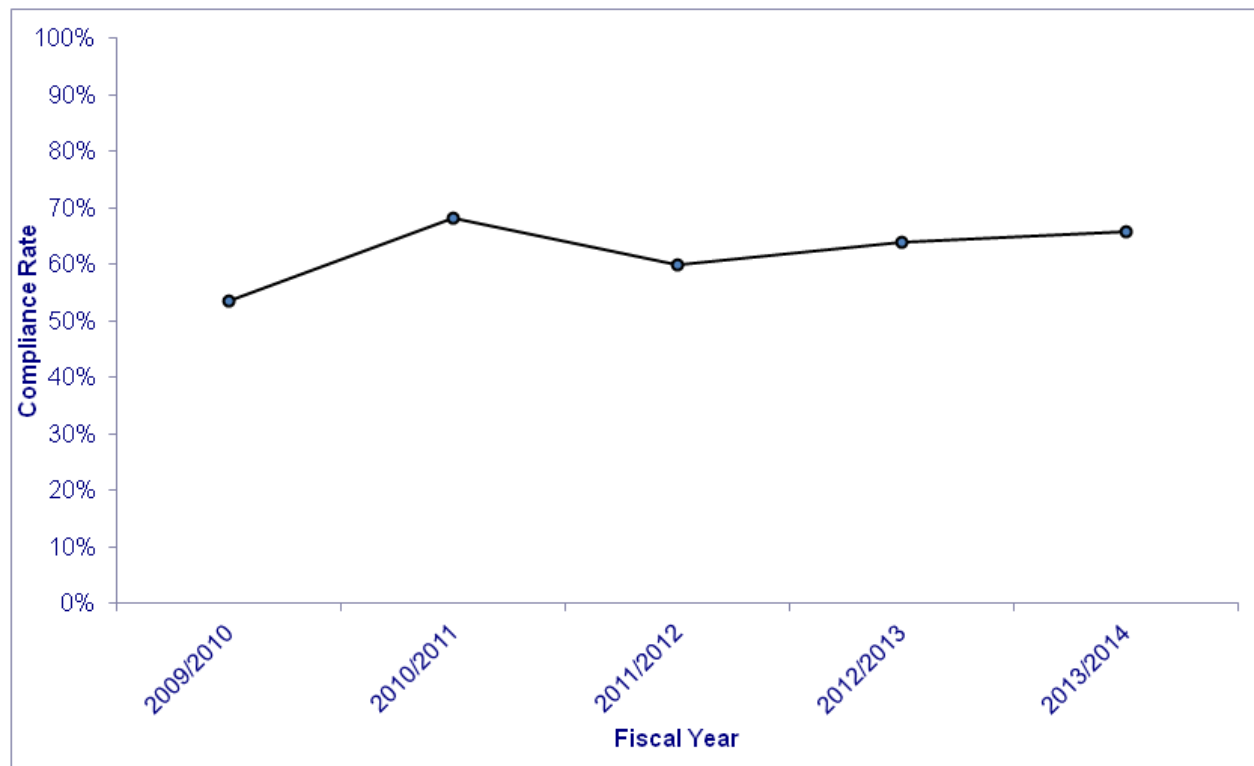
7,441 inspection orders were issued across the non-compliant inspections during the five-year period. Since December 2013, approximately 533 inspection orders were issued, of which nearly 21% were identified to be high risk. Examples of high risk inspection orders include: addressing improper welding to repair cracks, appropriate fencing distance from any moving parts of the rides, and improper lap bar restraints.

18% of the inspection orders are low risk, examples of which include maintaining records of training of operators and attendants, affixing identification plates on passenger carrying unit identification, etc.

**Table AD-2: State of compliance for amusement devices as of 2013/2014.**

| Measure                                                         | Measured over Five-Year Period |
|-----------------------------------------------------------------|--------------------------------|
| Compliance Rate <sup>8</sup>                                    | 64% <sup>9</sup>               |
| Observed Trend in Compliance Rate                               | No significant quarterly trend |
| Percentage of High Risk Inspection Orders (since December 2013) | 21%                            |
| High Risk Inspection Orders Trend                               | Insufficient data              |
| Percentage of Low Risk Inspection Orders (since December 2013)  | 18%                            |
| Low Risk Inspection Orders Trend                                | Insufficient data              |

**Figure AD-5: Compliance rate for periodic inspections conducted on amusement devices over the last five years.**



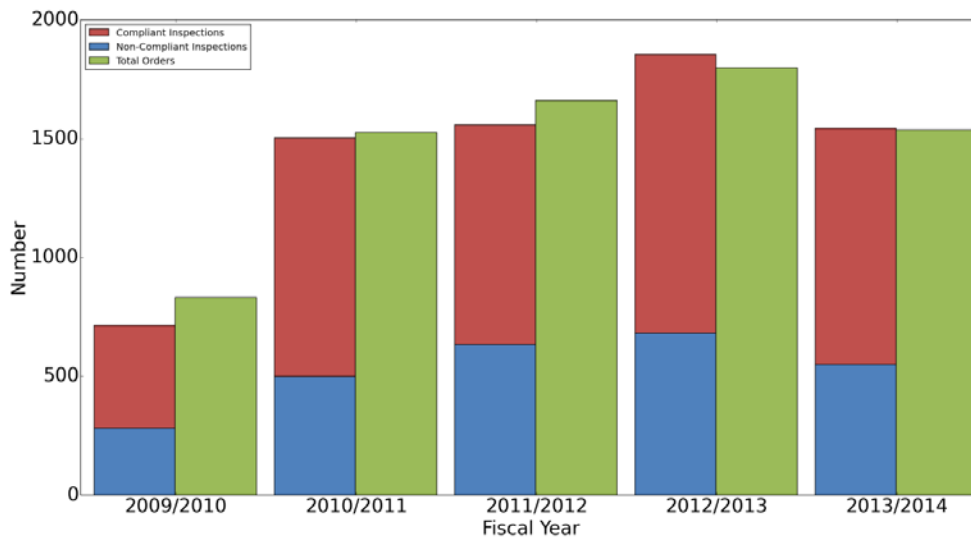
<sup>8</sup> Median of quarterly compliance rates over five years.

<sup>9</sup> Please note that prediction intervals have not been constructed for the 2014/2015 fiscal year due to the seasonality of inspections.



The number of compliant and non-compliant inspections, as well as the number of orders issued, is shown in Figure AD-6.

**Figure AD-6: Number of orders and compliant and non-compliant periodic inspections conducted on amusement devices over the last five years.**



For amusement devices, the ride operator performs an important role in ensuring that the riders are adhering to the rules for safe riding. Part of the TSSA inspection is to witness the operation of the ride and verify that operating procedures are being followed, thus managing the risk of non-compliance.

#### **Managing Risks due to External Factors**

With 92% of risk related to external factors, TSSA continued its on-site engagement campaign at five major waterparks in 2013. In addition, recognizing that public safety is a shared responsibility, TSSA piloted the Safety Ambassador program at two water parks which involved incorporating TSSA engagement strategy into the training for water park staff. For further detail, please refer to Amusement Devices in Appendix A.



## III.4 Elevators

TSSA regulates approximately 52,000 elevators in Ontario to ensure all devices conform to the Act, and applicable regulations, codes and standards. TSSA reviews and registers elevating devices, issues licences, conducts inspections and performs incident investigations. These devices include elevators (passenger, freight, hand-powered, observation, sidewalk, temporary elevators, and limited use/limited application elevators), dumbwaiters, material and freight platform lifts (type A and B), lifts for persons with physical disabilities, man-lifts, construction hoists, incline lifts, stage lifts, and parking garage lifts.

### III.4.1 Risk Assessment

Based on actual injuries and fatalities over the past seven years, the average rates of injury and fatality are 10 injuries/million people/year and 0.06 fatalities/million people/year. Using TSSA's approach to integrating injuries and fatalities, this corresponds to an observed injury burden of approximately 0.05 fatality equivalents/million people/year. Additionally, there have been over 300 occurrences during the seven-year period that did not result in any injuries.

Tables ED-1 provides statistics on past occurrences and associated trends. TSSA's prediction model estimates the risk of injury or fatality to Ontarians using elevators to be 0.83<sup>10</sup> fatality-equivalents/million people/year, an increase when compared to last year's estimate. Occurrences are demonstrating an increasing trend by approximately 14% per year. Non-permanent injury is increasing by 9% per year. Figures ED-1 and ED-2 illustrate these observations graphically.

**Table ED-1: State of safety measures for elevators for the period  
2007/2008 – 2013/2014.**

| Measure                                                                  | Seven Year<br>Quarterly Trend  | Year          |               |               |               |               |               |               |
|--------------------------------------------------------------------------|--------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
|                                                                          |                                | 2007/<br>2008 | 2008/<br>2009 | 2009/<br>2010 | 2010/<br>2011 | 2011/<br>2012 | 2012/<br>2013 | 2013/<br>2014 |
| Fatalities                                                               | No significant quarterly trend | 1             | 0             | 0             | 1             | 2             | 1             | 0             |
| Permanent Injuries                                                       | No significant quarterly trend | 6             | 3             | 7             | 4             | 12            | 11            | 4             |
| Non-Permanent Injuries                                                   | Increasing trend               | 106           | 84            | 101           | 104           | 165           | 144           | 134           |
| Occurrences<br>(Incidents and Near-Misses)                               | Increasing trend               | 193           | 174           | 194           | 200           | 337           | 369           | 298           |
| Risk of Injury or Fatality<br>(fatality-equivalents/million people/year) | Not applicable                 | Not reported  |               |               |               | 0.71          | 0.80          | 0.83          |

<sup>10</sup> Represents expected estimate of a simulated distribution; 5th and 95th percentiles are 0.41 and 1.32 fatality-equivalents per million people per year respectively.



**Figure ED-1: Occurrences involving elevators over the last seven years.**

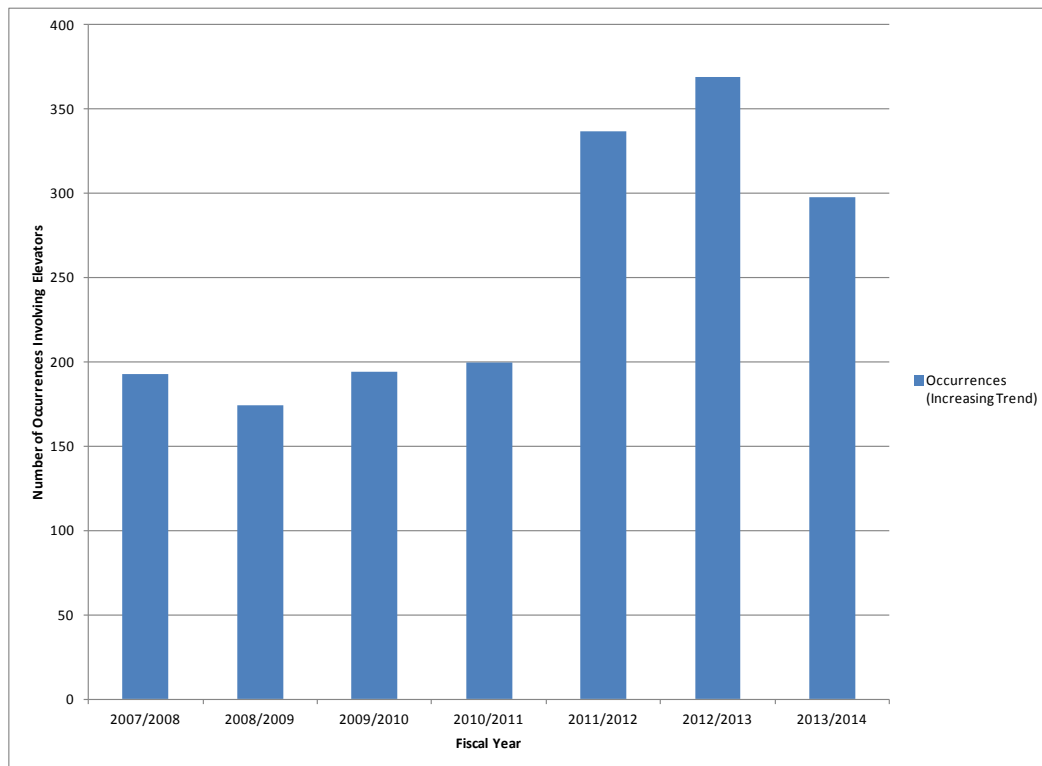


**Figure ED-2: Injuries involving elevators over the last seven years.**

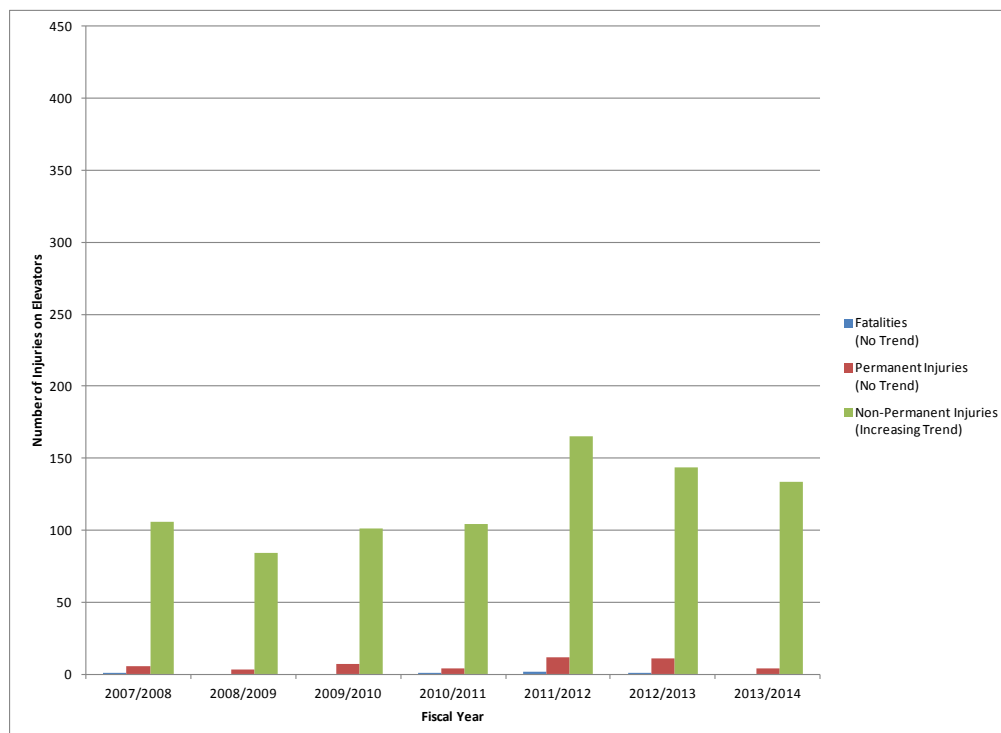
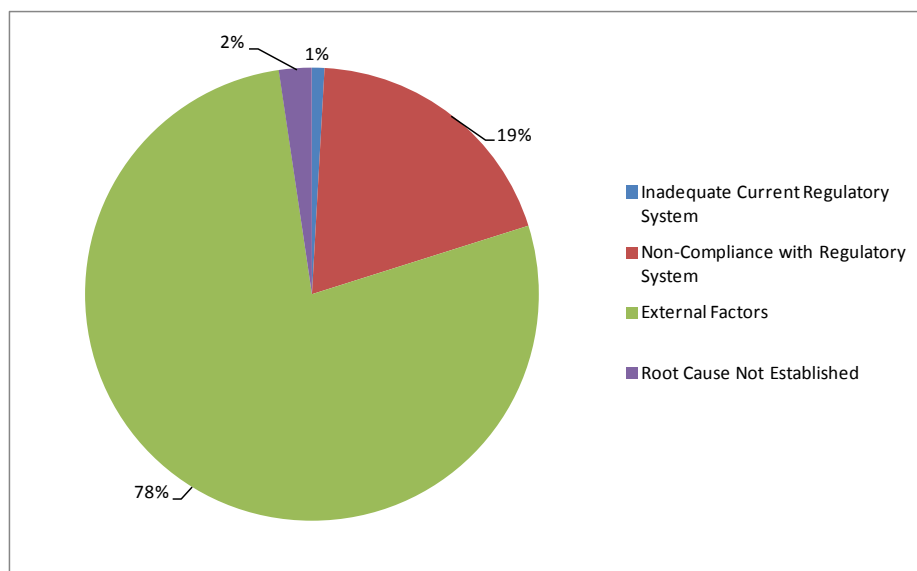




Figure ED-3 shows the distribution of the risk of injury or fatality across the three causal categories.

**Figure ED-3: Risk of Injury or Fatality in elevators by cause  
(based on period ending 2013/2014).**



#### **Risk of Injury or Fatality due to Potential Gaps in Regulatory System**

Less than 1% of the risk caused over the past seven years is due to potential gaps in the regulatory system. 16 occurrences, involving passenger elevators, construction hoists and elevators for the handicapped, contributed to this risk. Four of these occurrences were related to known safety issues and gaps. The gaps pertained to the possibility of passengers attempting to remove themselves from an entrapment situation, and leveling issues due to elevators of older design.

In response to occurrences due to leveling issues on elevators of older design (single/two-speed motor control traction elevators), a risk assessment was conducted to better understand the causal reasoning and the sources of risk. This risk assessment provided an understanding that the hazards and associated failures, that lead to the undesirable consequences of elevators being out of level, were due over-speeding and unintended movement causing injury to users. Additionally, regulatory TSSA inspections provided observations of several non-compliance issues, involving the operation and maintenance of elevator brakes and its associated components, across the entire inventory within the province of Ontario that carry potential safety risks.

The risk of injury or fatality due to these hazards and associated failures was estimated that, at the current occurrence rate for cars being out of level on single/two-speed traction elevators, would reach unacceptable levels of risk (e.g. 1.8 fatality-equivalents per million people per year) across the population of Ontario within 3 to 7.5 years. It was also determined that single/two-speed traction elevators located in rental buildings represent the largest percentage of single/two-speed inventory and account for most reported occurrences and non-compliances the most orders issued.

Corrective actions for design limitations of older single/two-speed traction elevators were recommended to address safety issues related to leveling, such as an update of the motor motion control system, along with the implementation of an emergency brake to help stop elevator car unintended movements (e.g. Director's Order - 267/14, Retroactive Leveling Requirement for Passenger Elevators with Single Speed Controls).



### **Risk of Injury or Fatality due to Non-Compliance with Regulatory System**

19% of the estimated risk is as a result of non-compliance with the regulatory system. This source of risk has reduced when compared to last year. Occurrences due to this causal category involved less than 1% of the nearly 52,000 elevators in the province. Poor maintenance of elevators present in residential buildings, including rental units and condominiums, contributed to the most frequent of these types of occurrences. Poor maintenance of elevators at commercial/office locations and hospitals were also identified as contributors to this estimated risk. Nearly 16% of these elevators have undergone major alterations since the occurrences took place.

12% of these elevators are identified as high operational risk as per TSSA's model of risk-based inspection scheduling [6] and require to be inspected annually. Over 80% of the elevators, however, are low operational risk as verified by subsequent TSSA inspections.

In terms of risk of injury or fatality due to non-compliance with respect to specific device classes, incline lifts contribute to 20% of the risk arising from less than 1% of the inventory. Risk related to passenger elevators due to non-compliance is 10% and is driven largely from 80% of the inventory population.

### **Risk of Injury or Fatality due to External Factors**

Nearly 78% of the estimated risk is attributed to factors external to regulatory requirements including unsafe user behaviour on elevators, an increase as compared to last year. Again, occurrences at residential locations contribute to nearly 40% of these types of occurrences. Examples include: doors closing on users attempting to enter closing elevators (e.g. injury to hands, shoulders, etc.), trips and falls entering and exiting elevator cars (e.g. car out of level with landing floor), as well as riders with hand-held electronic devices that are not paying attention as they enter or exit the elevator.

Figure ED-4 shows the percentage distribution of risk across the different device classes and by the three causal categories.



Figure ED-4: Risk of Injury or Fatality in elevators classified by device class and causal category.

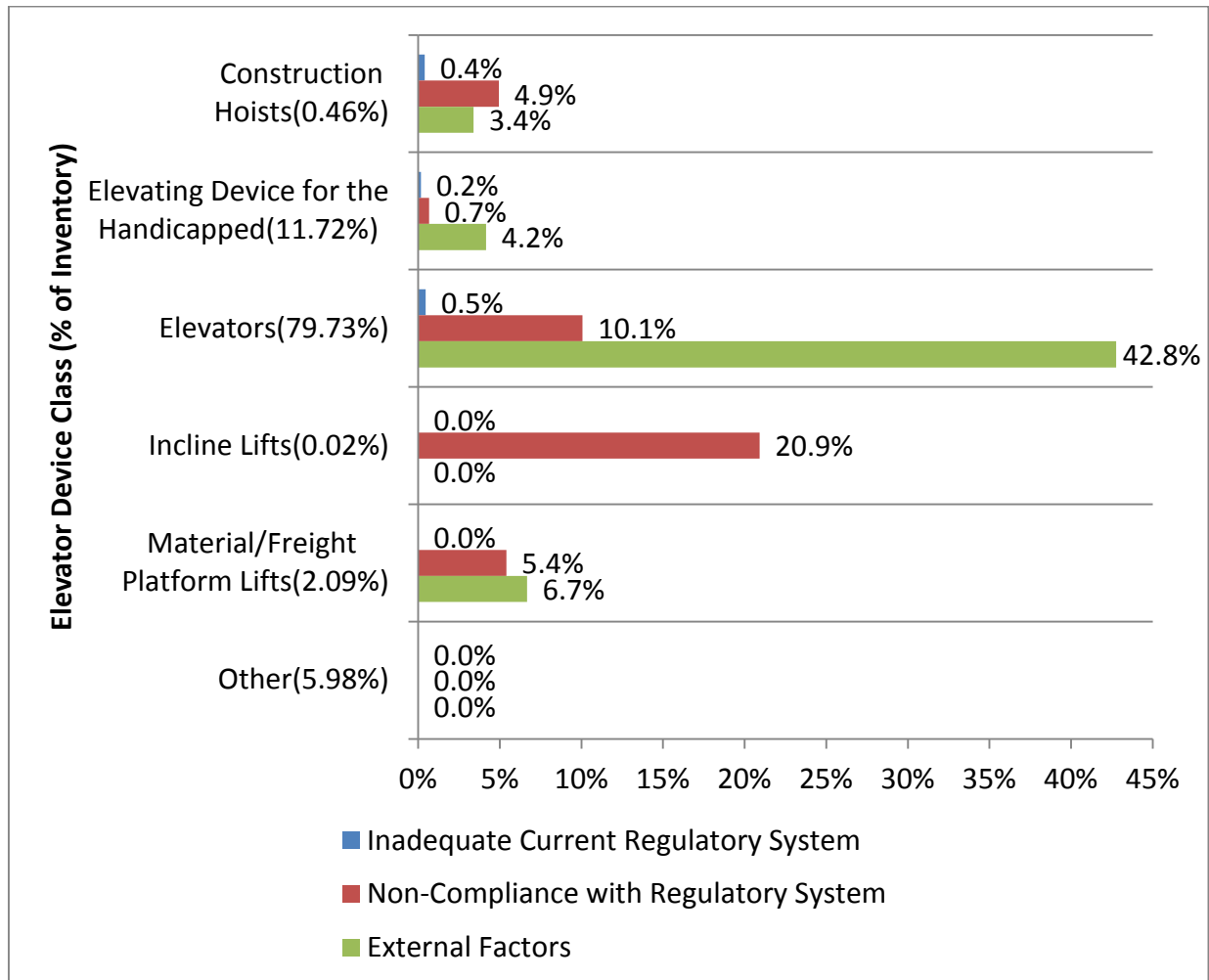
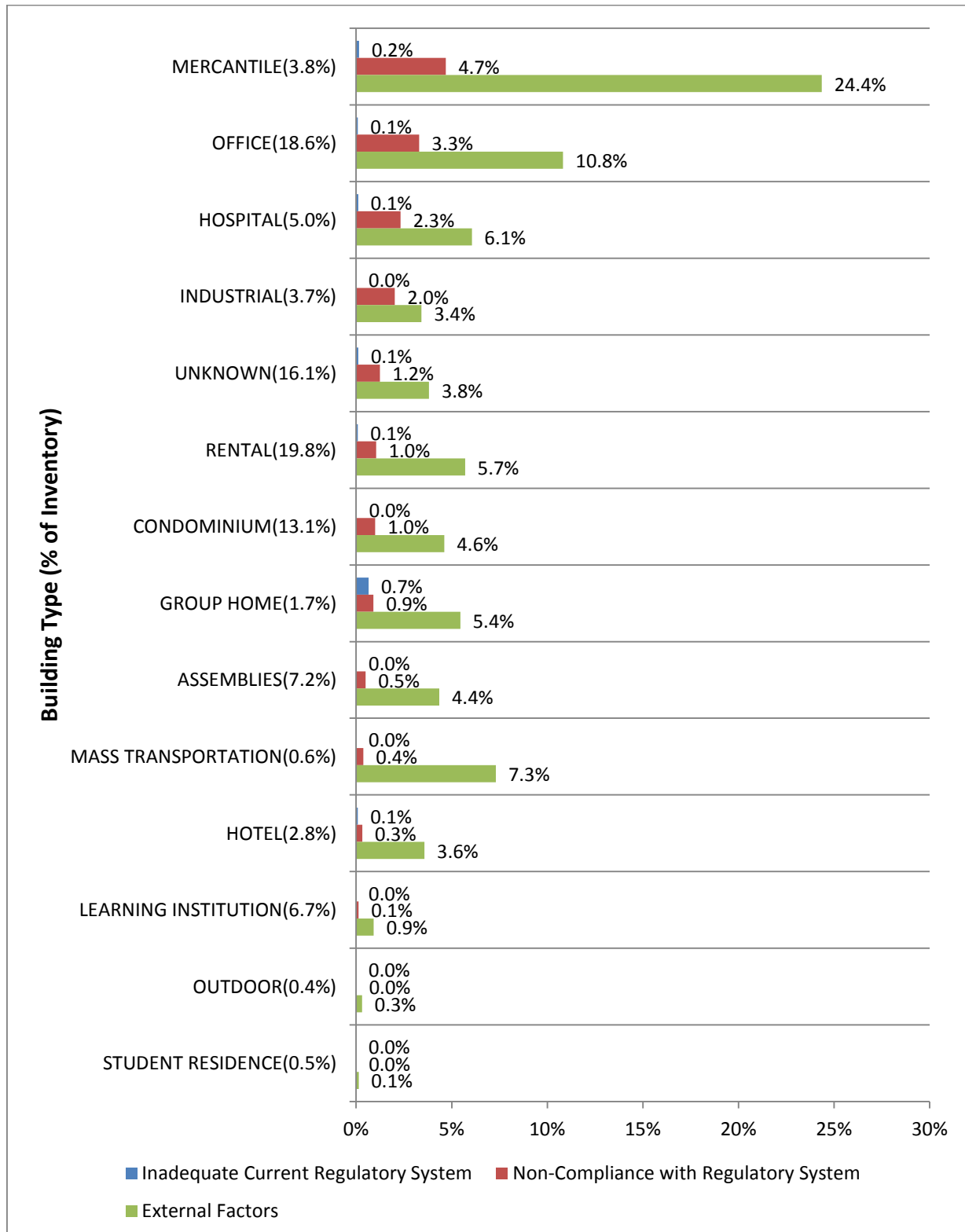


Figure ED-5 shows the percentage distribution of risk across different building types and by the three causal categories considering the approximate number of riders per year estimated based on the usage rate (cycles per hour).



Figure ED-5: Risk of Fatality or Injury in elevators classified by building type and cause.





### III.4.2 Risk Management

#### **Managing Risks due to Potential Gaps in Regulatory System**

TSSA released two Director's Orders to mitigate the risk due to gaps in the regulatory system. Director's Order 260/14, issued on March 17, 2014, ensures that all elevators in residential or educational facilities have either a long apron plate to prevent falls during exiting, or door restrictors to prevent trapped passengers from removing themselves, mitigating the risk of falling. All work is to be completed by March 31, 2016. Director's Order 267/14 issued on May 15, 2014 requires the retrofitting of all existing elevators with single-speed motor control with a speed control system that will ensure levelling meets current code requirements. This work is to be completed between January 1, 2018 and January 1, 2022, commencing with the older units.

#### **Managing Risks due to Non-Compliance in Regulatory System**

TSSA conducts periodic inspections of all elevators on a risk-based approach to oversee and manage the state of compliance across approximately 52,000 elevators in the province of Ontario. TSSA deals with non-compliances by requiring the owner/operator to address observed failures within an appropriate timeframe through the issuance of inspection orders. This periodic inspection process contributes to the preventative management of risk associated with elevators.

Table ED-2 provides information on key indicators associated with the results of the periodic inspections. Over the past five years, 82,350 periodic inspections were conducted on elevators. The compliance rate measured over the last five years is 32% and demonstrates a decreasing trend at 3% per year. Figure ED-6 illustrates these observations graphically.

198,746 inspection orders were issued across the non-compliant inspections over five years. TSSA's newly implemented standard inspection orders process for the elevating and amusement devices program allows for capturing specific details associated with these issued orders. Specifically, and since December 2013, it was determined that nearly 5% of these orders are high risk inspection orders. It is important to note that nearly 40% of the inspection orders issued were not previously assessed for their risk significance due to system limitations. TSSA will continue to enhance its process to reduce such instances in order to obtain a more complete risk profile of the inspection orders. Examples of high risk inspection orders include: addressing maintenance of door restrictors, adjustment of kinetic energy associated with door closing, ensuring that elevators are substantially level with the landings, etc.

53% of known inspection orders are low risk. Examples of low risk inspection orders include: updating the maintenance log book on various required periodic tests, posting of licences at conspicuous locations, maintenance of emergency lighting, etc.

**Table ED-2: State of compliance for elevators as of 2013/2014.**

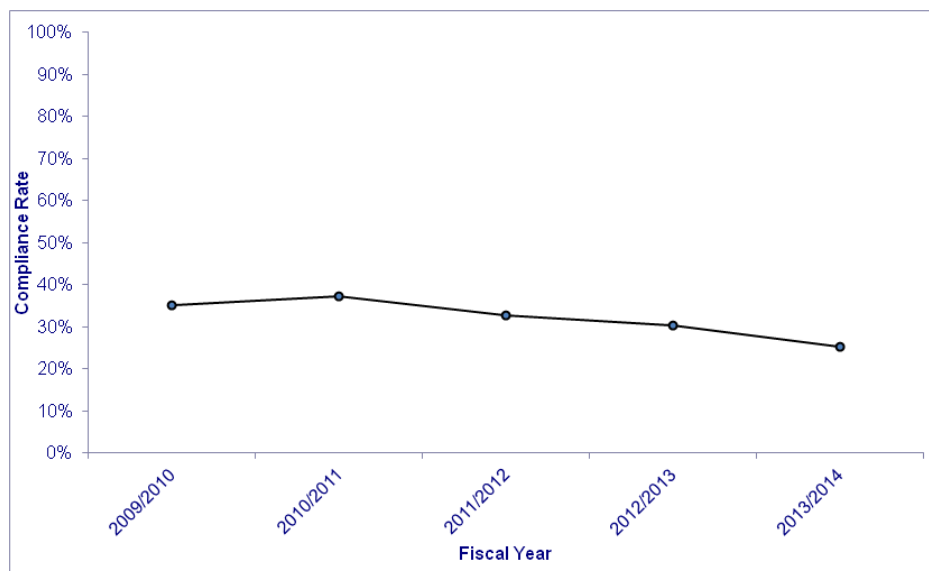
| Measure                                                         | Measured over Five-Year Period |
|-----------------------------------------------------------------|--------------------------------|
| Compliance Rate <sup>11</sup>                                   | 32% <sup>12</sup>              |
| Observed Trend in Compliance Rate                               | Decreasing trend               |
| Percentage of High Risk Inspection Orders (since December 2013) | 5%                             |
| High Risk Inspection Orders Trend                               | Insufficient data              |
| Percentage of Low Risk Inspection Orders (since December 2013)  | 53%                            |
| Low Risk Inspection Orders Trend                                | Insufficient data              |

<sup>11</sup> Median of quarterly compliance rates over five years.

<sup>12</sup> Median value for a prediction interval of 21% to 43%.

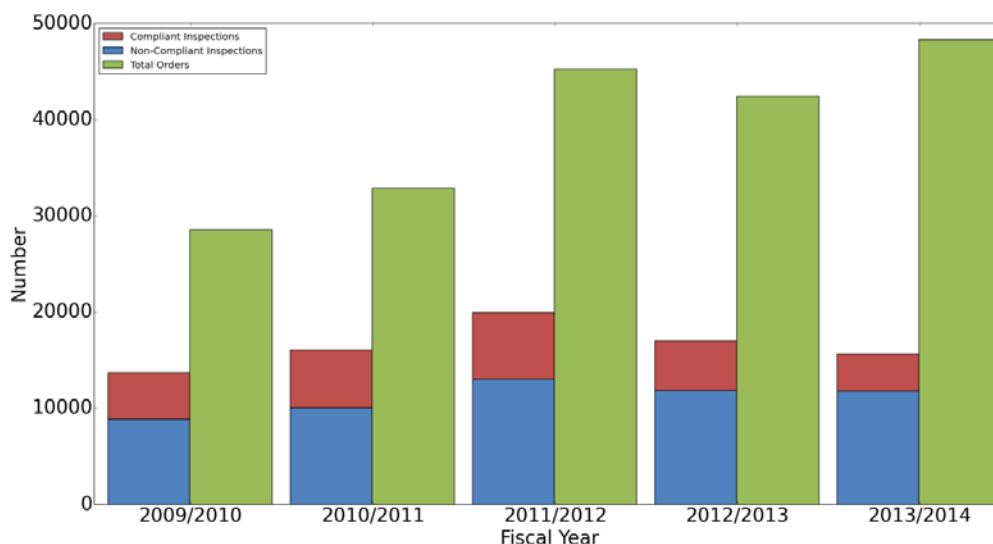


**Figure ED-6: Compliance rate for periodic inspections conducted on elevators over the last five years.**



The number of compliant and non-compliant inspections, as well as the number of orders issued is shown in Figure ED-7.

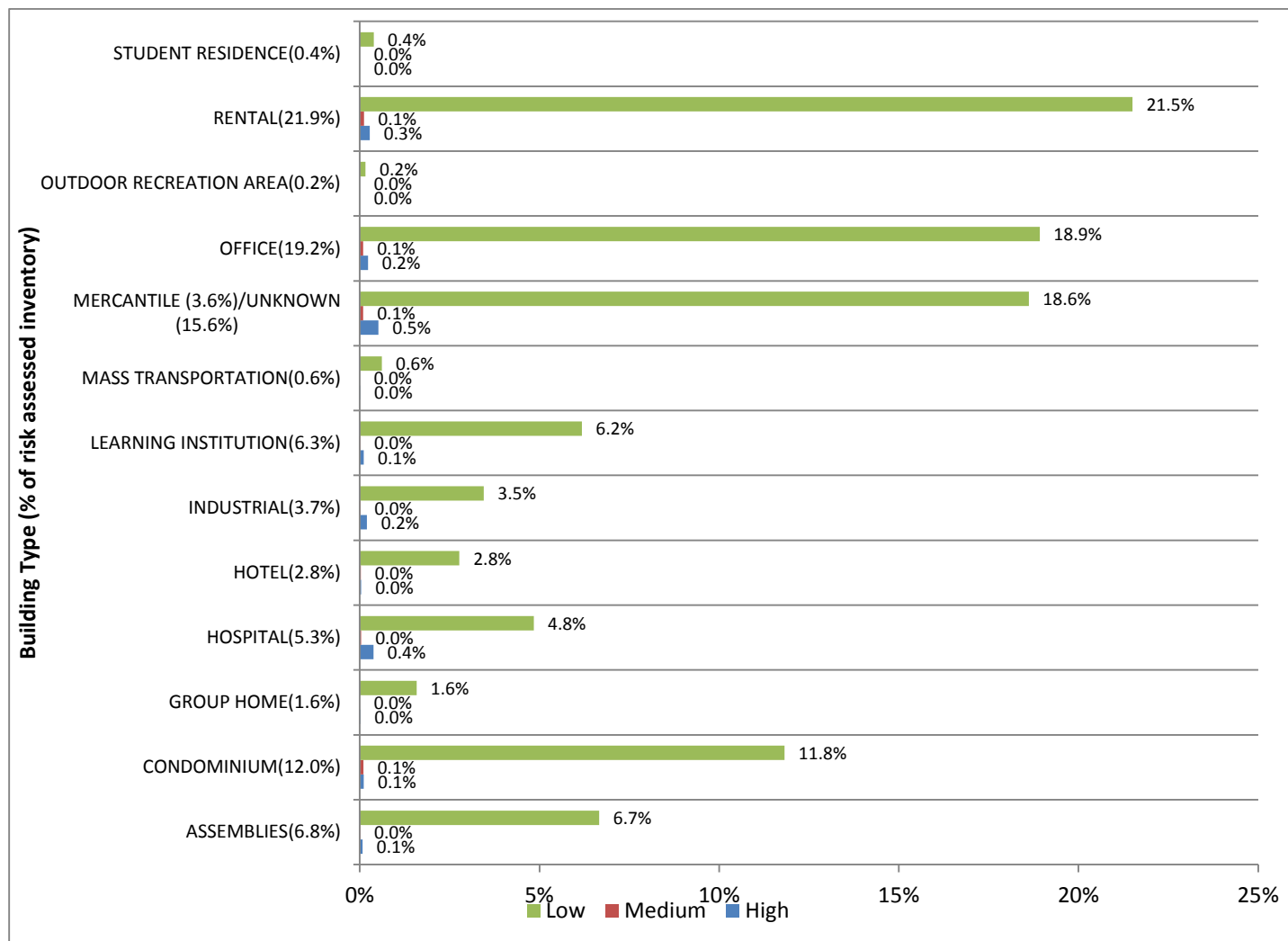
**Figure ED-7: Number of orders and compliant and non-compliant periodic inspections conducted on elevators over the last five years.**



TSSA's risk-based scheduling model (RBS2.0) [6] indicates that approximately 97% of the active elevators in the province, based on their past compliance history, are identified as being low operational risk and are inspected once every three years. 2% of active elevators in the province, based on their past compliance history, are identified as being high operational risk and are inspected annually. Nearly one-third of these high risk devices are located in hospitals and rental buildings. Hospitals and rental buildings form 25% of the total inventory in the province. Figure ED-8 shows the percentage distribution of the risk profile across all building types (also shown is the building type distribution of the total inventory). 1% of the active elevators represent medium operational risk.



**Figure ED-8: Percentage distribution of the risk profile for elevators across all building types determined through the Risk-Based scheduling model.**



The current compliance strategy involves shutting down elevators when certain non-compliances are found during periodic inspections, such as overdue annual maintenance test that the maintaining contractor failed to complete on time. Another compliance strategy is the high follow-up inspection fee when orders remain outstanding. Both these strategies are under review as they have not resulted in improved compliance.

### **Managing Risks due to External Factors**

Risk due to external factors are estimated to be 78% for elevators and this risk is increasing. User engagement and education are the key risk mitigation strategies to address these results. TSSA enhanced its research and engagement initiatives in 2013/2014 with a particular focus on elevators. As TSSA's incident data and risk assessments have identified four key elevator device locations that involve higher risk users (rentals, condominiums, office towers and institutions – mainly hospitals, learning institutions, and retail), the research will focus on rider behaviour in these environments. For further detail, please refer to Elevators/Escalators in Appendix A.



## III.5 Escalators and Moving Walks

TSSA regulates approximately 2,000 escalators and moving walks in Ontario to ensure all devices conform to the Act and applicable regulations, codes and standards. TSSA reviews and registers escalators and moving walks, issues licences, conducts inspections and performs incident investigations.

### III.5.1 Risk Assessment

Based on actual injuries and fatalities over the past seven years, the average rate of injury and fatality is approximately 30 injuries/million people/year and 0.01 fatalities/million people/year respectively. Using TSSA's approach for integrating fatalities and injuries this corresponds to an observed injury burden of approximately 0.03 fatality equivalents/million people/year, representing a decrease from last year.

Combining the injury burden with over 861 occurrences with no observed health impacts, TSSA's predictive model [4] estimates the risk of injury or fatality to Ontarians riding escalators to be approximately 0.06<sup>13</sup> fatality-equivalents/million people/year, as indicated in Table EM-1 below. Figures EM-1 and EM-2 illustrate observations related to occurrences and injuries graphically.

**Table EM-1: State of safety measures for escalators and moving walks for the period 2007/2008 – 2013/2014.**

| Measure                                                               | Seven Year Quarterly Trend     | Year         |           |           |           |           |           |           |
|-----------------------------------------------------------------------|--------------------------------|--------------|-----------|-----------|-----------|-----------|-----------|-----------|
|                                                                       |                                | 2007/2008    | 2008/2009 | 2009/2010 | 2010/2011 | 2011/2012 | 2012/2013 | 2013/2014 |
| Fatalities                                                            | No significant quarterly trend | 0            | 0         | 1         | 0         | 0         | 0         | 0         |
| Permanent Injuries                                                    | No significant quarterly trend | 8            | 1         | 4         | 2         | 4         | 3         | 2         |
| Non-Permanent Injuries                                                | No significant quarterly trend | 406          | 390       | 347       | 362       | 359       | 386       | 331       |
| Occurrences (Incidents and Near-Misses)                               | No significant quarterly trend | 539          | 531       | 508       | 512       | 521       | 523       | 453       |
| Risk of Injury or Fatality (fatality equivalents/million people/year) | Not Applicable                 | Not reported |           |           |           | 0.16      | 0.15      | 0.06      |

<sup>13</sup> Represents expected estimate of a simulated distribution; 5th and 95th percentiles are 0 and 0.17 fatality-equivalents per million people per year respectively.



**Figure EM-1: Occurrences involving escalators and moving walks over the last seven years.**

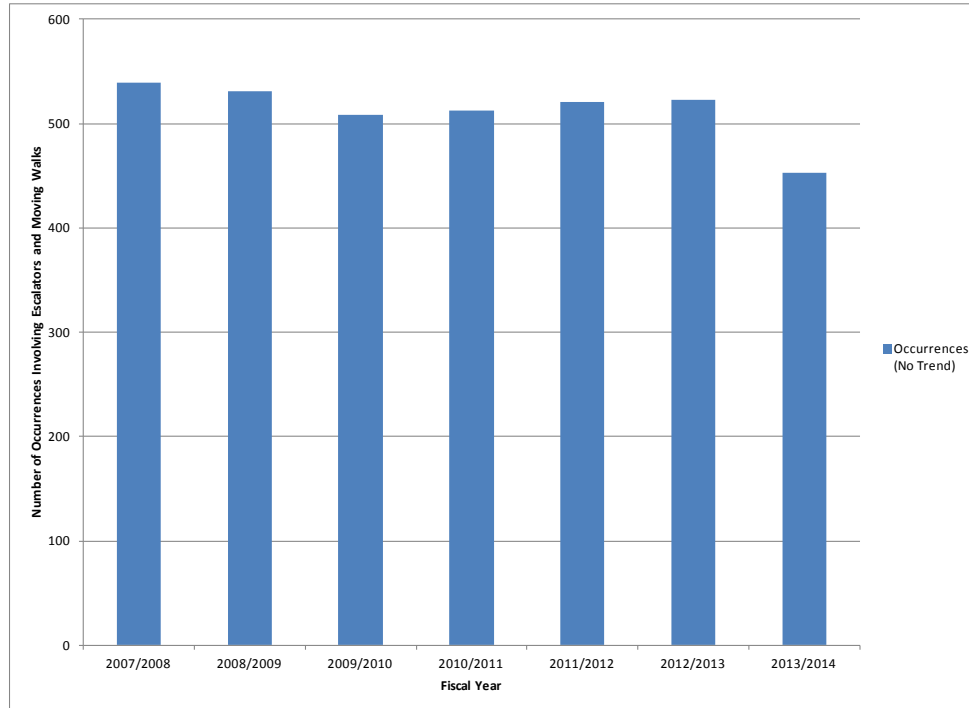


**Figure EM-2: Injuries involving escalators and moving walks over the last seven years.**

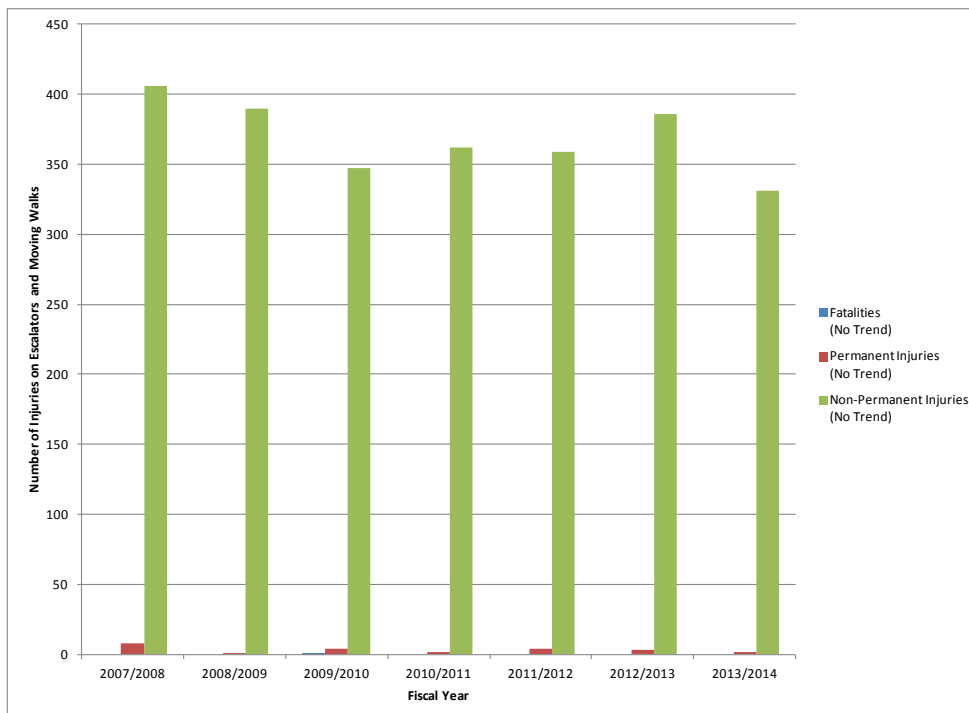
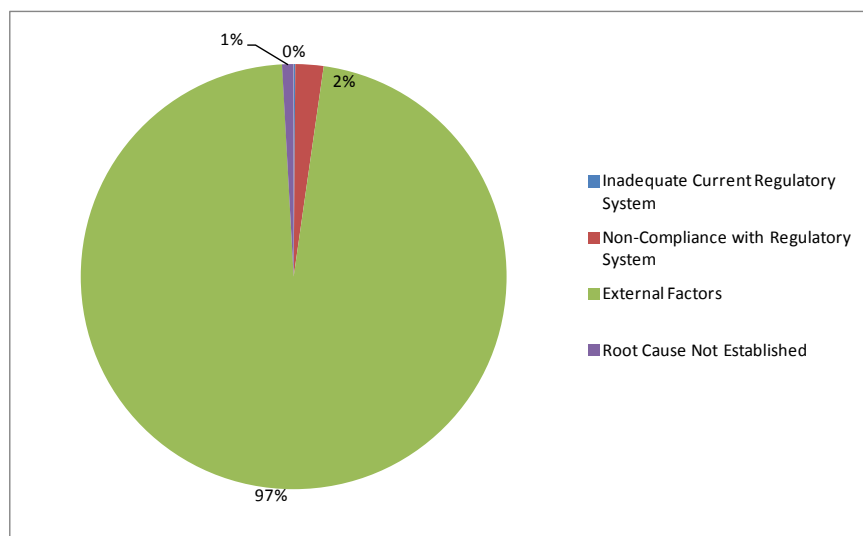




Figure EM-3 shows the distribution of the risk of injury or fatality across the three causal categories.

**Figure EM-3: Risk of Injury or Fatality in escalators and moving walks by cause (based on period ending 2013/2014).**



#### **Risk of Injury or Fatality due to Potential Gaps in Regulatory System**

Less than 1% of the risk caused over the past seven years is due to potential gaps in the regulatory system. Five occurrences contributed to this risk. Two of these occurrences related to riders walking up stopped escalators.

#### **Risk of Injury or Fatality due to Non-Compliance with Regulatory System**

2% of the estimated risk is as a result of non-compliance with the regulatory system. This represents a decrease compared to last year. These occurrences took place on approximately 3% of the escalators and moving walks in the province. Defective equipment and poor maintenance of escalators at commercial locations like malls contributed most significantly to this source of the risk.

11% of these escalators and moving walks are identified as high operational risk as per TSSA's model of risk-based inspection scheduling [6] and are required to be inspected annually. The remaining 89% of these escalators, however, are low operational risk as verified by subsequent TSSA inspections and are inspected once every three years.

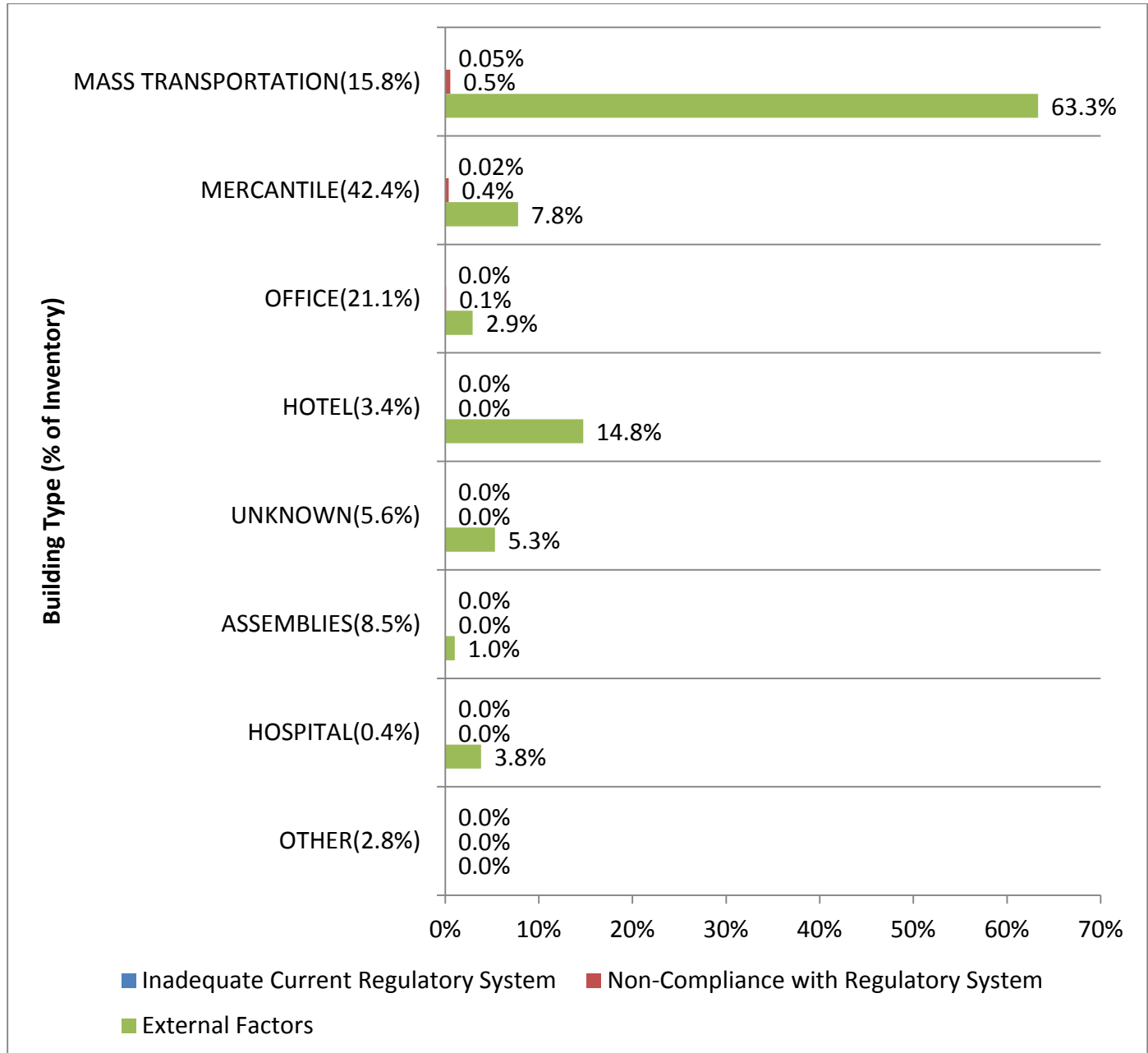
#### **Risk of Injury or Fatality due to External Factors**

Nearly 97% of the estimated risk is attributed to factors external to regulatory requirements including unsafe user behaviour by escalator and moving walks riders. A majority of these types of occurrences in the past took place at mass transit locations, such as subway stations. Examples of behavioural practices include: shoe entrapment in escalator moving parts, slips and falls on moving escalators, and inappropriate actions on moving escalators (i.e. unattended children).

Figure EM-4 shows the percentage distribution of risk across different building types and by the three causal categories based on ridership estimated using maximum number of persons allowed to ride per hour.



**Figure EM-4: Risk of Injury or Fatality in escalators and moving walks classified by building type and causal category.**



### III.5.2 Risk Management

#### Managing Risks due to Potential Gaps in Regulatory System

With the adoption of the 2010 Elevator/Escalator Safety Code, TSSA provided a warning on using a stopped escalator as a means of access and departure unless the performance of the brake has been verified (Code Adoption Document 261-13 R1 issued on September 15, 2013).



### **Managing Risks due to Non-Compliance in Regulatory System**

TSSA conducts periodic inspections of all escalators and moving walks using a risk-based approach to oversee and manage the state of compliance across approximately 2,000 escalators and moving walks in the province of Ontario. TSSA deals with non-compliances by requiring the owner/operator to address observed failures within an appropriate timeframe through the issuance of inspection orders. This periodic inspection process contributes to the preventative management of risk associated with escalators and moving walks.

Table EM-2 provides information on key indicators associated with the results of the periodic inspections. Over the past five years, 3,158 periodic inspections were conducted on escalators and moving walks. The compliance rate measured over the last five years is 19% and demonstrates a decreasing trend of 5% per year. Figure EM-5 illustrates these observations graphically.

9,940 inspection orders were issued across the non-compliant inspections. TSSA's newly implemented standard inspection orders process for the elevating and amusement devices program allows for capturing specific details associated with these issued orders. Since December 2013, it was determined that nearly 11% of the 1,468 total inspection orders were high risk. Examples of high risk inspection orders include: addressing damaged skirt panels, inadequate friction reducing treatment for exposed skirt panel surfaces, and inappropriate maintenance of deck barricades for low deck escalators. It is important to note that nearly 42% of the inspection orders issued were not previously assessed for their risk significance due to system limitations. TSSA will continue to enhance its process to reduce such instances in order to obtain a more complete risk profile of the inspection orders.

46% of the inspection orders since December 2013 were low risk, examples of which include: posting of maintenance procedures at appropriate locations, maintenance of log books, etc.

**Table EM-2: State of compliance for escalators and moving walks as of 2013/2014.**

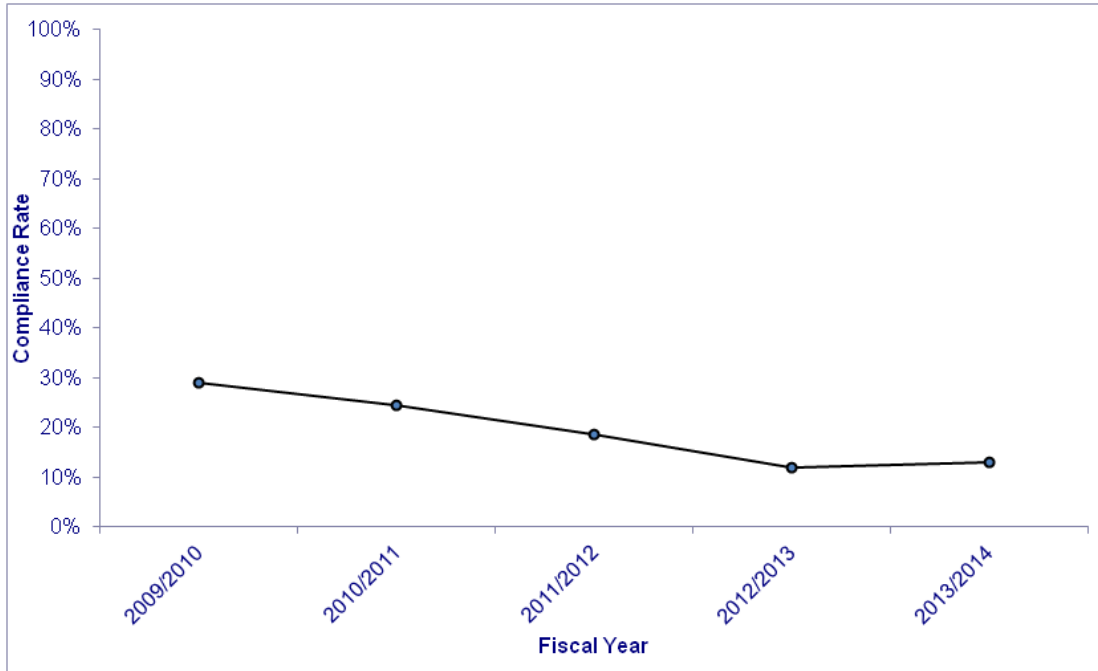
| Measure                                                         | Measured over Five-Year Period |
|-----------------------------------------------------------------|--------------------------------|
| Compliance Rate <sup>14</sup>                                   | 19% <sup>15</sup>              |
| Observed Trend in Compliance Rate                               | Decreasing Trend               |
| Percentage of High Risk Inspection Orders (since December 2013) | 11%                            |
| High Risk Inspection Orders Trend                               | Insufficient data              |
| Percentage of Low Risk Inspection Orders (since December 2013)  | 46%                            |
| Low Risk Inspection Orders Trend                                | Insufficient data              |

<sup>14</sup> Median of quarterly compliance rates over five years.

<sup>15</sup> Median value for prediction interval of 3% to 36%.



**Figure EM-5: Compliance rate for periodic inspections conducted on escalators and moving walks over the last five years.**



The number of compliant and non-compliant inspections, as well as the number of orders issued, is shown in Figure EM-6.

**Figure EM-6: Number of orders and compliant and non-compliant periodic inspections conducted on escalators and moving walks over the last five years.**





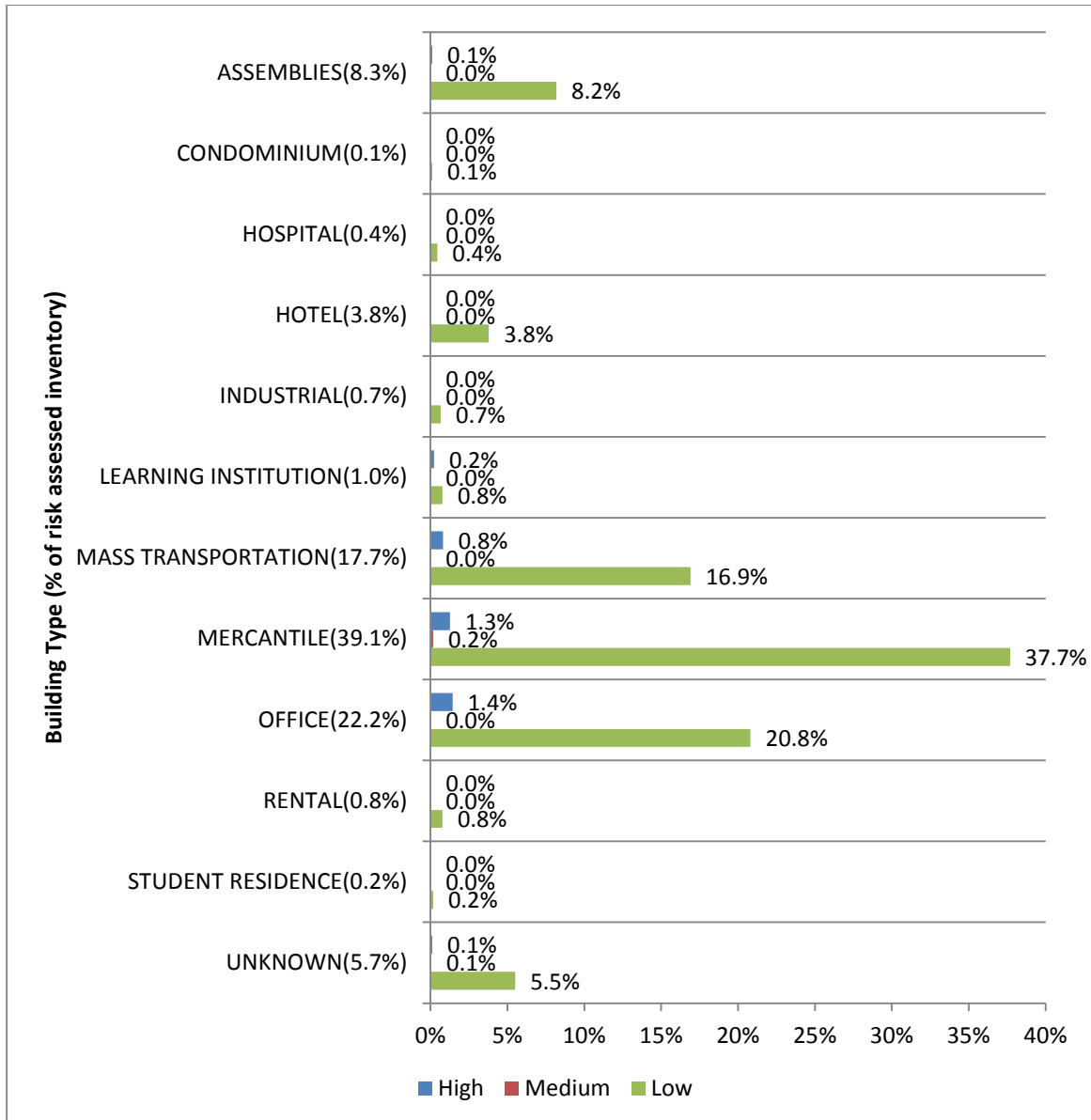
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TSSA's risk-based scheduling model (RBS2.0) [6] indicates that approximately 95% of the active escalators and moving walks in the province, based on their past compliance history, are identified as low operational risk and are inspected once every three years. 4% of active escalators in the province, based on their past compliance history, are identified as high operational risk and are inspected annually. A majority of these high risk devices are located in mass transit stations and office buildings. They represent 37% of the total inventory in the province. Figure EM-7 shows the percentage distribution of the risk profile across all building types (also shown is the building type distribution of the total inventory).



**Figure EM-7: Percentage distribution of the risk profile for escalators and moving walks across all building types determined through the Risk-Based Scheduling Model.**



The current compliance strategy involves shutting down escalators when certain non-compliances are found during periodic inspections. These are non-compliances such as annual maintenance tests that the maintaining contractor failed to complete on time. Another compliance strategy is the high follow-up inspection fee when orders remain outstanding. Both these strategies are under review as they have not resulted in improved compliance.

#### **Managing Risks due to External Factors**

For escalators and moving walks, the estimated risk due to external factors remains high at 97%; however, the overall risk posed by escalators is relatively low. For further detail, please refer to Elevators/Escalators in Appendix A.



## III.6 Passenger Ropeways (Ski Lifts)

TSSA regulates chair lifts, bar lifts, outdoor recreational conveyers, rope tows and tube tows, totalling approximately 300 ski lifts in Ontario, to ensure all devices conform to the Act and applicable regulations, codes and standards. TSSA reviews and registers lift designs, conducts inspections, and performs incident investigations. It also licenses lift devices, ensuring they conform to Ontario safety standards. In partnership with the Ontario Snow Resorts Association, TSSA additionally provides public education throughout the province, promoting safer ski lift behaviour.

The trend analysis outlined in this section should be considered in predominantly seasonal nature of these devices. The trend analysis confirmed and took into account seasonality while establishing historical patterns of safety and compliance performance.

### III.6.1 Risk Assessment

Based on actual injuries and fatalities over the past seven years, the average rate of injury is approximately 6 injuries/million people/year. No fatalities have been reported during this period. Using TSSA's approach to integrating fatalities and injuries, the observed injury burden corresponds to approximately 0.02 fatality equivalents/million people/year.

Combining the injury burden with over 87 occurrences with no observed health impacts, TSSA's predictive model [4] estimates the risk of injury or fatality to Ontarians riding ski lifts to be approximately 0.01<sup>16</sup> fatality-equivalents/million people/year, as indicated in Table SL-1 below. This estimate assumes that entire population of Ontario (approximately 13 million), would ride a ski lift at least once over the course of a year. A more realistic prediction of risk of injury or fatality may be estimated by obtaining reliable information on ridership. TSSA is working with the ski lift operators to obtain such an estimate. Table SL-1 provides statistics on past occurrences and associated trends. Figures SL-1 and SL-2 illustrate these observations graphically.

**Table SL-1: State of safety measures for ski lifts for the period  
2007/2008 – 2013/2014.**

| Measure                                                               | Seven Year Quarterly Trend     | Year          |               |               |               |               |               |               |
|-----------------------------------------------------------------------|--------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
|                                                                       |                                | 2007/<br>2008 | 2008/<br>2009 | 2009/<br>2010 | 2010/<br>2011 | 2011/<br>2012 | 2012/<br>2013 | 2013/<br>2014 |
| Fatalities                                                            | No significant quarterly trend | 0             | 0             | 0             | 0             | 0             | 0             | 0             |
| Permanent Injuries                                                    | No significant quarterly trend | 6             | 4             | 3             | 1             | 0             | 0             | 0             |
| Non-Permanent Injuries                                                | No significant quarterly trend | 76            | 87            | 74            | 66            | 115           | 69            | 18            |
| Occurrences (Incidents and Near-Misses)                               | No significant quarterly trend | 98            | 105           | 86            | 83            | 129           | 82            | 22            |
| Risk of Injury or Fatality (fatality-equivalents/million people/year) | Not Applicable                 | Not reported  |               |               |               | 0.03          | 0.03          | 0.01          |

<sup>16</sup> Represents expected estimate of a simulated distribution; 5th and 95th percentiles are 0 and 0.08 fatality-equivalents per million people per year respectively.



**Figure SL-1: Occurrences involving ski lifts  
over the last seven years.**

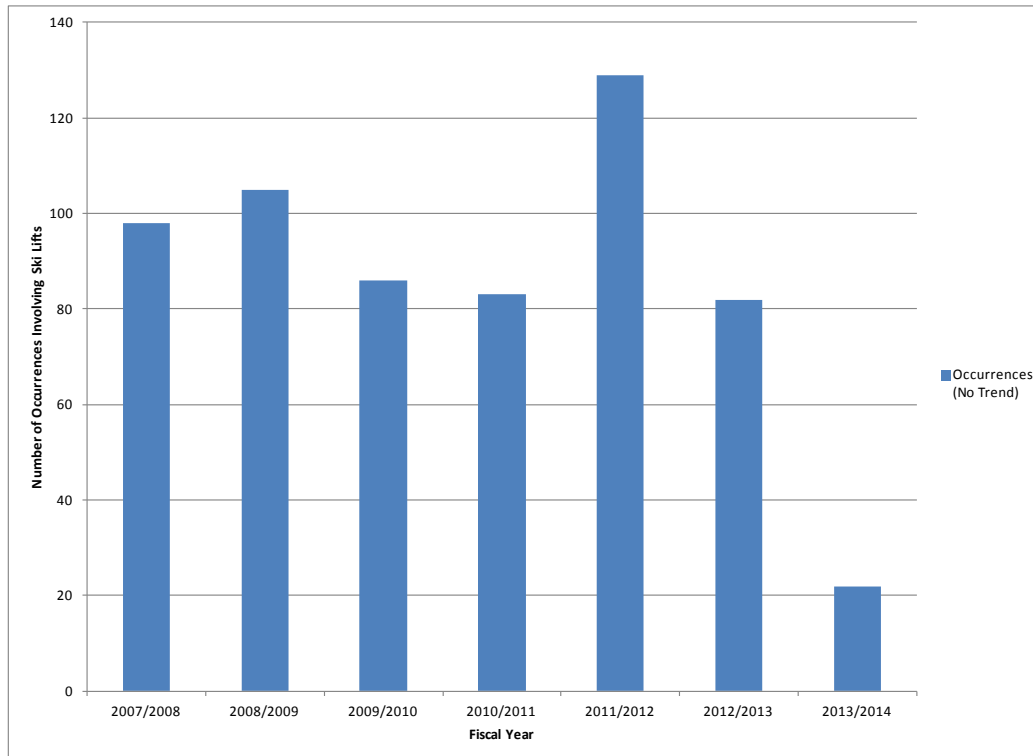


**Figure SL-2: Injuries involving ski lifts  
over the last seven years.**

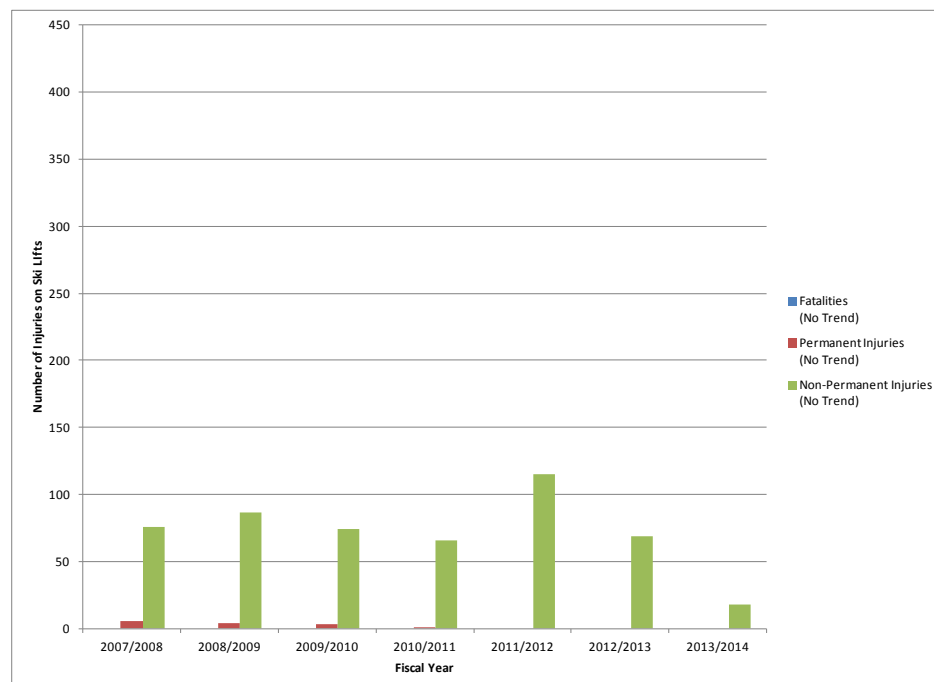
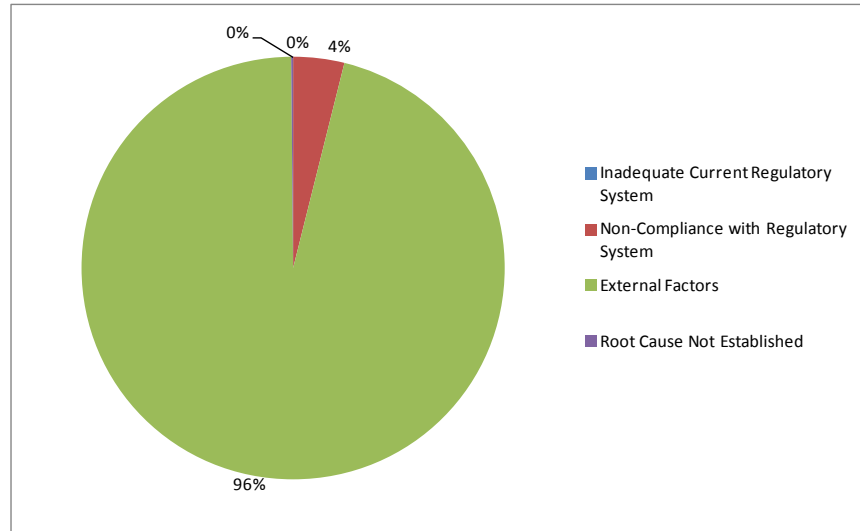




Figure SL-3 shows the distribution of the risk of injury or fatality across the three causal categories.

**Figure SL-3: Risk of injury or fatality in ski lifts by cause  
(based on period ending 2013/2014).**



#### **Risk of Injury or Fatality due to Potential Gaps in Regulatory System**

No occurrences resulted during the last seven years under this causal category.

#### **Risk of Injury or Fatality due to Non-Compliance with Regulatory System**

4% of the risk of injury or fatality is as a result of non-compliance with the regulatory system. Lack of, or poor maintenance of chair lifts contributed mostly to this source of the risk.

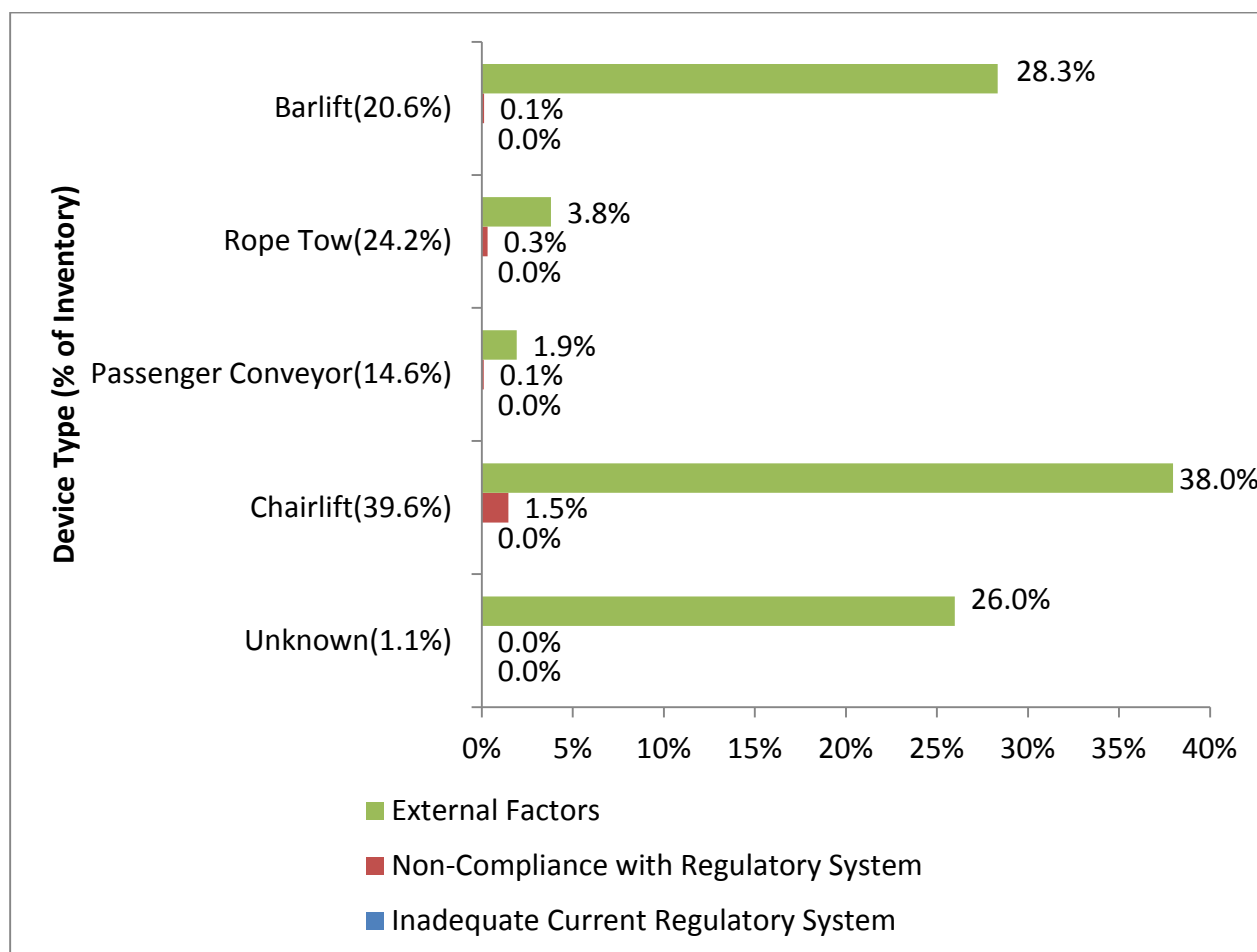
#### **Risk of Injury or Fatality due to External Factors**

Nearly 96% of the risk of injury or fatality caused by factors external to the regulatory requirements is due to unsafe behaviour by ski lift riders. Examples of occurrences include distracted riders falling while getting on and off ski lifts, and falls due to ski equipment getting entangled during loading and unloading.

Figure SL-4 shows the percentage distribution of risk across different device types and by the three causal categories.



Figure SL-4: Risk of Injury or Fatality classified by device type and causal category.



### III.6.2 Risk Management

#### Managing Risks due to Non-Compliance in Regulatory System

TSSA conducts periodic inspections of all ski lifts on a historical compliance weighted approach to oversee and manage the state of compliance across approximately 300 ski lifts in the province of Ontario. TSSA deals with non-compliances by requiring the owner/operator to address observed failures within an appropriate timeframe through the issuance of inspection orders. This periodic inspection process contributes to the preventative management of risk associated with ski lifts.

Table SL-2 provides information on key indicators associated with the results of the periodic inspections. Over the past five years, 655 periodic inspections were conducted on ski lifts. The compliance rate measured over the last five years is 42% and demonstrates an increasing quarterly trend. Figure SL-5 illustrates these observations graphically.

1,074 inspection orders were issued across the non-compliant inspections over five years. TSSA's newly implemented standard inspection orders process for the elevating and amusement devices program allows for capturing specific details associated with these issued orders. Since December 2013, it was determined that 23% of the 111 inspection orders issued were identified as high risk. Examples of high risk inspection orders include: addressing inadequate slopes for walking surfaces, inappropriate functioning of pressure sensing devices, and electrical protective devices on towers. It is important to note that nearly 67% of the inspection orders issued were



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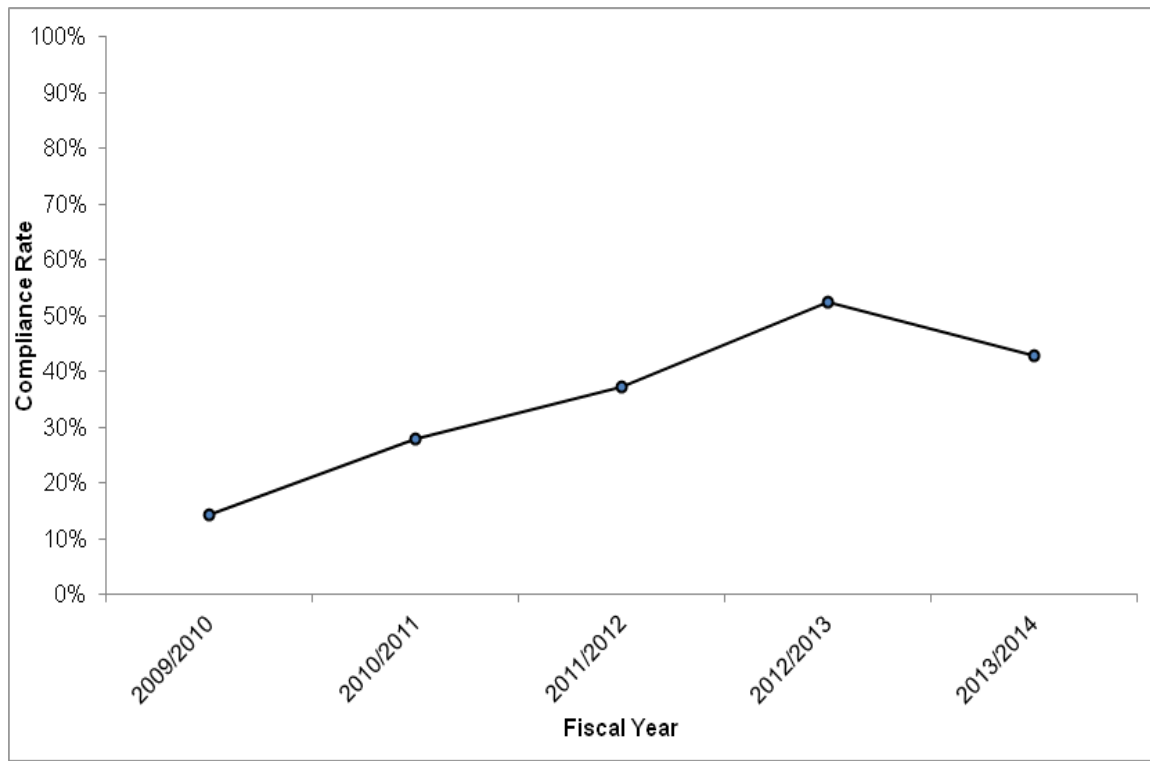
not previously assessed for their risk significance due to system limitations. TSSA will continue to enhance its process to reduce such instances in order to obtain a more complete risk profile of the inspection orders.

11% of known inspection orders issued are low risk, examples of which include updating of the maintenance log book on the results of periodic tests required to be performed.

**Table SL-2: State of compliance for ski lifts as of 2013/2014.**

| Measure                                                         | Measured over Five-Year Period |
|-----------------------------------------------------------------|--------------------------------|
| Compliance Rate <sup>17</sup>                                   | 42% <sup>18</sup>              |
| Observed Trend in Compliance Rate                               | Increasing trend               |
| Percentage of High Risk Inspection Orders (since December 2013) | 23%                            |
| High Risk Inspection Orders Trend                               | Insufficient data              |
| Percentage of Low Risk Inspection Orders (since December 2013)  | 11%                            |
| Low Risk Inspection Orders Trend                                | Insufficient data              |

**Figure SL-5: Compliance rate for periodic inspections conducted on ski lifts over the last five years.**



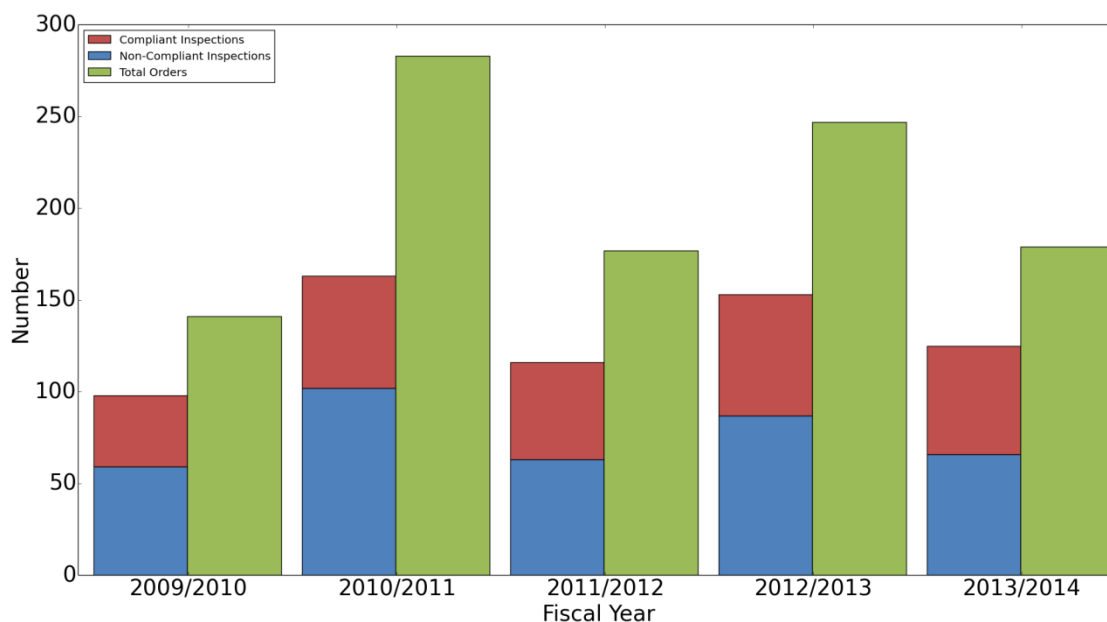
<sup>17</sup> Median of quarterly compliance rates over five years.

<sup>18</sup> Please note that prediction intervals have not been constructed for the 2014/2015 fiscal year due to the seasonality of inspections.



The number of compliant and non-compliant inspections, as well as the number of orders issued is shown in Figure SL-6.

**Figure SL-6: Number of orders and compliant and non-compliant periodic inspections conducted on ski lifts over the last five years.**



### **Managing Risks due to External Factors**

Of the risk on ski lifts, 96% is related to user behaviour, especially during loading and unloading operations. As such, ski lift user engagement and education is a key risk mitigation strategy. TSSA has completed research focused on the higher risk users and tested engagement strategies to refine its on-site public awareness/ education initiatives. For further detail, please refer to Ski Lifts in Appendix A.



### III.7 Fuels Safety

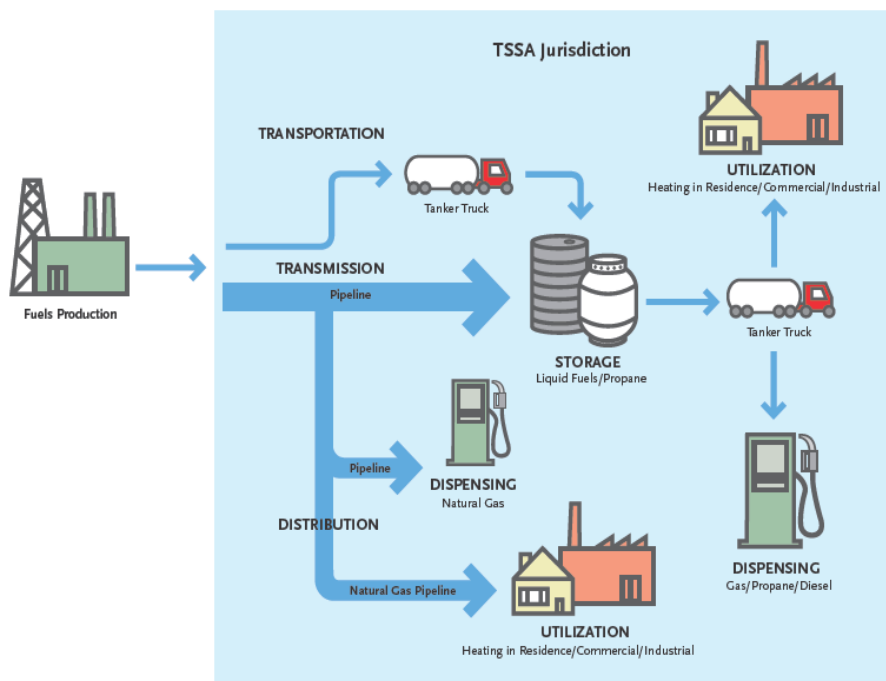
TSSA regulates the transportation, storage, handling and use of fuels to ensure compliance with the Act and applicable regulations, codes and standards. These fuels include: natural gas, propane, butane, hydrogen, digester gas, landfill gas, fuel oil, gasoline and diesel. TSSA licenses fuel facilities, registers contractors and certifies tradespersons who install and service equipment.

Additionally, TSSA reviews and approves facility plans for sites licensed by TSSA, and performs custom equipment approvals and inspection services to ensure fuel is handled and used safely.

The three stages of the fuels life-cycle that fall under TSSA's jurisdiction as illustrated in Figure FS-1 are:

- transmission, distribution and transportation;
- storage and dispensing; and
- utilization (burning).

**Figure FS-1: The fuels lifecycle.**



#### III.7.1 Risk Assessment

Based on actual injuries and fatalities over the past seven years, the observed average rate of injury and fatality is approximately 4 injuries/million people/year and 0.4 fatalities/million people/year respectively. Using TSSA's approach for integrating injuries and fatalities, these rates approximately correspond to an observed injury burden of 0.4 fatality-equivalents/million people/year.

Based on over 6,000 occurrences over this period, a majority of which did not cause health impacts, TSSA's prediction model estimates the risk of injury or fatality to be approximately 1.33<sup>19</sup> fatality-equivalents/million people/year, an increase by 25% from last year.

<sup>19</sup> Represents expected estimate of a simulated distribution; 5th and 95th percentiles are 0 and 4.5 fatality-equivalents per million people per year respectively.



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Table FS-1 provides the statistics and associated trends for the past occurrences. Figures FS-2 and FS-3 illustrate these observations graphically.

**Table FS-1: State of safety measures for fuels for the period 2007/2008 – 2013/2014.**

| Measure                                                               | Seven Year Quarterly Trend     | Year          |               |               |               |               |               |               |
|-----------------------------------------------------------------------|--------------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
|                                                                       |                                | 2007/<br>2008 | 2008/<br>2009 | 2009/<br>2010 | 2010/<br>2011 | 2011/<br>2012 | 2012/<br>2013 | 2013/<br>2014 |
| Fatalities                                                            | No significant quarterly trend | 6             | 14            | 1             | 3             | 2             | 3             | 8             |
| Permanent Injuries                                                    | Decreasing trend               | 13            | 22            | 21            | 9             | 7             | 6             | 9             |
| Non-Permanent Injuries                                                | No significant quarterly trend | 66            | 66            | 13            | 34            | 48            | 23            | 33            |
| Occurrences (Incidents and Near-Misses)                               | Decreasing trend               | 1,209         | 1,085         | 1,138         | 1,102         | 646           | 784           | 829           |
| Pipeline Strikes                                                      | No significant quarterly trend | 1,894         | 2,163         | 1,980         | 2,012         | 2,146         | 2,073         | 2,057         |
| Risk of Injury or Fatality (fatality-equivalents/million people/year) | Not Applicable                 | Not reported  |               |               |               | 1.16          | 1.06          | 1.33          |

**Figure FS-2: Occurrences involving fuels safety over the last seven years.**

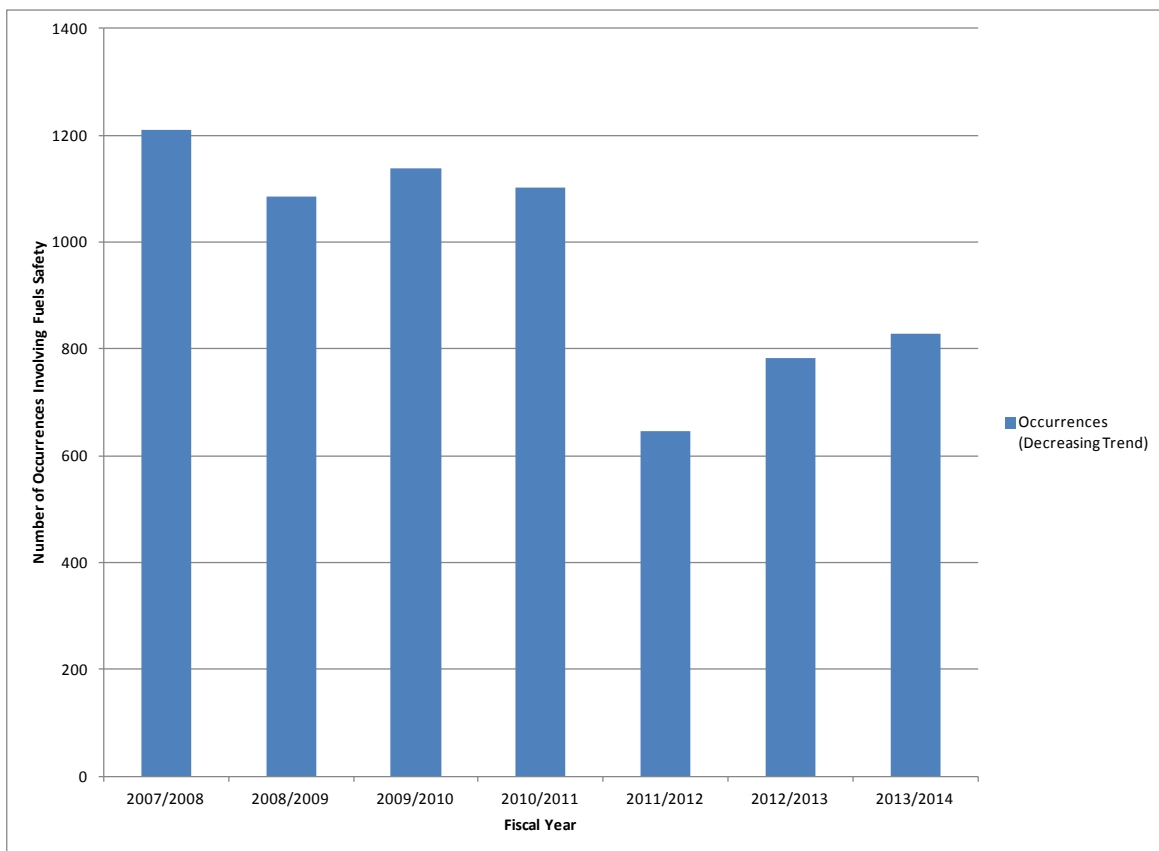




**Figure FS-3: Injuries involving fuels safety over the last seven years.**

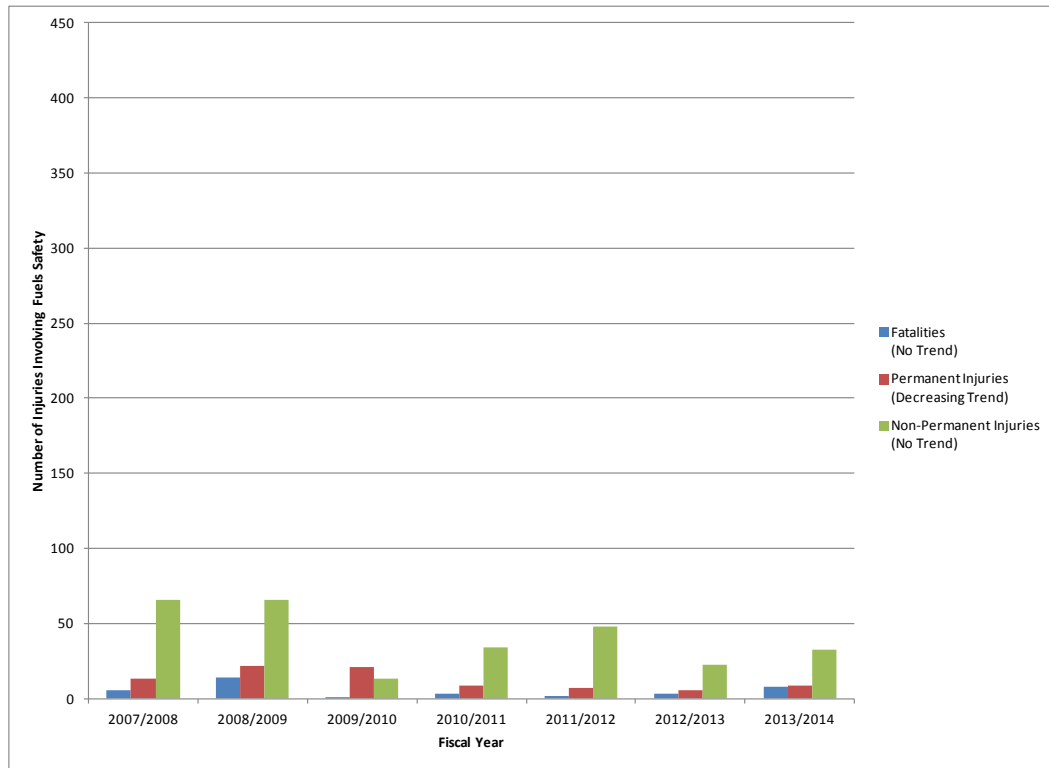


Figure FS-4 shows the distribution of the risk of injury or fatality across the three causal categories.

**Figure FS-4: Risk of Injury or Fatality in fuels by cause (based on period ending 2013/2014).**

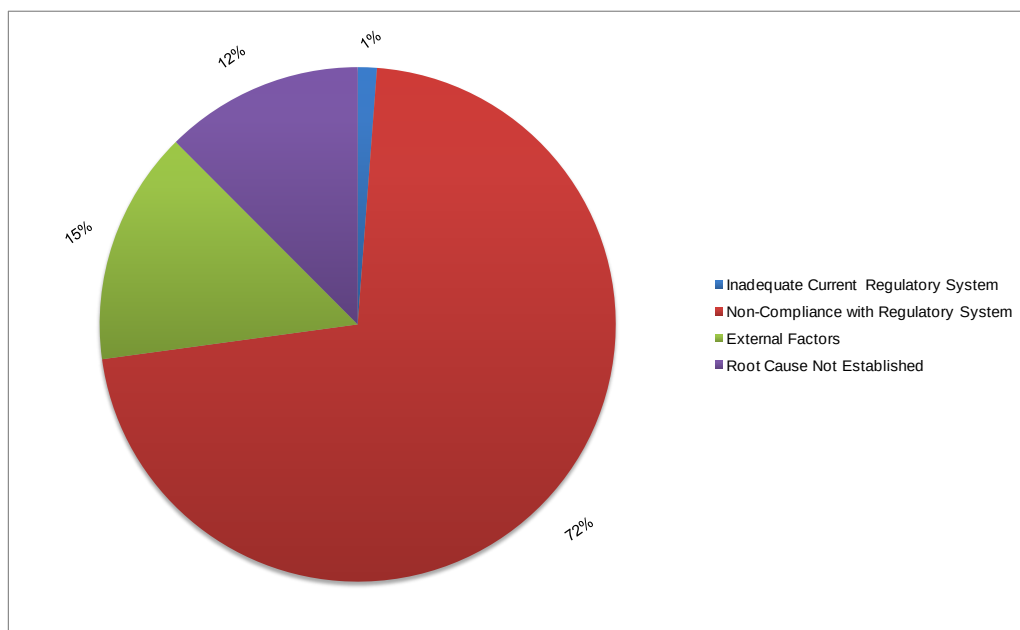




Figure FS-5 shows the number of the pipeline strikes over the last seven years.

**Figure FS-5: Pipeline strike occurrences involving fuels over the last seven years.**

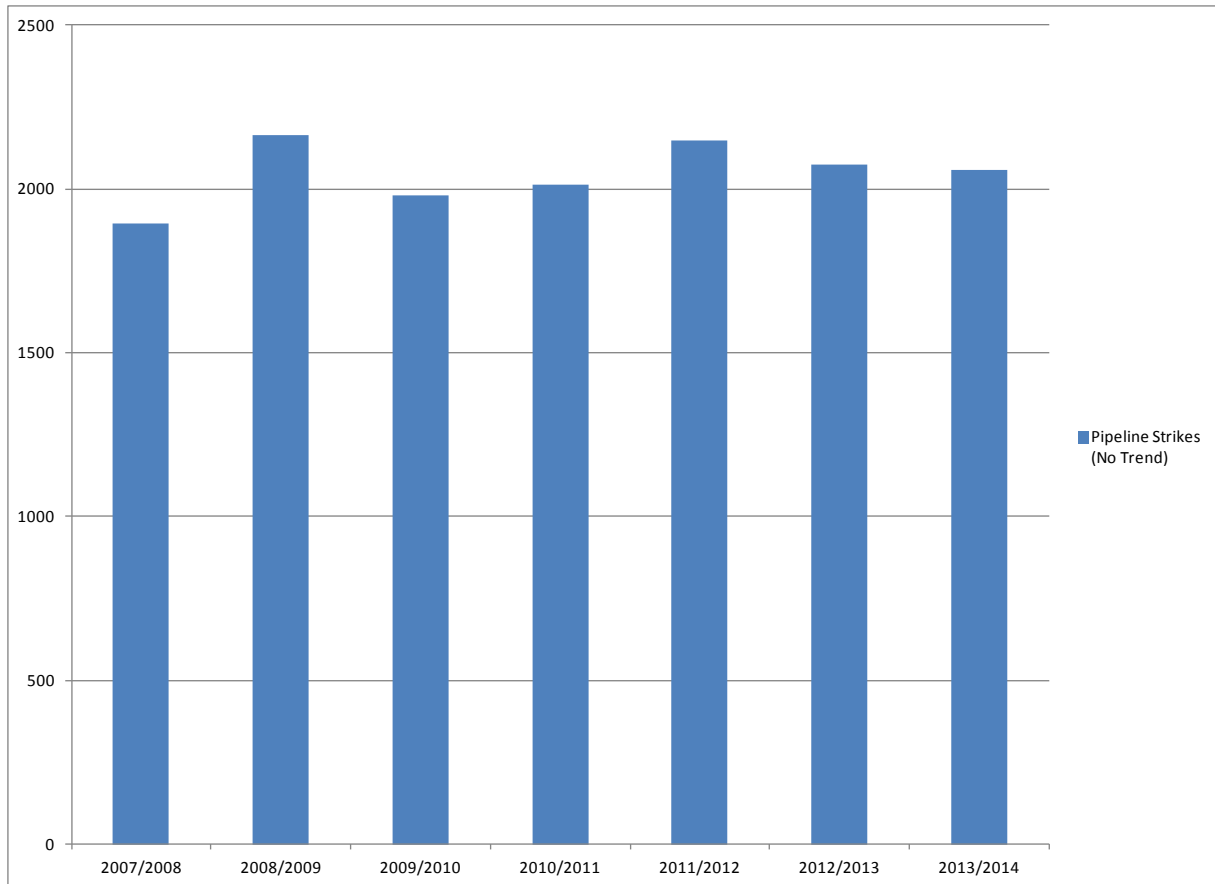
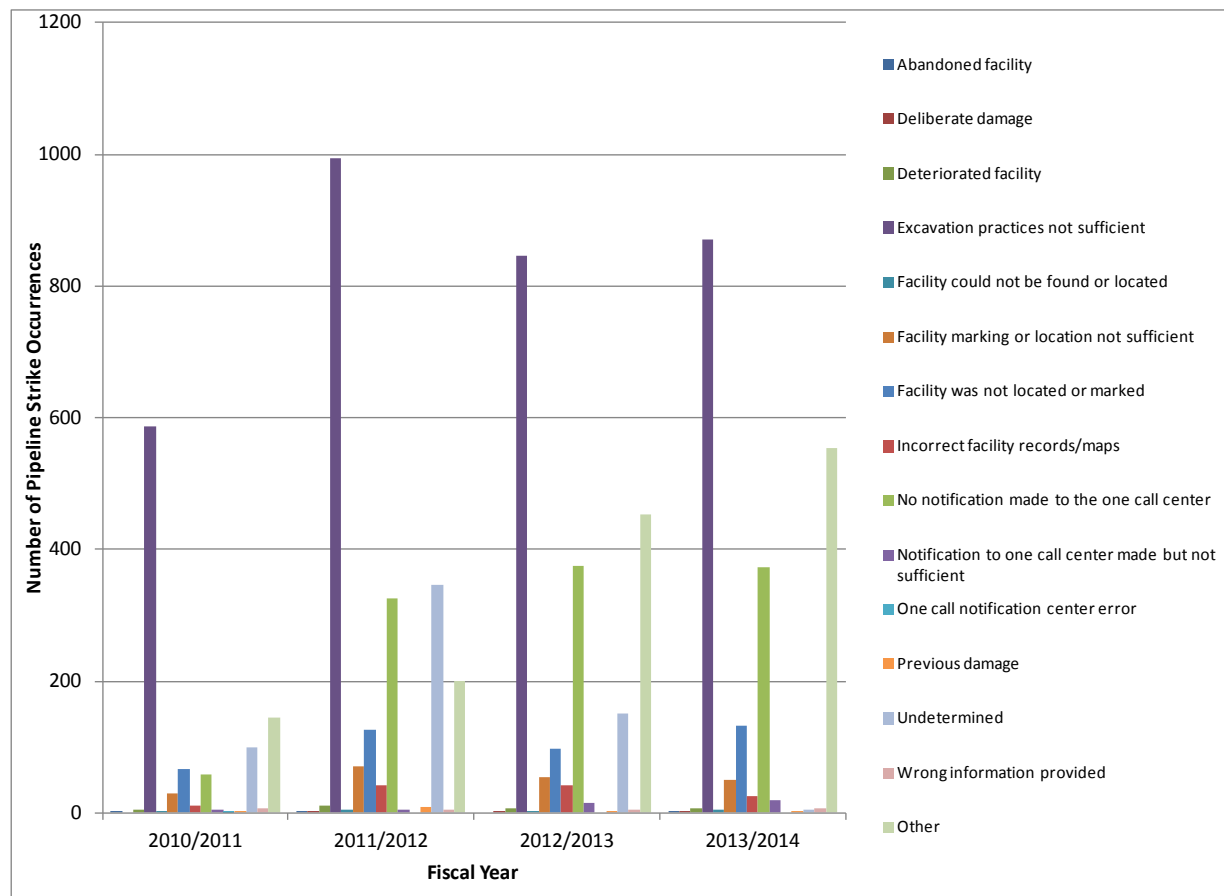




Figure FS-6 illustrates the distribution of pipeline strikes over the last four years by their damage reason.

**Figure FS-6: Causal reasons for pipeline strikes over the last four years.**



## Risk of Injury or Fatality due to Potential Gaps in Regulatory System

Approximately 1% of the risk of injury or fatality caused over the past seven years is due to potential gaps in the regulatory system. 65 occurrences contributed to this risk. Defective or wearing gas valves on fireplaces due to potential lack of testing and quality assurance requirements have been identified as a potential safety issues that are currently being investigated. Other known safety issues include corrosion-related failures on aboveground fuel oil residential tanks [7, 8].

## Risks due to defective/wearing gas valves on Direct Vent Gas Fireplaces

TSSA embarked on a risk assessment study to assess the state of safety of direct vent gas fireplaces in Ontario. Fireplace occurrences are known to result in fire and explosion due to delayed ignition while attempting to light the pilot. The most significant root cause is known to be wear-and-tear of gas valves for the supply gas system of the fireplace. Relief dampers act as mitigation controls; however, there is no stringent quality control mandated in the standards to verify that the damper performs as intended. As a result, approximately 50% of them fail to mitigate a delayed ignition condition.



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The risk of injury or fatality due to a delayed ignition in a fireplace based on an observed occurrence rate of 2.75 per year and severity associated with cuts, bruises, burns, etc. is estimated<sup>20</sup> to be 0.4 fatality-equivalents/million people/year. Further analysis suggests that risk could be beyond acceptable<sup>21</sup> limits if actual gas valve failure rate is about six in 10,000 fireplaces a year<sup>22</sup>. Failure of valves not resulting in incidents may not be reported to TSSA.

## Corrosion Related Failures on Single Wall Aboveground Fuel Oil Storage Tanks

From May 2007 to April 2014, approximately 15% of all fuels safety occurrences have resulted from leaks which involve fuel oil release into the environment. These occurrences were found to take place largely in residential locations, and a large share due to single-wall aboveground storage tank failures. While they do not have an immediate health impact, their impacts to the surrounding environment, including the potential to contaminate Ontario's water supply, may be of significant concern.

Field investigations and metallurgical laboratory analyses of perforated oil steel tanks have indicated that the largest source of these tank failures could be attributed to internal corrosion. The failure of these tanks results in oil leakage with expensive cleanup costs. In order to avert these incidents, a proactive approach is warranted to help make informed decisions regarding the replacement interval for these tanks.

In response to this safety issue, a methodology to establish replacement intervals for single-wall fuel oil aboveground storage tanks using a risk-informed approach was completed. The results of the analysis using available information in the TSSA database predict the failures to occur between 1.3 years (5th percentile) and 28 years (90th percentile) after installation with a 50th percentile value of 12 years. Additionally, TSSA issued Fuel Oil Code Adoption Document FS-202-12 that requires installation of double-bottom aboveground fuel oil storage tanks, effective January 1, 2013, in order to reduce environmental impacts related to leaks from single-bottom fuel oil tanks.

## Risk of Injury or Fatality due to Non-Compliance with Regulatory System

72% of the risk of injury or fatality is attributed to non-compliance with the regulatory system. The risks may be as a result of non-compliant practices at various stages of the fuels lifecycle and due to installation, operation, maintenance and use of fuels equipment and appliances.

## Risk of Injury or Fatality due to External Factors

Approximately 15% of the estimated risk is attributed to factors external to the regulatory requirements including owners failing to follow user instructions while operating appliances, such as barbecues, portable heaters at campsites, etc. Other factors including criminal activity and sabotage, also contribute to some of the occurrences which may have involved TSSA's role as technical support to other regulatory agencies.

Figure FS-7 shows the percentage distribution of risk across different stages of the lifecycle and by the three causal categories. Figure FS-8 shows the percentage distribution of risk across different operation types and by the three causal categories.

<sup>20</sup> Estimate based on an assumed inventory size of one million fireplaces and one exposed individual per fireplace.

<sup>21</sup> The fatality-equivalent measure facilitates benchmarking against internationally recognised risk acceptability criteria of 1 fatality per million people in a year.

<sup>22</sup> Assuming a probability of 1% fatality due to glass breakage.



**Figure FS-7: Percentage distribution of risk across occurrence types, lifecycle stages and by causal categories.**

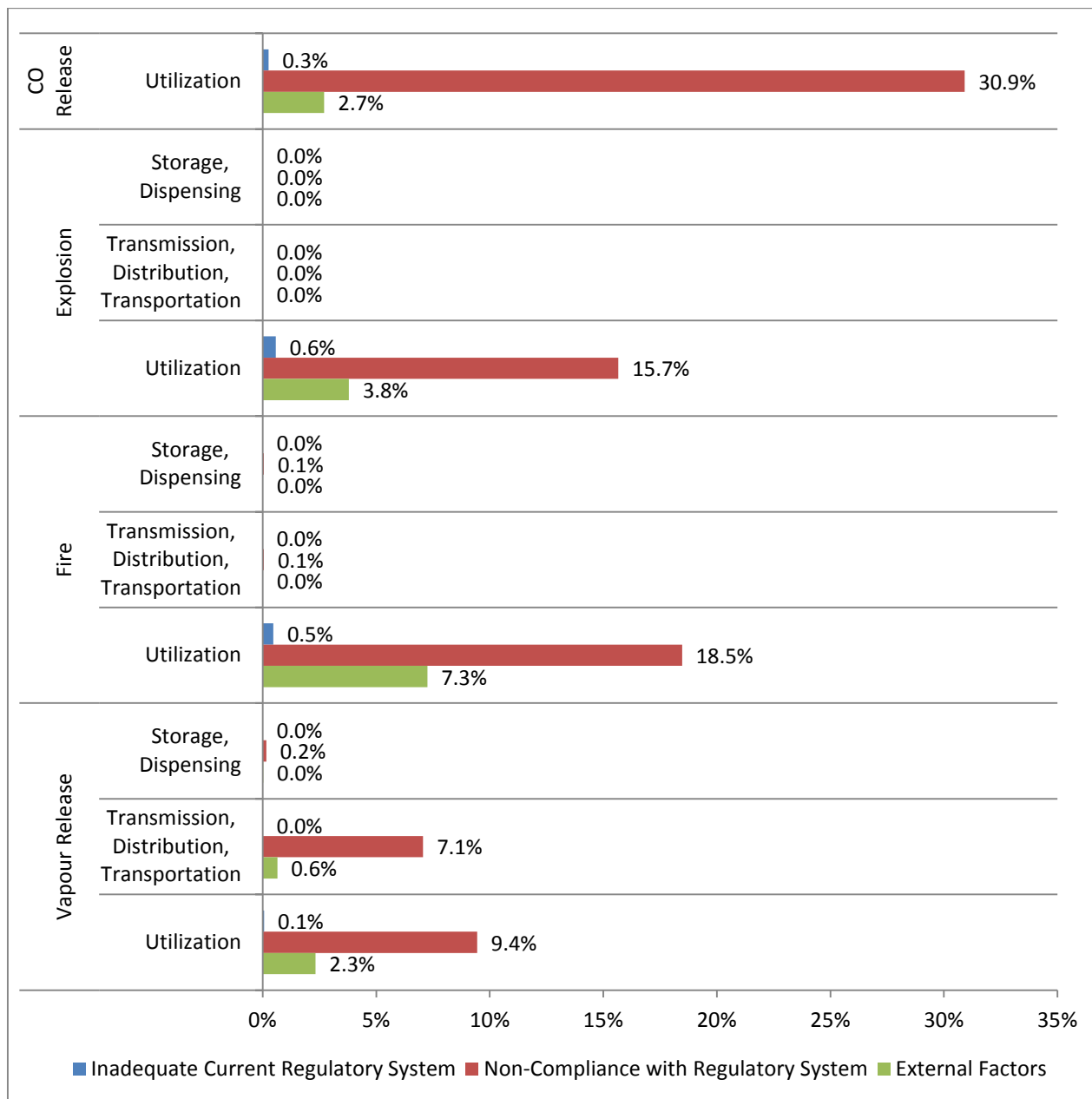




Figure FS-8: Percentage distribution of risk across operation types and causal categories.

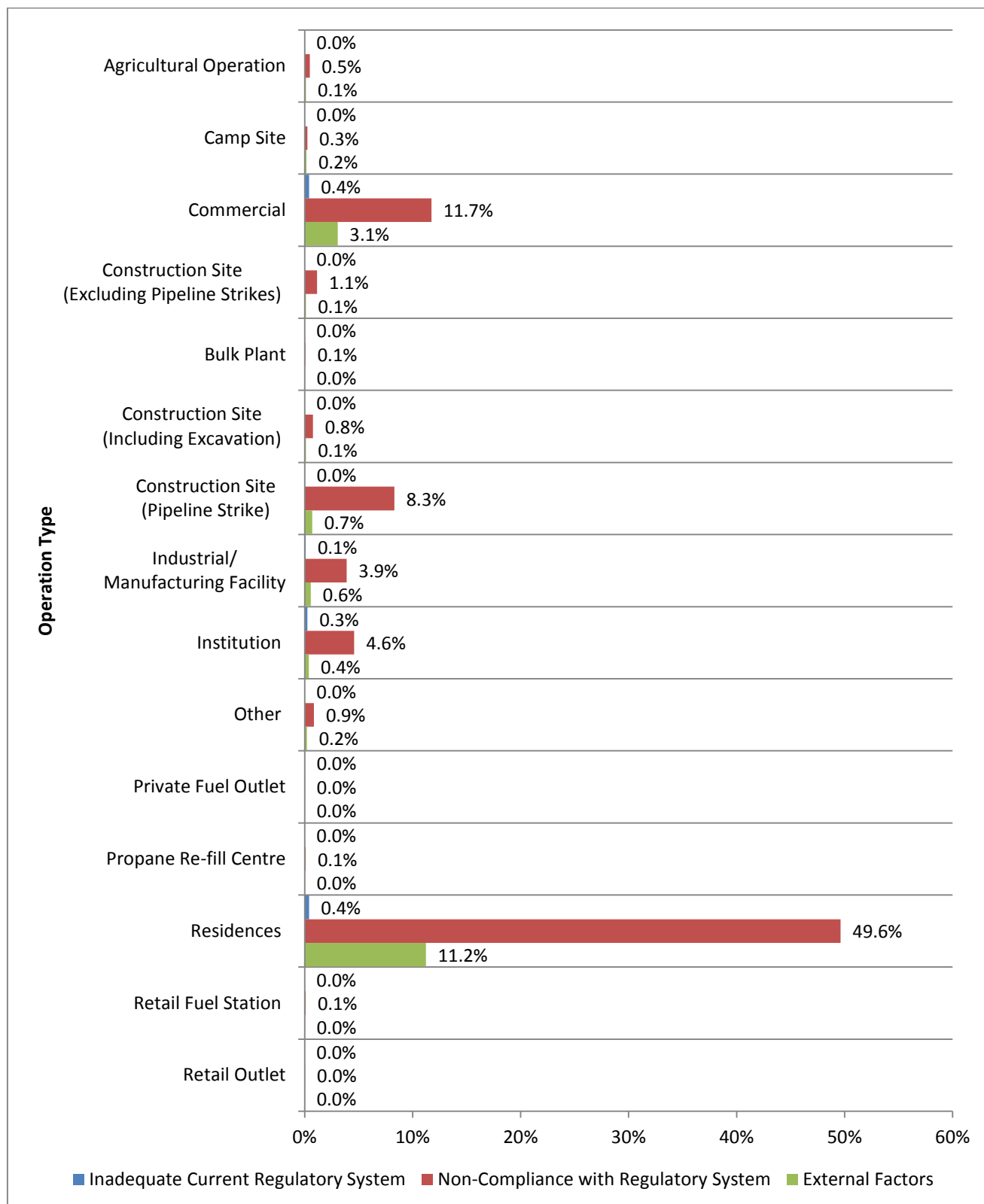




Figure FS-9: Percentage distribution of equipment type risk across occurrence types.

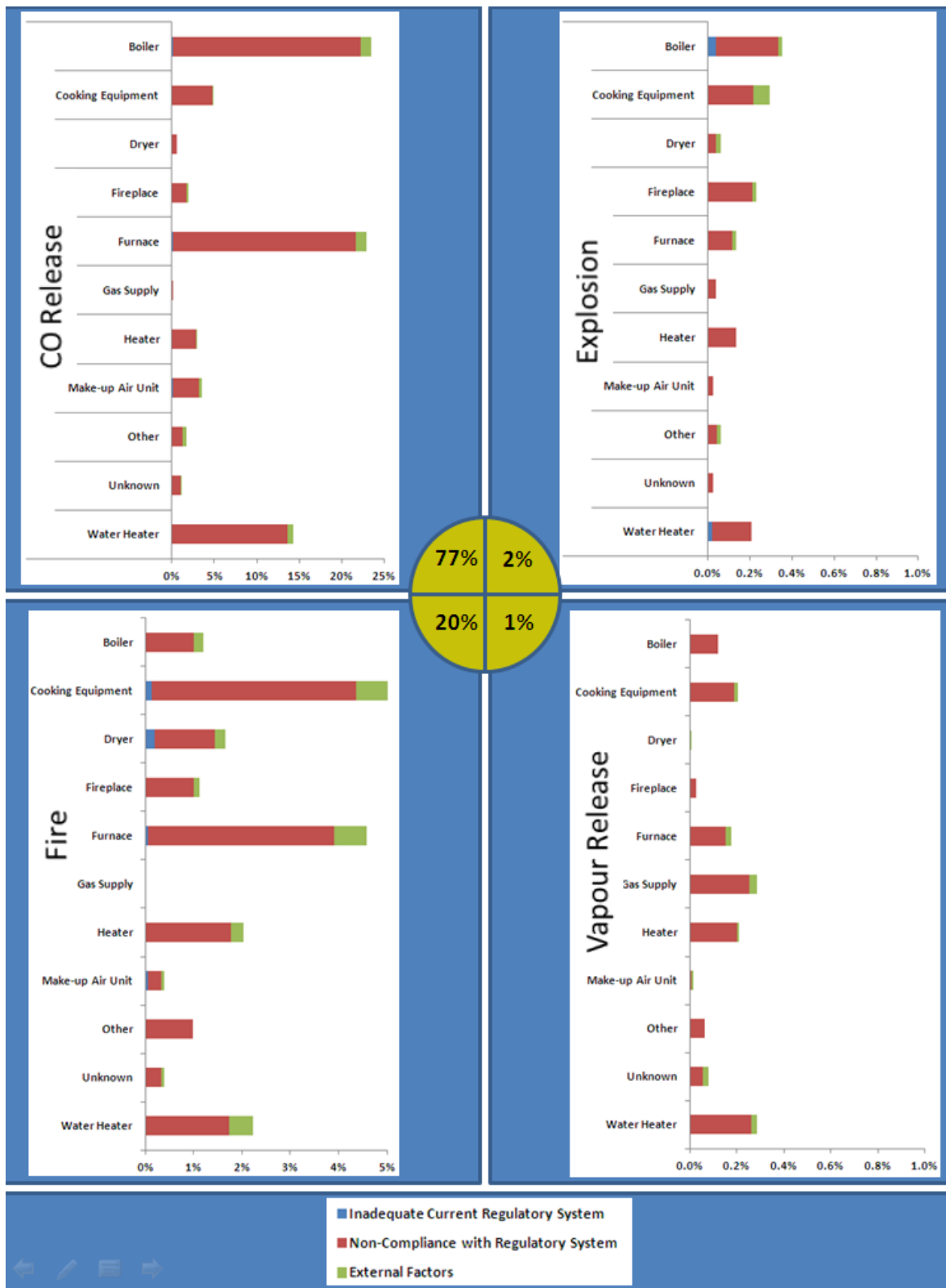




Figure FS-9 illustrates the distribution of equipment risk derived from the subset of occurrences reported to the TSSA with discernible equipment forms. CO release accounts for 77% of the risk, wherein the largest sources continue to be boilers, furnaces and water heaters. In particular, TSSA's prediction model estimates the risk of injury or fatality to be approximately 1.33 fatality-equivalents/million people/year for occurrences involving boilers resulting in CO release. As indicated in Figure FS-9, the majority of the risk stemming from boilers is due to non-compliance with regulatory requirements.

In response to continued reports of incidents and fatalities associated with natural gas-fired natural draft boilers in residences, TSSA issued directors' orders in 2006 and 2009 to address the deficiencies with boilers installation and maintenance, which was incorporated into the Gaseous Fuels Code Adoption Document in November 2012. Inspection data indicate that the directors' orders have been served since 2006, and that over 20% were due to failure to check for carbon monoxide in the flue gas.

Occurrences involving these appliances in residences demonstrate an increasing trend at a rate of 12% per year over the last seven years, and continue to demonstrate deficiencies due to installation and maintenance of boilers. This may indicate that the issue continues to remain a significant risk at residences with no formal maintenance program in place. Other risk reduction strategies, including public education, may need to be considered for reducing overall risk.

### III.7.2 Additional Analysis

This section compares the risk of injury or fatality to Ontarians resulting from technologies/appliances required to be inspected by TSSA at one or more stages of their lifecycle (design, installation, operation, maintenance and use), against those not having any formal or periodic regulatory inspections. The intent of this analysis is to determine the impact of TSSA inspections on the risk of injury or fatality and to evaluate the potential need for enhancing/modifying the scope of its inspections program.

#### III.7.2.1 Risks associated with TSSA inspected Technologies/Locations

TSSA licenses and periodically inspects facilities that store and dispense fuels including diesel, gasoline, and propane. Liquid fuels storage and dispensing facilities are inspected once every three years while propane storage and dispensing sites are required to be inspected annually. Risks at these facilities account for less than 1% of the total risks, which represent a reduction when compared to last year.

#### III.7.2.2 Risks Associated with Other Regulated Technologies

Nearly 90% of the risk of injury or fatality is associated with the utilization of fuels by fuel-burning appliances in residential, commercial, institutional and industrial/manufacturing locations. Appliances used at these locations are required to be approved prior to operation; however they are not required to be periodically inspected by TSSA. Additionally, TSSA has no legal authority to enter and inspect private dwellings as Section 17 of the Act [1] specifically prohibits TSSA from entering without a warrant or consent from the occupier.

#### Risk of Injury or Fatality at Residential Locations

Risk of injury or fatality at private and multi-residential dwellings due to occurrences resulting from heating appliances has increased by 7% since last year. Nearly 60% of all occurrences, involving regulated fuels and approximately 70% of the health impact, are related to these locations. Specifically, risk of injury or fatality due to carbon monoxide poisoning at private and multi-residential dwellings has increased by nearly 15% since last year. These occurrences continued to be caused primarily due to inadequate maintenance of heating appliances including boilers, furnaces and water heaters.



### Risk of Injury or Fatality at Institutions with Vulnerable Populations

Risk of injury or fatality due to non-compliant installation and maintenance practices of heating appliances and associated fuel supply and venting systems at institutions with vulnerable populations (hospitals, schools, nursing homes, etc.), has increased by 2% since the last year. Occurrences involving carbon monoxide poisoning are increasing by nearly 15% per year. The acceptability threshold at these locations [5] due to the type of occupants is understandably much lower than normal locations [2, 3] of exposure.

### Risk of Injury or Fatality at Commercial Establishments

Risk of injury or fatality at commercial establishments has increased by 5% since the last year. Poor maintenance practices of appliances, such as stoves and burners at food service locations like bakeries and restaurants, posed the most risk while occurrences resulting from damage to gas supply lines (risers, meters, regulators etc.) into these locations are most frequent.

### Risk of Injury or Fatality during Transmission, Transportation and Distribution of Fuels

Approximately 9% of the risk of injury or fatality is due to occurrences during the transmission, transportation and/or distribution of fuels through pipelines and/transport tankers. Vapour releases resulting from pipeline strikes at construction sites contribute significantly to this risk. A significant portion of the risk is due to non-compliant practices by regulated parties responsible for the safe operation of technologies during this stage of the fuel lifecycle.

## **III.7.2 Risk Management**

### **Managing Risks due to Potential Gaps in Regulatory System**

In response to risks associated with potential gaps Fuels Safety has utilized Director's Orders to address concerns. The Natural Draft Boiler Order (Director's Order FS-072-08) was utilized for several years to enhance boiler safety and reduce CO occurrences; these requirements were embodied in the latest edition of the natural gas installation code (Gaseous Fuels Code Adoption Document FS 200-12).

As a result of several incidents with direct vent fireplaces TSSA continues to work with the industry to enhance the standards used by manufacturers to increase safety requirements to prevent future incidents and address ageing equipment.

TSSA became aware of many instances of above ground storage tank failures, many occurring after a short operating life. Since the failure mode was not immediately evident, TSSA, after industry consultation, issued a Code Adoption (FS-202-12 on November 1, 2012), after extensive industry consultation, for all tanks to be double-bottom or incorporate secondary containment.

Liquefied natural gas for small plants, refuelling and vehicles is an emerging market with insufficient regulatory requirements. For these instances, TSSA has developed local criteria until such time that code requirements are completed.

### **Managing Risks due to Non-Compliance in Regulatory System**

#### Managing Risks due to TSSA Periodically Inspected Technology

TSSA conducts periodic inspections of liquid fuels storage and dispensing facilities at least once every three years and propane storage and dispensing facilities annually to oversee and manage the state of compliance across approximately 9,100 licensed sites in the province of Ontario.



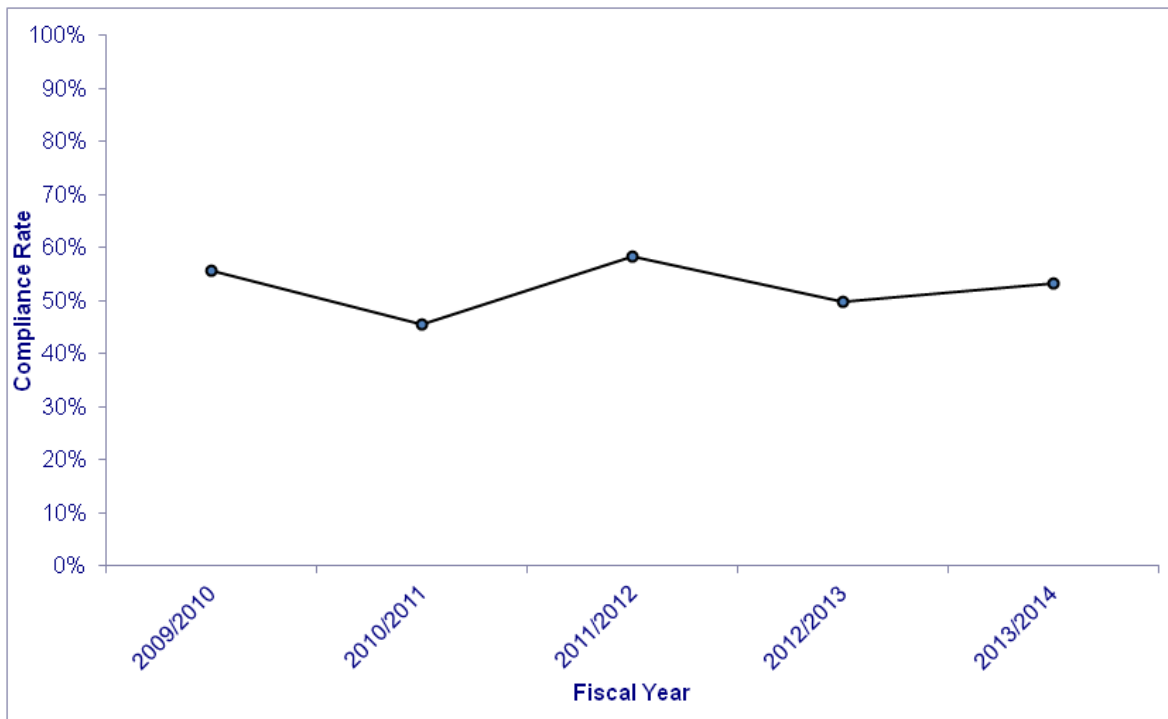
Table FS-2 provides information on key indicators associated with the results of the periodic inspections. Over the past five years, there have been 13,271 periodic inspections across storage and dispensing facilities. The compliance rate measured over the last five years is 54% and demonstrates no significant quarterly trend.

**Table FS-2: State of compliance for fuels storage and dispensing facilities as of 2013/2014.**

| Measure                                   | Measured over Five-Year Period |
|-------------------------------------------|--------------------------------|
| Compliance Rate <sup>23</sup>             | 54% <sup>24</sup>              |
| Observed Trend in Compliance Rate         | No significant quarterly trend |
| Percentage of High Risk Inspection Orders | 16%                            |
| High Risk Inspection Orders Trend         | Decreasing trend               |
| Percentage of Low Risk Inspection Orders  | 42%                            |
| Low Risk Inspection Orders Trend          | Increasing trend               |

Figure FS-10 illustrates these observations graphically.

**Figure FS-10: Compliance rate for periodic inspections conducted on fuels licensed sites over the last five years.**



Specifically, the compliance rate measured over the last five years at liquid fuels storage and dispensing facilities is 33%<sup>25</sup> and demonstrates a decreasing trend of 3% per year. The compliance rate associated with propane storage and dispensing facilities is 69%<sup>26</sup> and demonstrates an increasing trend of 5% per year. Figure FS-11 illustrates these observations graphically.

<sup>23</sup> Median of quarterly compliance rates over five years.

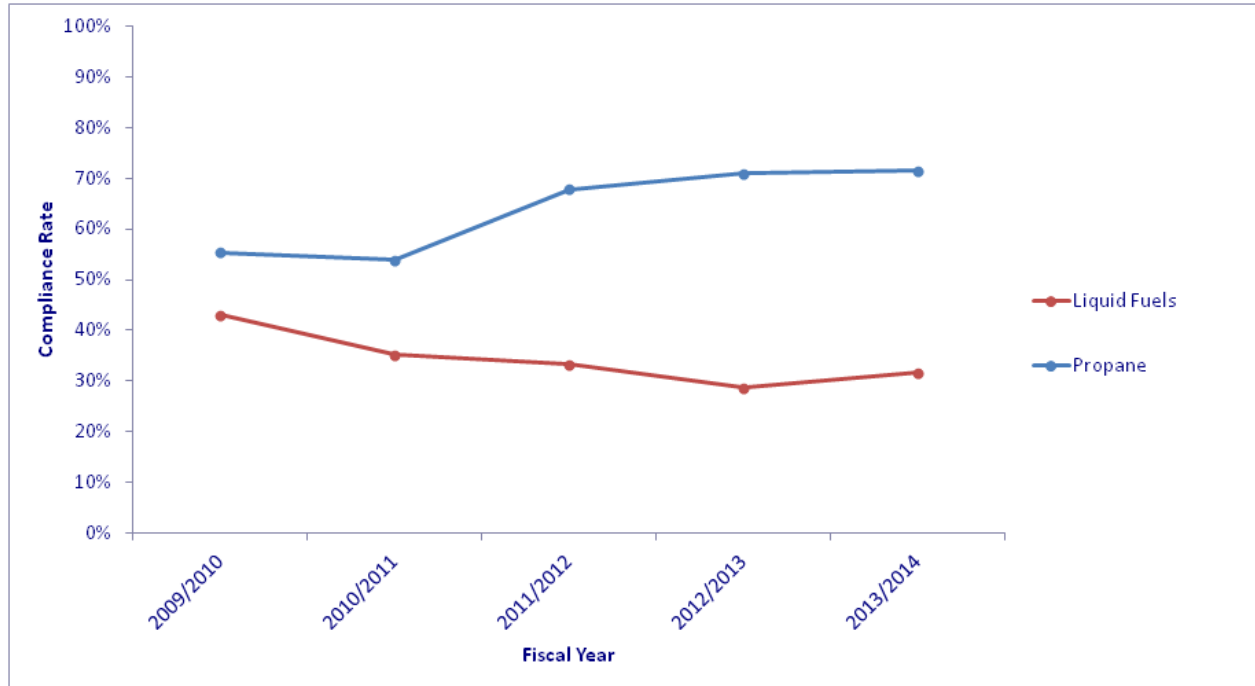
<sup>24</sup> Median value for a prediction interval of 36% to 63%.

<sup>25</sup> Median value for a prediction interval of 15% to 58%.

<sup>26</sup> Median value for a prediction interval of 43% to 84%.

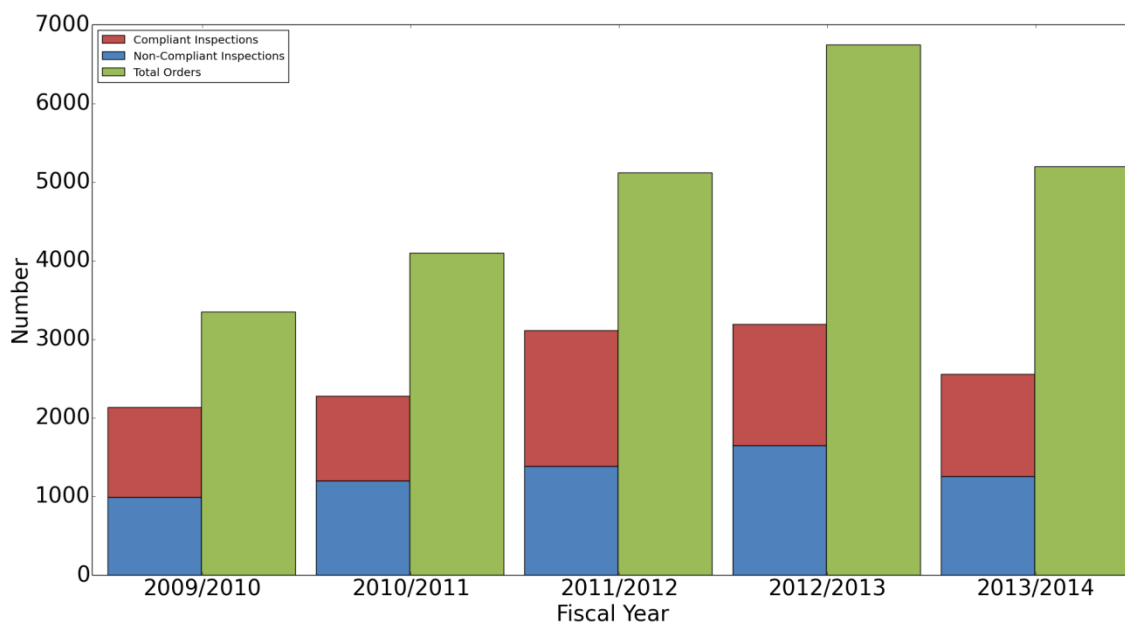


**Figure FS-11: Compliance rate for periodic inspections conducted on liquid fuel and propane licensed sites over the last five years.**



The number of compliant and non-compliant inspections, as well as the number of orders issued is shown in Figure FS-12.

**Figure FS-12: Number of orders and compliant and non-compliant periodic inspections conducted on licensed sites over the last five years.**





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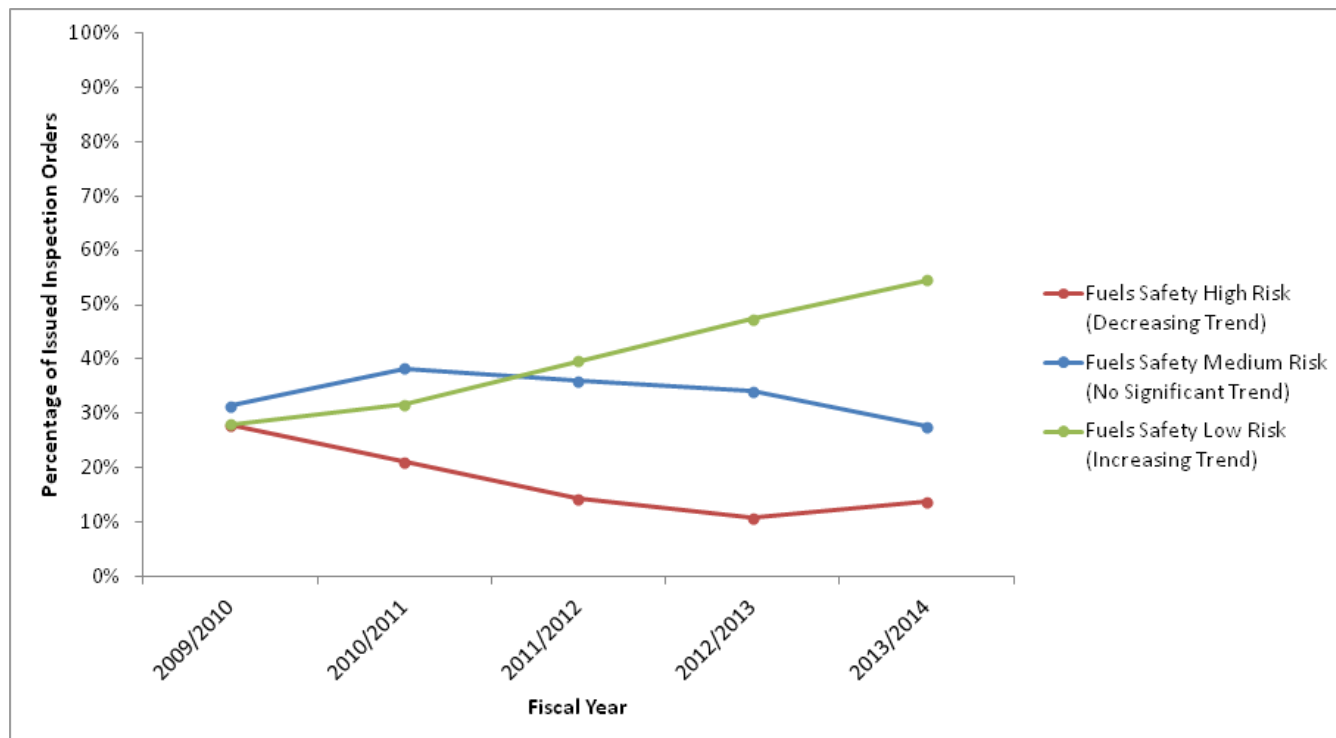
Approximately 24,000 inspection orders were issued across the non-compliant inspections. Nearly 16% of these were high risk inspection orders and demonstrates a decreasing trend. Examples of high risk inspection orders include addressing lack of fire protection devices such as fire extinguishers at retail gas stations, potential for corrosion failures due to lack of painting of steel tanks at propane storage and dispensing sites, safe storage of portable propane cylinders in accordance with the requirements, etc. Table FS-3 and Figure FS-13 illustrate these observations graphically.

42% of the inspection orders were determined as low risk, examples of which include cleanliness of areas where fuel handling operations occur, signage, provision of reports of completed testing, etc.

**Table FS-3: Distribution of issued orders at fuels licensed sites for the period 2009/2010 – 2013/2014.**

| Order Risk | Year          |               |               |               |               |
|------------|---------------|---------------|---------------|---------------|---------------|
|            | 2009/<br>2010 | 2010/<br>2011 | 2011/<br>2012 | 2012/<br>2013 | 2013/<br>2014 |
| High       | 28%           | 21%           | 14%           | 11%           | 14%           |
| Medium     | 31%           | 38%           | 36%           | 34%           | 28%           |
| Low        | 28%           | 32%           | 40%           | 47%           | 55%           |

**Figure FS-13: Risk distribution of issued orders at fuels licensed sites over the last five years.**



In managing risk in various sectors, TSSA employs risk-based principles developed by the Public Safety and Risk Management Department (PSRM). For example in the propane sector TSSA recently completed a compliance analysis and developed a risk based inspection model that was presented to the Ministry of Government and Consumer Services (MGCS) to consider during a review of the propane regulation to replace the existing requirement for annual inspections.



## Managing Risks due to Other TSSA Regulated Technology

In response to the increasing risk of injury or fatality at institutions and commercial establishments, TSSA has initiated a three-year pilot of targeted inspections. The “Special Buildings Inspections” project will initially focus on inspecting long-term care and retirement homes in Ontario during the current year; while the other occupancy types will be phased in over the next three years. The inspections will focus on determining the nature and extent of non-compliances and the results will be closely monitored to determine future course of action.

Additionally, TSSA is seeing increased occurrences of gas service-line damages and will actively engage the various gas utilities through education sessions on the need to ensure that gas risers at commercial establishments are adequately protected from any potential damage.

## Managing Risks due to External Factors

Carbon monoxide incidents in private dwellings is the leading cause of incidents in Fuels. TSSA has no jurisdiction in private dwellings.

As indicated in Appendix A poor maintenance of residential heating equipment such as furnaces due to a lack of understanding of the risks is a major factor in these incidents. Fuels Safety, in conjunction with TSSA's Research and Education department, share information and insights on user behaviour with an aim to partner with industry stakeholders who have access to private dwellings through interaction with their customer base. TSSA has already engaged the Natural Gas Advisory Council in this regard and formed a task group to further explore areas of collaboration.



### III.8 Upholstered and Stuffed Articles

The role of the Upholstered and Stuffed Articles Safety Program is to protect the public from potential hazards associated with the use of unclean or unsafe filling materials in upholstered and stuffed articles in Ontario. In addition to promoting safety, TSSA's aim is to protect consumers against fraud, misrepresentation of filling materials in upholstered and stuffed articles, and to provide a level playing field for the industry. Under *Ontario Regulation 218/01, Upholstered and Stuffed Articles*, only new and clean filling materials are allowed in upholstered and stuffed articles, and all articles are required to be labelled. Such articles include: toys, sporting goods, pet items, furniture, mattresses, down-filled apparel, bedding items, handbags, luggage and seasonal ornaments. The requirements for new and clean filling materials are enforced through inspections at point-of-sale and the manufacturing level.

The stages of the upholstered and stuff articles lifecycle that fall under TSSA's jurisdiction are:

- supplier;
- manufacturer;
- importer/distributor;
- renovator; and
- retailer.

#### III.8.1 Risk Assessment

Occurrences are currently not required to be reported to TSSA under *Ontario Regulation 218/01, Upholstered and Stuffed Articles*. TSSA does not have any reports of health impacts and hence cannot assess the state of safety for this program.

#### III.8.2 Risk Management

In the last year, TSSA's Upholstered and Stuffed Articles program has conducted over 1100 inspections focusing mainly on retailers. There is an increase of manufacturers not registered in Ontario, due to new products being sold in the marketplace and unfamiliarity with the Regulation. Measures are taken to educate stakeholders as required.

Over 19,000 inspection orders were issued over the course of the year. The majority of the 'Other' infraction type corresponds to articles which are soiled or contaminated and are ordered for destruction. It is important to note that the volume of orders issued do not necessarily equate with the number of articles affected. For instance, nine orders were issued for 'Unclean/unsafe filling material'; however the affected volume may have been thousands of articles.

**Table USA-1: Inspections by inspection type for the period  
2007/2008 – 2013/2014.**

| Inspection Type      | Compliant Inspections | Non-Compliant Inspections | Total        |
|----------------------|-----------------------|---------------------------|--------------|
| Retailer             | 1,964                 | 1,324                     | 3,288        |
| Importer/Distributor | 485                   | 258                       | 743          |
| Manufacturer         | 540                   | 166                       | 706          |
| Renovator            | 490                   | 140                       | 630          |
| Home Hobbyist/Craft  | 66                    | 6                         | 72           |
| Supplier/Printer     | 46                    | 2                         | 48           |
| <b>Total</b>         | <b>3,591</b>          | <b>1,896</b>              | <b>5,487</b> |



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**Table USA-2: Issued Inspection Orders by Infraction Type for the period 2013/2014.**

| Infraction Type                                       | No. Of Inspection Orders issued |
|-------------------------------------------------------|---------------------------------|
| Other                                                 | 7,610                           |
| Manufacturer not registered in Ontario                | 4,714                           |
| No Provincial Label                                   | 3,436                           |
| Non-Approved label format                             | 1,448                           |
| No contents declared                                  | 1,045                           |
| Expired Registration                                  | 291                             |
| Location of Label                                     | 255                             |
| Incorrect content declaration                         | 231                             |
| Country of origin conflicts with registration address | 94                              |
| Non-Generic Name                                      | 65                              |
| Material of Label                                     | 21                              |
| Renovator not Registered in Ontario                   | 21                              |
| Storage of Filling Materials/Articles                 | 18                              |
| Unclean/Unsafe filling material                       | 9                               |
| Separation of Filling Materials                       | 6                               |
| Home Hobby Craft Operator not registered in Ontario   | 1                               |
| No Second-Hand Label                                  | 1                               |
| Label Not Securely Affixed                            | 1                               |
| <b>Total</b>                                          | <b>19,267</b>                   |



## References

- [1] Technical Standards and Safety Authority. Technical Standards and Safety Act, 2000. Retrieved on July 29, 2014 from [http://www.e-laws.gov.on.ca/html/statutes/english/elaws\\_statutes\\_00t16\\_e.htm](http://www.e-laws.gov.on.ca/html/statutes/english/elaws_statutes_00t16_e.htm)
- [2] Jørn Vatn. "A discussion of the acceptable risk problem." *Reliability Engineering & System Safety* 61 (1998): 11-19.
- [3] Terje Aven, "Reliability & Risk Analysis." North Holland, 1992.
- [4] Arun Veeramany and Srikanth Mangalam. "Application of disability-adjusted life years to predict the burden of injuries and fatalities due to public exposure to engineering technologies." *Population Health Metrics* 12 (2014): 1-9.
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- [6] Srikanth Mangalam, Lency Abraham Mulamootil, Arun Veeramany, David Witt, and Rene Karavas. "System and method for inspecting and assessing risk of mechanical equipment and facilities." U.S. Patent No. 13/894,812, May 15, 2013.
- [7] Technical Standards and Safety Authority (2013). "Above Ground Storage Tanks: A Risk Assessment Study," Toronto, ON.
- [8] Technical Standards and Safety Authority. FS-202-12. Amendment to the Fuel Oil Code Adoption Document – Double wall tanks, double bottom tanks and spill containment. Retrieved on July 29, 2014 from <http://www.tssa.org/regulated/fuels/fuelsLegislation.aspx?loc3=act>



## Appendix A – User Behaviour Research and Public Education

### TSSA's User Behaviour Strategy

Early in its administration of its delegated responsibilities, TSSA, as an outcome-based organization, identified human behaviour as the dominant root cause of incidents in four key sectors: amusement devices, fuels, ski lifts and elevators/escalators. While not mandated to do so, TSSA, essentially since its inception, developed a series of tailored public education/engagement initiatives for these four sectors. Over time, the initiatives and tactics have been modified as new insights and information became available.

In the early stages of public education/engagement initiatives, performance was measured using activity-driven metrics. While refinements continued to improve and enhance TSSA's public education/engagement initiatives, it became evident that achieving additional reduced health impacts would require an informed approach. As a result, TSSA adopted a multi-pronged public education/user behaviour strategy. In 2010, the organization, as part of its strategic planning process, identified that further advances in modifying public/user safety behaviour would be among the key prerequisites for achieving its re-stated corporate vision - *to be a valued advocate and recognized authority in public safety*.

### Multi-pronged Strategy

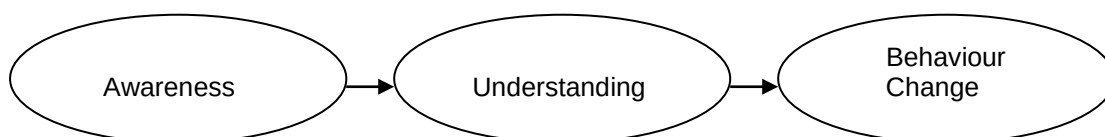
Recognizing the strategic importance of modifying public/user safety behaviour, TSSA uses a multi-dimension public education/user behaviour approach with three key objectives:

- continue to deliver existing public education/engagement initiatives;
- enhance existing initiatives based on sound research (qualitative and quantitative), input from other players in the safety system (i.e. owners/operations, other safety regulators, etc.), and incorporating insights gained through the assessment/evaluation of ongoing programs (i.e. performance measurement); and
- design and implement foundational user behaviour research focused on developing a comprehensive understanding of the 'how' and 'why' Ontarians make decisions that put them at risk, particularly within the sectors TSSA regulates.

This approach has ensured that TSSA continues to deliver public education programs in tandem with developing a more fundamental understanding of how to more effectively assist the public in managing its safety risk responsibilities. The approach is perhaps best summarized as a parallel strategy incorporating pure and applied research, using the results from both to better define further research plans, as well as ongoing delivery of public engagement and education initiatives.

To illustrate, "pure" research, regarding risk perception and risk communication that influences the users across all four sectors, provides insights that apply generally, regardless of the specific activities in which the public engages. The "applied" research addresses the need to tailor public engagement initiatives to address unique characteristics; for example, differing key audiences, and position on the behaviour change continuum (see Figure 1), associated with each of the four sectors. By developing and conducting these research strategies at the same time, the results and insights gained from each will serve to inform the other.

**Figure 1: The Behaviour Change Continuum.**





As a result, TSSA's behavioural modification strategy has two interrelated components – research and ongoing delivery of public education/engagement initiatives. Naturally, there is a strong interrelationship among these two as each serves to inform the other.

The basic premise underlying the strategy is what can be described as the behaviour change continuum. Research and field experience has provided strong evidence that changing public safety behaviours is essentially a sequential three-step process. One of the key elements in achieving the desired outcome is to first identify where the public rests on this change continuum. This is important as the strategies for engaging key audiences will be very much shaped according to their location on the change continuum. Along with this “mapping process”, it is important to define, to the extent possible, the risk profile(s) of the target audience. TSSA has, over a number of years, been working in parallel on these two critical success factors and has been applying the knowledge gained to better inform continuing research, as well as to refine and/or redesign its public safety engagement initiatives.

As a result, TSSA developed and applies metrics that indicate if key audiences are moving along the behaviour change continuum; this provides confidence that the ultimate metric – improved health outcomes – can be achieved. For example, through increasing awareness and enhancing understanding, the probability that people will alter their behaviour is much higher.

Reflecting the progress achieved, TSSA's overall approach to user behaviour and its role in mitigating safety risks focuses on three interrelated steps that reflect fundamental elements of behavioural change. The three steps are:

1. **Research and Development** – this step involves gaining key insights regarding current risk perception, communication and decision-making particularly among high risk audiences. This understanding is essential to developing and testing effective engagement strategies (i.e. messaging, delivery tactics, and assessment tools). Based on the enhanced awareness and understanding of the target groups, strategies can then be developed and pilot tested in the field, which in turn provide critical feedback to inform refined public engagement strategies.
2. **Execution** – as the pilot strategies mature and results become more consistent, larger scale execution of the initiatives are conducted. The larger scale implementation allows for further refinements that increase efficiencies and the effectiveness of the strategies.
3. **Leveraging/Partnerships** – TSSA's strategic approach to user behaviour continues to be based on the premise that achieving enhanced safety outcome is a shared responsibility. As strategies mature through the step process, the focus becomes more concentrated on leveraging TSSA success through the participation/partnership of key stakeholders.

At present, TSSA public awareness and user behaviour initiatives span all three steps outlined above. Several of the carbon monoxide initiatives are at a stage where there is an increasing focus on leveraging/partnership while elevators/escalators efforts focus more on research and development. Ski lift and amusement devices public education initiatives are mostly at the execution and partnership steps. It is important to note that while the degree of ongoing research and testing declines, as progress is achieved in applying the results, there continues to be a limited investment across the more mature sectors, reflecting the changing environment surrounding public perceptions and decisions regarding risks associated with TSSA's regulated sectors. In fact, all four sectors where user behaviour is the dominant root cause have individual initiatives at all three steps in the process.

## **Fuel Safety**

TSSA regulates the transportation, storage, handling and use of fuels as to ensure conformance with the Act and its applicable regulations, codes and standards. These fuels include natural gas, propane, butane, hydrogen, digester gas, landfill gas, fuel oil, gasoline and diesel. TSSA licenses fuel facilities, registers contractors and certifies tradespersons who install and service equipment. Additionally, TSSA reviews and approves facility plans for sites licensed by TSSA, and performs custom equipment approvals and inspection services to ensure fuel is handled and used safely. The three stages of the fuels lifecycle that fall under TSSA's jurisdiction are:



- transmission, distribution and transportation;
- storage and dispensing; and
- utilization (burning).

The utilization of fuels continues to account for the vast majority of fuel related incidents. It is important to note that this aspect of the fuels lifecycle is also the one where users or the public are most involved as they use fuels for a wide variety of activities, including for example: residential heating, food preparation, water heaters and recreational activities. Further analysis of the data indicates that carbon monoxide (CO) incidents make up the largest proportion of these utilization incidents and identifies non-compliance with regulations as the most prevalent root cause. Specifically, owners of fuel-burning appliances, including the public, are failing to ensure that certified technicians complete proper maintenance of the appliance in accordance with manufacturer's specifications. This responsibility is clearly stated in the applicable provincial fuel regulations. However, TSSA has no legal authority to enter and inspect private dwellings, since Section 17 of the Act specifically prohibits TSSA from entering without warrant or consent. As a result, TSSA must rely on alternate initiatives, such as public education to address this safety risk. In Ontario, the vast majority (over 80% over the past seven years) of all CO incidents occur in private dwellings.

Consistent with its proactive, preventative strategy philosophy, TSSA's approach focuses first and foremost on changing the public's behaviour with respect to how they use and maintain fuel-burning appliances with a particular emphasis on those in private residential dwellings. Adopting the appropriate behaviours would address the hazard by preventing it at the source – in the home where most incidents occur. Based on comprehensive research and field experience, TSSA has a number of CO engagement strategies that have demonstrated success in terms of increased public awareness, understanding regarding the risks this hazard presents, as well as action they can take to mitigate those risks.

### **Carbon Monoxide Public Engagement Initiatives and Results – 2013-2014**

1. Seasonal Safety Direct Mail – three major direct mail campaigns were delivered reaching almost 1.9 million households in 104 communities across Ontario. Assessments of the campaigns found that on average 13.5% of individuals recalled receiving the booklets (note - recall rates of approximately 2-2.5% are the generally accepted marketing industry standard for successful direct mail initiatives) and greater than 50% read all or a portion of the booklet. Over 50% felt more informed after reading the materials, and more than 30% were now more likely to take additional actions to address the CO hazard in their home (approximately 65% purchasing and installing CO alarm(s) and 25% obtaining an inspection by certified fuels technicians).
2. Carbon Monoxide Community Blitz Campaigns – seven multi-dimensional campaigns (a series of four different public information elements delivered over a 12-14 day period) were delivered to over 870,000 households in 347 communities across Ontario. Assessments of the campaigns found that average recall rates were between 25-35%, of which over one-third of those reading the materials felt more informed after receiving the materials. Approximately 15% were now more likely to take additional actions to address CO risks in their home. Similar to the Seasonal Safety Direct Mail campaigns, approximately 65% indicated that they would be purchasing and installing CO alarm(s), and 25% obtaining an inspection by certified fuels technicians. Finally, individuals that recall the campaign materials indicated an increase in the probability that a CO incident might occur in their home. While all the results are important, the final one – sense of probability – is perhaps most important as TSSA's research has consistently identified that homeowners and tenants greatly underestimate the probability and number of CO incidents that occur, leading them to greatly underestimate the risk.
3. Carbon Monoxide Safety Kits – two campaigns were delivered reaching almost 42,000 households in two communities. Assessment of the campaign found that on average over 40% recall receiving the kits and 40% felt more informed. Similar to the blitz strategy over 15% are more likely to take additional actions to address CO risks in their home, of which 65% would buy and install CO alarm(s) and 20% obtain an inspection by a certified fuels technician.



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In addition to the ongoing CO research and execution of proven public engagement initiatives, TSSA also engaged other stakeholders to leverage TSSA's efforts. This approach proved successful with a number of stakeholders, including Enbridge Gas who provided additional funding for the winter seasonal safety direct mail campaign. Their participation increased the overall reach of the campaign by approximately 110,000 households. Kitchener Utilities has continued to adopt and use TSSA's proven creative approach including its messaging, replacing what they used previously based on TSSA performance results, in two of their CO campaigns: bill inserts to their 95,000+ customers and full-page advertisements in the Kitchener Record (daily newspaper serving the Kitchener/Waterloo/Cambridge region). Direct Energy has also adopted a number of TSSA's preventative messages in a number of their customer communication programs, including "Dave's Corner", a customer-focused strategy using digital and more traditional media. Finally, TSSA has continued to leverage its long-standing partnership with the Ontario Office of the Fire Marshal and the Fire Marshal's Public Fire Safety Council. Through these partnerships, fire services departments across the province are using TSSA's seasonal safety booklets and increasing its other CO safety materials in their public education initiatives across the province. Through this partnership, firefighters are delivering over 500,000 CO safety information pieces directly to homeowners and tenants across the province. Finally, TSSA continues to leverage its partnership with the Liquor Control Board of Ontario (LCBO) providing copies of its seasonal safety brochures to LCBO stores across the province.

### 2014-2015 Planned Initiatives

TSSA will continue to execute a number of CO initiatives in 2014/2015 building on and incorporating insights gained from its research and field experience. Building on the success of its partnership and leveraging efforts over the past year, TSSA will continue to engage other key stakeholders (i.e. fuel suppliers, service providers, manufacturers, government and others) to either enhance existing relationships or establish new ones. With a series of proven public engagement strategies, TSSA is now well positioned to increase the impact of its efforts to further address CO public risks. TSSA is also continuing to explore additional engagement strategies with the high-risk audiences. Behavioural research and engagement experience has clearly identified that a key misconception held by the public relates to the probability of a CO incident. As such, behavioural research will be focused on modifying these perceptions as they directly influence the public's view of the magnitude of CO risk: in simple terms, the public believes there is a virtual zero probability that a CO incident will occur in their home and therefore deems CO as a very low to non-existent risk. While current engagement and messaging has made inroads in modifying the probability perception, additional insights are required to further influence the public's basic CO risk perception, since this is a key precursor to modifying CO safety behaviours.

### Ski Lifts

TSSA Passenger Ropeways (Ski Lifts) Safety Program regulates chair lifts, bar lifts, outdoor recreational conveyors, rope tows and tube tows to ensure all devices conform to the Act and applicable regulations codes and standards. TSSA reviews designs and registers lift designs, licenses lift devices, conducts inspections, performs incident investigations, and delivers public awareness campaigns to address user behaviour, as it constitutes the dominant root cause of all incidents on ski lifts in Ontario.

As indicated, the vast majority of ski incidents continue to be related to user behaviour and further analysis has identified that new or beginner skiers and snow boarders are the most at risk group. As reported in the 2013/2014 Annual State of Public Safety Report, 96% of the risks on ski lifts is related to user behaviour, especially during loading and unloading operations. As such, ski lift user engagement and education is a key risk mitigation strategy. TSSA has completed research focused on the higher risk users and tested engagement strategies to refine its on-site public awareness/education initiatives.

### Ski Lift Public Engagement Initiatives and Results – 2013-2014

1. On-Site Public Education – the most successful time and/or place to engage and influence behavioural decisions is immediately before such decisions or actions are taken. Therefore, TSSA has concentrated its engagement strategies on-site to deliver safety messaging as skiers and snow boarders are using the lift devices. *RideSmart Safety* teams engage riders particularly at lifts that are used by new and beginner



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skiers/snow boarders. The focus of the messaging is *Look, Load and Lower* – specifically look back for the lift, load promptly and safely, and then lower the safety bar. Incident reports clearly demonstrate that not properly executing these three actions are the dominant cause of incidents during loading. Similarly, at the top of the lift, the messaging focuses on the most common errors namely *Lift, Stand and Leave*. Users are reminded to lift the safety bar when instructed (usually by prominent signage), stand and prepare to leave the lift, and then quickly move out of the landing area. By condensing the messaging into two groups of three clear actions, the *RideSmart Teams* can deliver those messages in an effective and efficient manner. By using observational assessment methods and with feedback from site operators, this approach has consistently achieved increases in proper lift behaviour. During the most recent 2014 ski lift initiative, safety messages were delivered to almost 40,000 new and beginner skiers/snow boarders at 13 different snow resorts. On average, the engagement program improved safety behaviours by between five to ten percent and those that were engaged were more likely to correctly load and unload during their use of the ski lift device.

2. Canadian Ski Instructors' Alliance (CSIA) – Recognizing that a large majority of new and beginner skiers/snow boarders take lessons from on-site ski schools, TSSA established and continues to maintain a partnership with CSIA to facilitate opportunities to reach the high risk groups. Over the past three years, the on-site program has incorporated TSSA's *RideSmart Team* into ski school sessions that allows them to deliver and enhance the instructor's ski lift safety messages. This has proven very successful in terms of focusing TSSA's efforts on its high risk audience and has increased the reach of the program using the same resources. For example, in 2014 TSSA was able to increase its reach by 8% (approximately 4,000 additional engagements) using the same resources as were allocated in 2013. In addition, the partnership has increased the ski instructor's focus on ski lift safety and more fully incorporate TSSA's messaging into their programs. Building on this strong partnership, TSSA worked with the CSIA to produce a training video that focuses on TSSA's ski lift safety program. The video is now a part of the CSIA training program and, as such, is part of a process that is required for accreditation as a ski/snow board instructor.

### 2014-2015 Planned Initiatives

TSSA will continue its work with snow resort owners/operators to further enhance the efficiency of its on-site engagement initiatives. Based on feedback from operators and incident data, additional attention to unloading issues offers opportunities to further enhance user behaviour. To assist, TSSA increased its observational data collection at the top of the lifts and is working with industry to explore options for tailoring engagement strategies. TSSA is also continuing with its strong and effective relationship with CSIA and will explore other options to leverage the *Look/Load/Lower Lift/Stand/Leave* messaging through their members and associated on-site ski schools.

### Elevators/Escalators

TSSA's Elevating Devices (ED) Safety Program regulates elevating devices in Ontario as to ensure all devices conform to the Act and applicable regulations, codes and standards. TSSA reviews and registers elevating devices, issues licences, conducts inspections, performs incident investigations and delivers public awareness programs as user behaviour continues to be the dominant root cause of incidents related to these devices.

As indicated, the vast majority of elevating device incidents continue to be related to user behaviour and further analysis has identified that older and younger users are at a higher risk of being involved in such incidents. As reported in the 2013/2014 Annual State of Public Safety Report, 78% of the risks on elevators and over 97% risks on escalators are related to user behaviour. Further analysis indicates that the risk is increasing for elevators and again mostly related to user behaviour. User engagement and education are the key risk mitigation strategies to address these results. TSSA enhanced its research and engagement initiatives in 2013/2014 with a particular focus on elevators.

### Elevator/Escalator Public Engagement Initiatives and Results – 2013-2014

1. Commercial Properties – TSSA established and continues to maintain partnerships with three large commercial property management firms – Oxford, Brookfield and Cadillac-Fairview. The focus on the



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partnerships is to provide safety messaging in their commercial properties (i.e. office towers, retail malls, etc.). Such signage reaches millions of elevator and escalator riders throughout the year on a cyclical basis. As the messages are delivered adjacent to the devices, the probability of influencing safety behaviour immediately when riders are using elevators/escalators is enhanced.

2. Toronto Transit Commission (TTC) – TSSA has had a long-term partnership with the TTC – *Move with the Grooves* campaign – focused on escalator safety behaviours. The program materials (in-station and in-car posters) continue to be used by the TTC in a cyclical fashion.
3. Association of Day Care Operators of Ontario (ADCO) – Recognizing that younger riders (escalators and elevators) are among the higher risk groups, TSSA established and has maintained a multi-year partnership with ADCO to reach out to this key audience. ADCO has over 450 members across Ontario and has endorsed TSSA's escalator activity sheets for use in their member's locations. Over 30,000 escalator activity sheets have been distributed to ADCO members on an annual basis for the past three years. Very positive feedback has been received from the Association as well as individual members. Their continued desire to extend the partnership demonstrates a strong commitment to working with TSSA to deliver fun and important age-appropriate safety messages to day care attendees.

Leveraging the ADCO endorsement, TSSA has expanded the day-care program to include an additional 3,000 registered day care operators. The endorsement of ADCO provides critically important credibility for TSSA's safety initiatives. ADCO and other operators are extremely sensitive to who and what materials are used in their facilities. The ADCO partnership helps to ensure that an additional 22,000 activity sheets were positively received by non-member day care operators.

4. School Program – In addition to leveraging the ADCO endorsement with non-ADCO members, TSSA has incorporated this successful relationship with Ontario elementary schools. Activity packages were sent to over 5,000 school principals across Ontario encouraging their use in the JK-Grade 1 classes. The combination of TSSA's not-for-profit status and, equally important, the longer-term partnership with ADCO greatly assisted in addressing the concerns teachers and principals have regarding external classroom materials. The program was initiated in 2012/2013 and has resulted in a series of request from educators for additional copies of the materials. This clearly indicates that the approach offers many additional opportunities for all of TSSA public education programs.
5. Older Adults Centre's Association of Ontario (OACAO) – As older adults constitute another high risk group, TSSA has been exploring avenues to reach this audience with key safety messages. Safety posters were sent to over 150 Seniors Centers in cooperation with the OACAO.
6. Chirp (Owl Kids) and ChickaDEE – These two print magazines are specifically targeted to younger audiences that include several of TSSA's high risk groups. The publications have a long and successful history of providing educational and entertaining articles, activities and other engaging materials. In 2013/2014, TSSA placed both its existing escalator safety activity sheet and the new elevator activity sheet in both magazines. The creative approach for TSSA's materials is very much aligned with the publications' tone and look. These placements reached almost 1.2 million readers, most if not all, of which are specifically in TSSA's high risk user groups.

### 2014-2015 Planned Initiatives

Recognizing the increasing trend in elevator risks, research efforts focused on defining the risk perceptions of high risk groups were completed in 2013/2014. This is a critical first step, identical to the approach used with CO, to enhancing TSSA's knowledge of riders' risk perception and how that influences their behaviour while using the devices. This research along with messages and engagement testing will be the focus of the ED behavioural research initiative for 2014/2015. The initial qualitative research had indicated a notable difference in user risk perceptions of different devices and their general attitude in accepting a role in managing those risks. For example, the initial findings indicate that users are more likely to identify that they may have a role in terms of managing escalators when compared to elevators. This important risk differentiator will again be explored in the



current year as it clearly has significant potential for safety messages and their delivery. Finally, recognizing that TSSA's incident data and risk assessments have identified four key elevator device locations (rental, condominiums, office towers and institutions - hospitals, learning institutions, and retail) that involve higher risk users, the research will focus on rider behaviour in these environments.

In addition to its research and development initiatives, TSSA will explore opportunities to further enhance its existing public engagement programs including:

- Working with building management partners to enhance on-site delivery of elevator/escalator safety messages;
- Explore with the TTC, opportunities to evolve the *Move with the Grooves* campaign to include elevator safety messaging;
- Building on the success of the escalator activity sheet initiatives, introduce an elevator version and distribute through existing channels (i.e. day-cares and schools); and
- Piloting residential-based public engagement strategy.

### **Amusement Devices**

TSSA's Amusement Device Safety (AD) program regulates amusement rides in Ontario as to ensure all amusement devices conform to the Act and applicable regulations, codes and standards. TSSA reviews and registers rides, issues permits for each ride in the current operating season, licenses operators, conducts inspections and incident investigations, and delivers public awareness campaigns throughout the province.

Amusement devices under TSSA's jurisdiction include roller coasters, Ferris wheels, merry-go-rounds (and other circular motion rides), water slides, flume rides, dry slides, go-karts, bumper cars, inflatables (inflatable bouncers), bungee devices, bungee-assisted bounces, zip lines (track and cable rides) and other generic spinning and whirling rides.

Over 90% of the estimated risk on amusement devices is related to user behaviour. Water slides account for approximately 40% of all amusement device occurrences and are related to approximately 60% of all health impacts. To assist in mitigating these risks, TSSA continues its multi-year public engagement strategies focusing on water slides users and specifically the most at risk users – 10-14 year old riders. Based on enhanced positive results over the past two years, TSSA continues to refine and deliver its positive behaviour reward campaigns at a number of major water parks across Ontario. Based on on-site observational data, this approach achieves positive behavioural change with 10-20% improvements. Building on the success of TSSA's on-site public education strategies, a new initiative, the Safety Ambassador program, was piloted at two water parks. This initiative involves incorporating TSSA engagement strategy into training for water park staff. The goal is to equip park staff with additional engagement techniques that will assist them in delivering positive safety messaging to slide users at their locations.

### **Water Park Public Engagement Initiatives and Results – 2013-2014**

1. On-Site Public Engagement Campaign – In 2013, TSSA's public safety teams conducted on-site campaigns at five major parks over 79 days and completed just over 82,000 interactions with the most at-risk device users. This represents a 25% increase over the 2012 campaign. Observational data demonstrated that users who interacted with TSSA's safety teams were significantly less likely to engage in improper safety behaviours. Improved safety behaviour, as compared to users who did not engage with the safety teams, was observed across the five most common behaviour errors: sliding head first, sitting up, arms/legs outside of slide, running on facility decks, and not clearing splash area. The 2013 results are consistent with those observed in 2011 and 2012. Based on enhanced engagement with water park operators, the on-site refinements, such as altering the timing and location of safety team activities, were incorporated into the 2013 execution strategy. These refinements assist in extending the reach and effectiveness of the on-site program.
2. Safety Ambassador Pilot – Over the past three years TSSA has, based on qualitative and quantitative research as well as on-site experience, evolved its engagement strategy to specifically focus on positive reinforcement of proper safety behaviours. Observational data supports the effectiveness of this approach in



terms of positively influencing user behaviour associated with water slides. While TSSA's efforts are effective, it is also recognized that additional user engagement offers opportunities to further mitigate the public risks associated with the use of these devices. Recognizing that the water park staff engage users constantly through the operating season, TSSA developed an initiative, the Safety Ambassador program, to provide park staff with another engagement tool to use with their visitors/customers. In 2013, TSSA developed a pilot program to assess the Safety Ambassador concept. Two water park operators participated in the pilot. The key findings, collected through ongoing discussion with park staff and management, included:

- Park staff recognized the value of positive reinforcement messaging as another engagement tool.
- Park staff, consistent with the results associated with TSSA's on-site campaigns, observed a positive change among water park users when positive reinforcement messaging was employed.
- Park staff themselves found that incorporating the TSSA engagement approach was positive in terms of their work experience.

TSSA and the pilot participants collectively concluded that the pilot was successful and offered an effective enhancement to TSSA's on-site public education strategies. The learning from the pilot will serve to refine the Safety Ambassador program for the 2014 season.

### **2014-2015 Planned Initiatives**

TSSA will continue to execute its on-site programs at major water parks and, to the extent possible considering resources available, will seek opportunities to expand this program. As with previous years, the on-site programs continue to be refined in consultation with industry partners to reflect the individual characteristics and operating practices at each location. TSSA will also pursue, again in consultation with the water park operators, further refinements to its Safety Ambassador program and seek additional industry participants. TSSA is also continuing to explore other engagement opportunities, specifically related to the most at-risk group (10-14 year old users), as it recognizes that a multi-dimensional strategy using a variety of platforms offers additional means to reduce public safety risks associated with user behaviour at water parks.



## Appendix B – Statistical Methods

The statistical analysis of the time-series of data in this report includes:

- graphical data analysis;
- construction of prediction intervals; and
- trend tests.

Time-series plots are used to present the data graphically, which provide insight into the data for the analysts and readership.

A prediction interval is an estimate of an interval into which a new observation will fall, with a certain probability, given what has already been observed. In this report, the prediction interval covers between the 5 and 95 percentiles of the measured data. Observations for those indicators lying outside the prediction intervals are made with a 95% confidence level. Prediction intervals allow indicators to be checked on a quarterly basis, verifying if they fit the behaviour of historical observations.

Trend tests allow for statistical hypotheses testing. This has two advantages over graphical data analysis:

- it ensures that every analyst of a data-set using the same methods will arrive at the same result; and
- it presents a measure of the strength of the evidence (the p-value).

The Mann-Kendall test is a non-parametric trend test, and does not require any assumption of normality or canonical distributions in the data. This test is robust and allows missing data to be present in the analysis. There are many instances where seasonality is the source of variation in the response variable. This report uses Kruskal-Wallis statistics for testing seasonality in the time series. These statistical tests on the data are done using the Minitab 16® software. The assertions of any of these tests are made with 95% confidence. If evidence is found for seasonality, then the Seasonal Mann-Kendall trend test is used instead of the Mann-Kendall test.

While the trend tests are performed on the quarterly data, this data is aggregated into median annual data for plotting purposes. As such, it may be the case that a trend is reported as statistically significant, but is not obvious to the reader from the plot of the data and vice-versa.



## Appendix C – Risk of Injury or Fatality Metric

### Disability-Adjusted Life-Year (DALY)

The Risk of Injury or Fatality metric is determined using Disability-Adjusted Life-Years (DALY) metric. The DALY metric is a universal health impact metric, introduced by the World Health Organization as a single measure to quantify the burden of diseases and injuries. The DALY can be thought of as equivalent years of “healthy” life lost by virtue of being in states of poor health or disability and/or due to premature fatality.

*A DALY of 1.0 is the loss of one year of healthy life of a single person due to an injury. For example, a DALY of 28.1 means that 28.1 years of useful life were lost for that year due to injuries arising from all the sectors that TSSA regulates.*

The expected health impact for a fatality is calculated based on the standard life expectancy at age of death in years and is based on age and sex (e.g., fatality of a male child aged 5 would translate to 70 DALY assuming an average life expectancy of 75 years). The expected health impact for an injury is calculated by multiplying the average duration of the injury by a weight factor that reflects the severity of the injury on a scale from 0 (being in perfect health) to 1 (being dead).

Health loss is characterized by three dominant aspects of public health:

- quality of life;
- quantity of life; and
- social magnitude.

The quality of life is measured by duration of injury and life expectancy of a victim. The quantity of life lost is expressed through disability weights, and the social magnitude is characterized by the number of people affected.

The expected health impact in units of DALY can be calculated by the following equation:  
(Short-term Weight \* Short-term Duration) +  
(Fraction Long-term) \* (Long-term Weight \* Long-term Duration)

There are four injury types categorized in the TSSA database: i) fatality, ii) permanent injury, iii) non-permanent injury, and iv) no injury. The permanent and non-permanent injuries are further characterized by 28 specific types of injury descriptions. In the above equation, disability weights, fraction long-term and short-term durations, associated with the various injury descriptions, have been adopted and/or modified from the Australian Burden of Disease and Injury Study<sup>27</sup>. The long-term duration is the expected life expectancy at the time of injury and is applicable in the case of a permanent injury.

A hypothetical example is presented to better understand the evaluation of expected health impact. Assume a male victim sustains a spinal injury at the age of 30 years due to the malfunctioning of a regulated technology. Using the cohort life expectancy of 48.1 years for males aged 25 to 34, the equivalent healthy years lost due to the spinal injury can be calculated as 34.87 DALY by using the above equation. In this calculation, the short-term weight of 0.725 and duration of 0 years were used respectively and the fraction long-term and long-term duration parameters were taken to be 1 and 0.725 respectively.

### Injury Burden

The observed health impact is quantified based on each victim's age and injury type in denominations of DALY and is then scaled by the time period under study, the median life expectancy and the exposed population to determine the injury burden in units of fatality-equivalents per exposed population per year. Note that the scaling

<sup>27</sup>Begg S, Vos T, Barker B, Stevenson C, Stanley L and Lopez A: The burden of disease and injury in Australia 2003. Cat. No. PHE 82. Canberra: AIHW 2007.



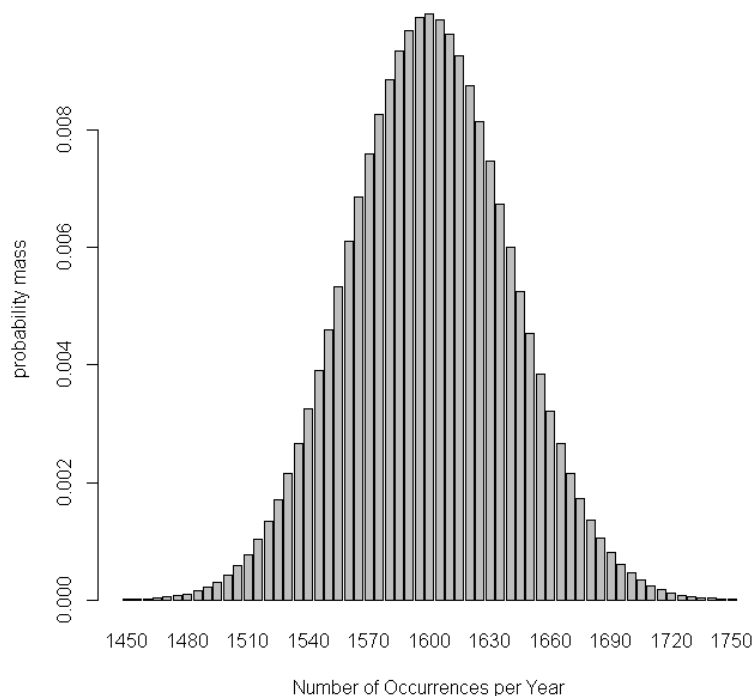
factors are dynamic and subject to change year-over-year or once every five years during a nation-wide census update.

### Risk of Injury or Fatality

The Risk of Injury or Fatality<sup>28</sup> approach determines predicted injury burden by accounting for historic occurrences while taking into consideration the uncertainties and variability inherent in the involved parameters and predicts the future state of safety in terms of fatality-equivalents per exposed population per year. The rationale behind this approach is that there is a potential for some of the occurrences without health impacts to manifest themselves as incidents with injuries and fatalities in the future. A simulation approach is used to conduct the predictions based on actual observations. The prediction model is exposed to parametric uncertainties and henceforth is dealt with by considering various inputs as probability distributions:

- (a) One major uncertainty is in the actual number of occurrences. This attribute is subject to reporting bias which means that an unknown fraction of incidents go unreported to TSSA. The randomness is assumed to follow a Poisson distribution with the observed occurrence rate as the input parameter.

**Figure C1: Probability mass distribution of the occurrence rate.**



The figure above illustrates the breadth of uncertainty in the occurrence rate when, for example, 1600 occurrences a year are observed on average.

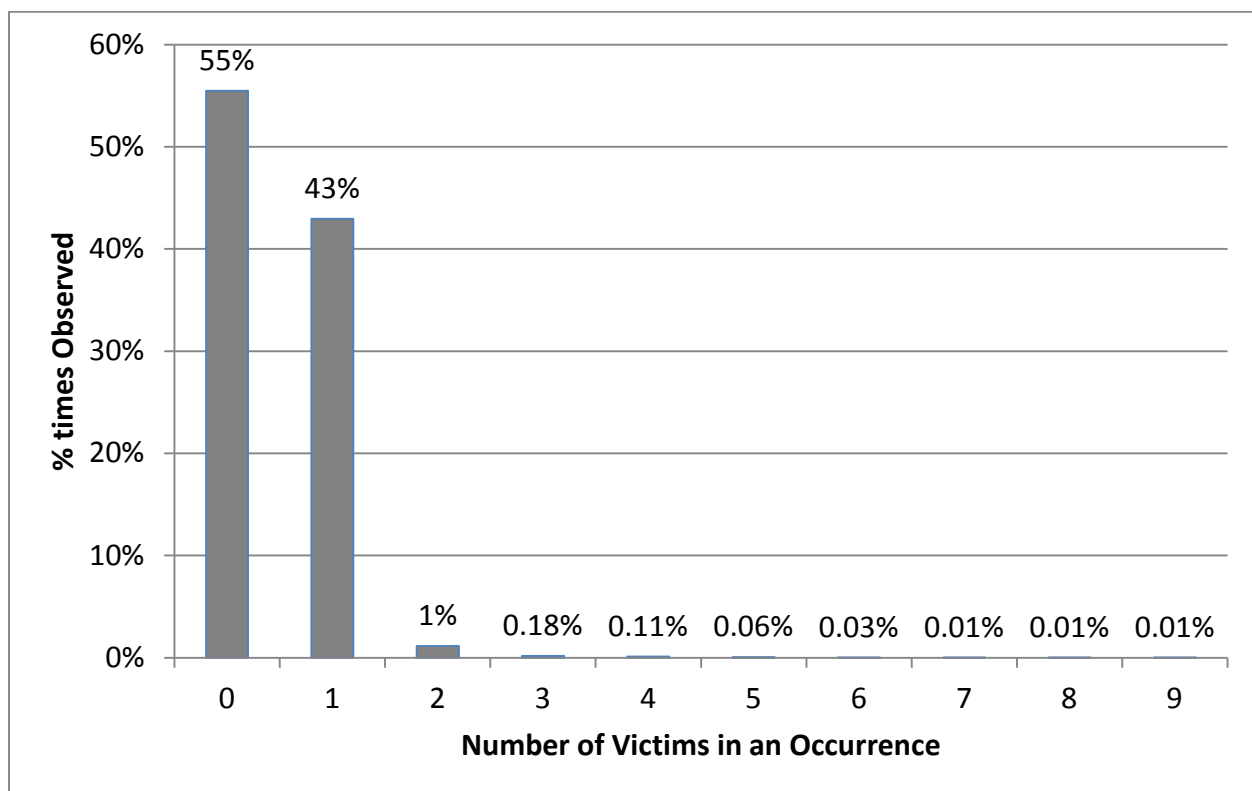
- (b) The number of victims involved in an occurrence is assumed to be a discrete probability distribution based on historic observations. In cases where there is adequate evidence, a categorical distribution is used. An example is the determination of the TSSA composite prediction.

<sup>28</sup> Veeramany, Arun, and Srikanth Mangalam. "Application of disability-adjusted life years to predict the burden of injuries and fatalities due to public exposure to engineering technologies." *Population health metrics* 12.1 (2014): 1-9.



The TSSA Composite Risk of Injury or Fatality assumes that the number of victims per occurrence follows a discrete empirical probability distribution constructed from historical observations instead of the prior (FY12-13) assumption that the number of occurrences is uniformly distributed between zero and the maximum number observed in the past. This scheme ensures that extreme tail events are assigned a minimal probability, instead of assuming that they are equally likely compared to the most representative estimate. In the case of granular drill-downs where there is inadequate evidence, the number of occurrences is assumed to be equally likely between zero and the 99.9th percentile of historically observed number of victims. This ensures that unexpected or misreported events occurring as extreme outliers with large impact, are excluded from the analysis.

**Figure C2: Frequency of the number of victims in an occurrence.**

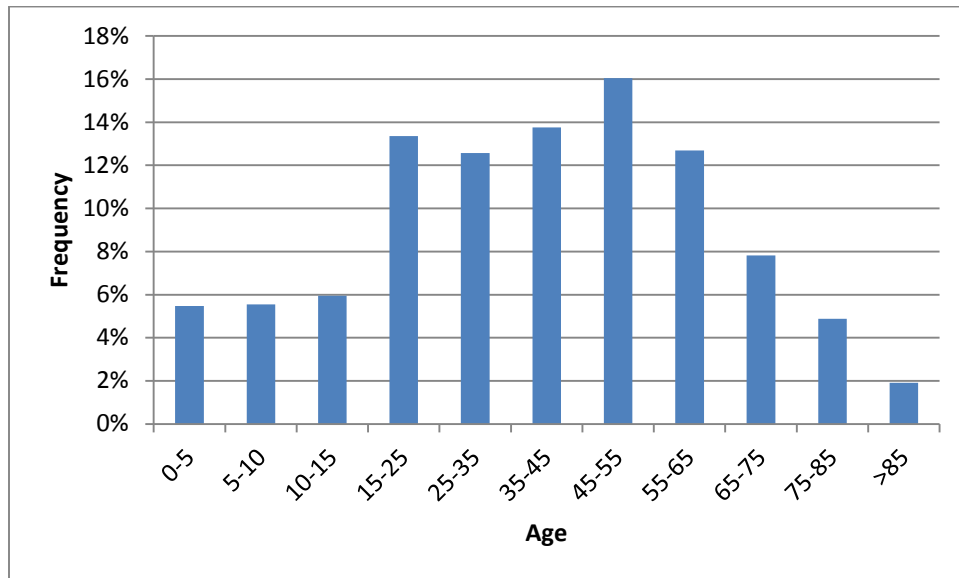


The above figure illustrates the victim count distribution for a typical composite TSSA State of Safety prediction. The example shows that there are no victims involved in 55% of the cases, one victim involved in 43% of the occurrences and as high as nine victims in less than 1% of the occurrences.

- (c) The age of a victim is also uncertain and the range is between that of being an infant and an elderly person. It is sampled from the most recent age-based population census estimates from Statistics Canada.



**Figure C3: Age distribution for predicted risk simulation.**

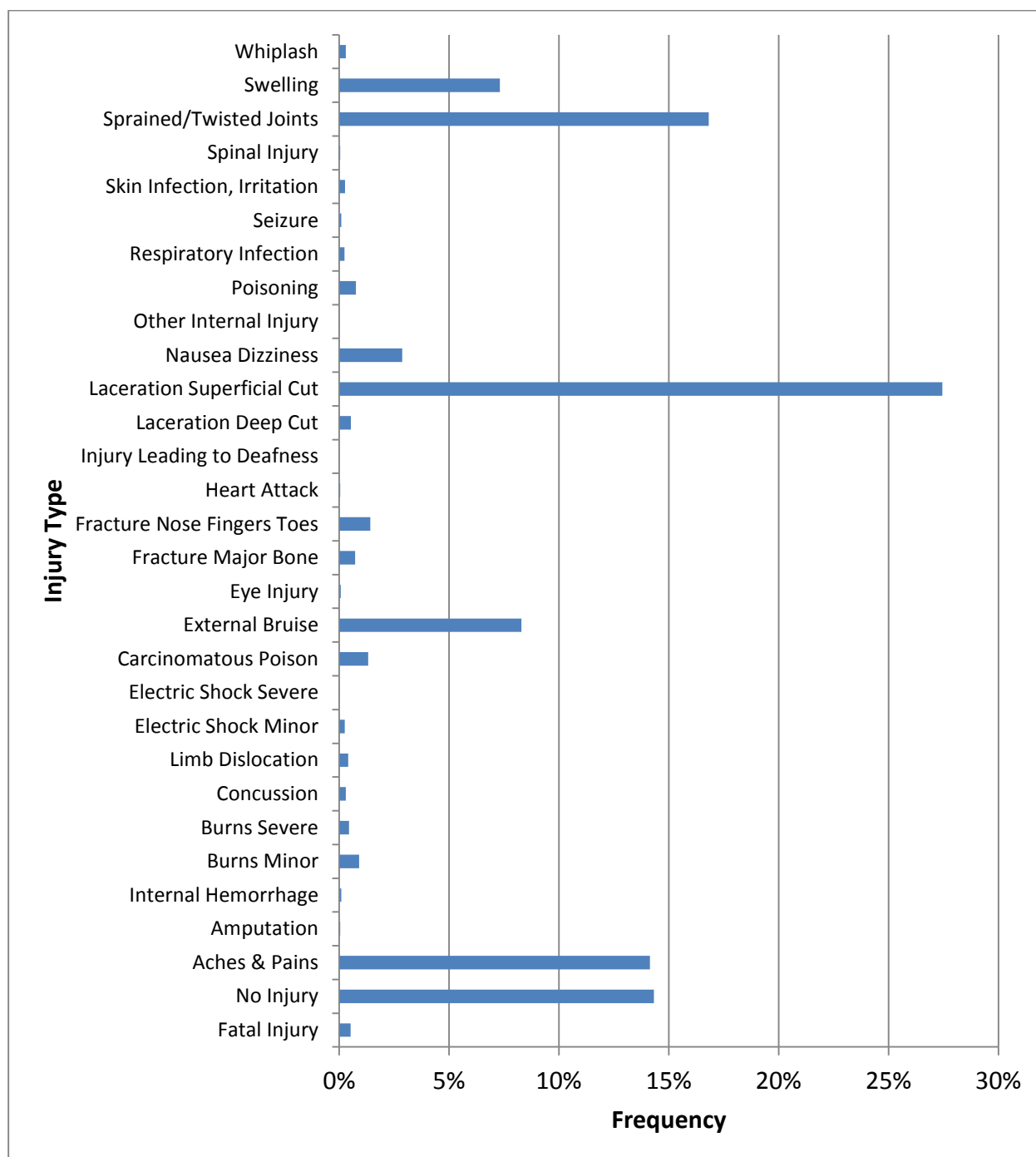


Ontarians aged 15-65 constitute about 70% of the population as seen in the above chart and are more likely to be victims of an occurrence than otherwise.

- (d) The number and type of injuries is sampled from a distribution constructed out of observations. This distribution is dependent on the program and the specific occurrence type under consideration.



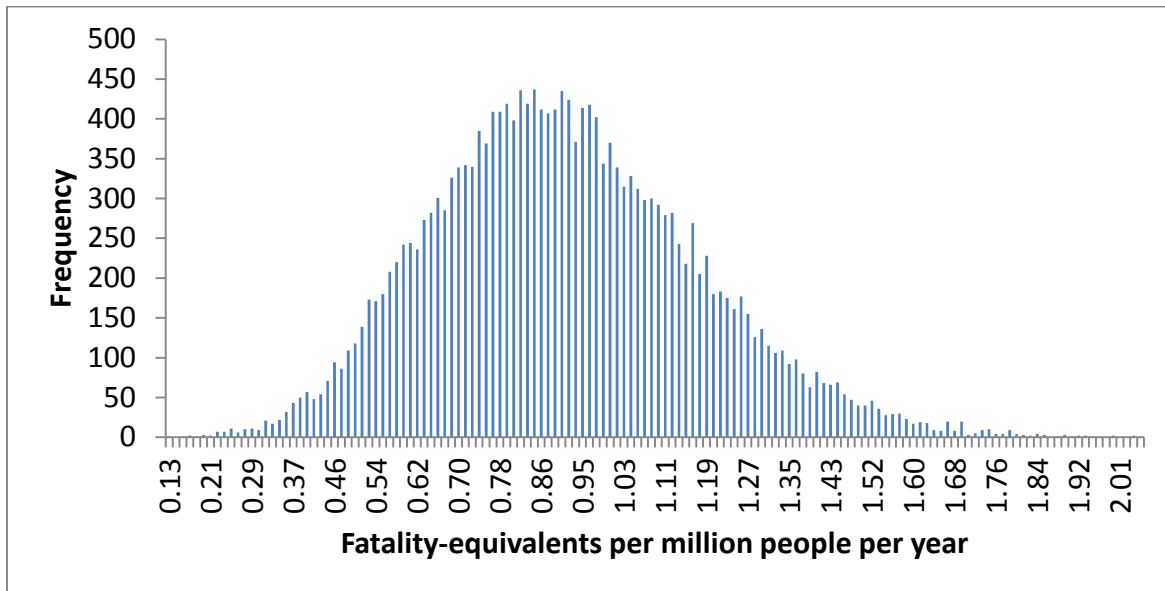
Figure C4: Injury distribution for the composite risk of injury or fatality.



An injured victim is likely to sustain superficial cuts, sprains, aches and pains or no injury at all more often than a fatal injury as seen in the above figure. The distribution is for illustrative purposes only and varies depending on the regulated sector under study.



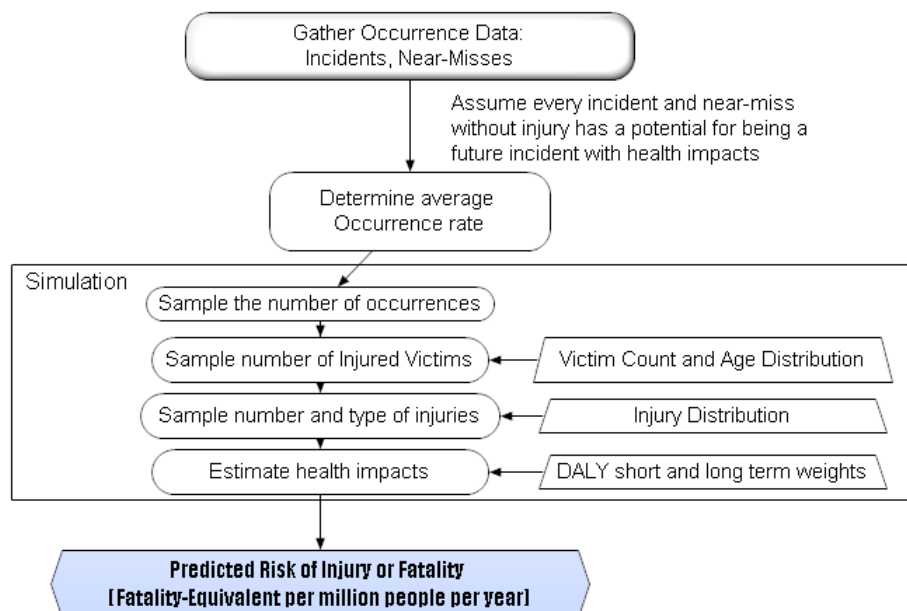
**Figure C5: Risk of injury or fatality distribution.**



The end result of a risk simulation is a frequency distribution of predicted health impacts as exemplified in the above figure. The mean value, fifth and 95th percentiles of the distribution are used for reporting purposes in the report. In the above figure, the respective estimates are 0.51, 0.91 and 1.37 fatality-equivalents/million/year. Note that the risk of injury or fatality is expected to be a few orders of magnitude larger than the corresponding observed risk. This is result of the model design to consider near-misses as potential incidents and to ensure that a larger set of uncertainties are incorporated into the model that are not exhaustively captured in the actual observations.

The procedure followed to determine the anticipated health impacts is shown in the flowchart below.

**Figure C6: Flowchart to predict future health impacts.**





## Appendix D – Causal Analysis Categories

There are three causal analysis categories into which occurrences with a root cause can be categorized. The description of each category and the associated mapping of root cause information are listed below. Occurrences that do not have an established root cause after inspection are contained in a fourth category, root cause not established.

### Inadequate Current Regulatory System

Occurrences in this causal category indicate potential areas in need of regulatory change or improvement. They are consistent with the regulatory gap and impact analysis currently used by the Ministry of Government and Consumer Services to effectively improve the regulatory system without imposing unnecessary additional regulatory burden.

**Table D-1: Causes contained in the Inadequate Current Regulatory System category.**

| Category          | Definition                                                                                                                       | Sub-Categories                                                                                                                               |
|-------------------|----------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Design</b>     | Factors related to the engineering outline and physical make-up of a device for its intended purpose.                            | <ul style="list-style-type: none"> <li>Defective or inadequate design.</li> <li>Defective/inadequate safety features, or devices.</li> </ul> |
| <b>Management</b> | Factors related to the levels of responsibility that are accountable for specific activities, programs and systems of operation. | <ul style="list-style-type: none"> <li>Gaps in the regulatory management system.</li> </ul>                                                  |

### Non-compliance with Regulatory System

Occurrences in this causal category most appropriately reflect TSSA's effectiveness in administering the safety system and obtaining compliance. They allow TSSA to allocate enforcement resources to areas of greatest risk.

**Table D-2: Causes contained in the Non-compliance with Regulatory System category.**

| Category                            | Definition                                                                                                                                                      | Sub-Categories                                                                                                                                                                                                                                                                                                                                             |
|-------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Design</b>                       | Factors related to the engineering outline and physical make-up of a device for its intended purpose.                                                           | <ul style="list-style-type: none"> <li>Inappropriate equipment or material selection.</li> <li>Inappropriate drawing, specification or data.</li> </ul>                                                                                                                                                                                                    |
| <b>Equipment/Material/Component</b> | Factors related to a device (machinery), the physical constituents of a device (material used or make-up) or a specific unit of an overall device of machinery. | <ul style="list-style-type: none"> <li>Defective, failed, or malfunctioning equipment.</li> <li>Defective or failed component including safety devices.</li> <li>Defective or failed material.</li> <li>Defective assembly.</li> <li>Electrical or instrument noise or malfunction.</li> <li>Contamination of material, component or equipment.</li> </ul> |



| Category                      | Definition                                                                                                                                         | Sub-Categories                                                                                                                                                                                                                                                                                                                                                                                                                            |
|-------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Human Factors</b>          | Factors related to actions or inactions of humans in the execution of activities in the operation of equipment or in the general work environment. | <ul style="list-style-type: none"> <li>• Inadequate or unsafe operating environment.</li> <li>• Failure to follow maintenance procedures.</li> <li>• Failure to follow operating procedures.</li> <li>• Failure to follow installation procedures.</li> <li>• Inappropriate plant operator attendance.</li> <li>• Incomplete or inadequate internal communication.</li> <li>• Incomplete or inadequate external communication.</li> </ul> |
| <b>Maintenance Procedures</b> | Factors related to repair and upkeep activities required for the preservation of a device during its useful lifecycle.                             | <ul style="list-style-type: none"> <li>• Defective or inadequate maintenance procedures.</li> <li>• Lack of maintenance procedures.</li> </ul>                                                                                                                                                                                                                                                                                            |
| <b>Management</b>             | Factors related to the levels of responsibility that are accountable for specific activities, programs and systems of operation.                   | <ul style="list-style-type: none"> <li>• Inadequate or defective management systems.</li> <li>• Lack of management systems.</li> <li>• Improper or negligent work practices.</li> </ul>                                                                                                                                                                                                                                                   |
| <b>Procedures</b>             | Factors related to guidelines that outline how specific activities should be executed.                                                             | <ul style="list-style-type: none"> <li>• Defective or inadequate operating procedures.</li> <li>• Lack of operating procedures.</li> <li>• Lack of or inadequate safety procedures.</li> <li>• Defective or inadequate installation procedures.</li> <li>• Lack of installation procedures.</li> </ul>                                                                                                                                    |
| <b>Training</b>               | Factors related to documented programs that prepare employees for the proper execution of specific work activities as required.                    | <ul style="list-style-type: none"> <li>• Lack of training programs.</li> <li>• Defective or inadequate training programs.</li> </ul>                                                                                                                                                                                                                                                                                                      |

### External Factors

Occurrences in this causal category indicate those outside the control or influence of TSSA. This category prevents misrepresentation of TSSA's performance with respect to compliance or the effectiveness of provincial regulations, and allows for the identification of other mitigation measures.

**Table D-3: Causes contained in the External Factors category.**

| Category               | Definition                                                                                                                                       | Sub-Categories                                                                                                                                                                                                                                                                   |
|------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>External Events</b> | Events representing occurrences beyond human control or TSSA regulatory control.                                                                 | <ul style="list-style-type: none"> <li>• Weather or other environment conditions.</li> <li>• Utilities disruption or failure.</li> <li>• External incidents.</li> <li>• Sabotage, terrorism, vandalism or theft.</li> <li>• Non-compliance with non-TSSA regulations.</li> </ul> |
| <b>User Behaviour</b>  | Refers to the use of regulated technology by a user in a manner that the TSSA cannot reasonably know or anticipate and may result in occurrence. | <ul style="list-style-type: none"> <li>• Special conditions.</li> <li>• Failure to follow user instructions.</li> <li>• Deliberate intent or sabotage.</li> </ul>                                                                                                                |