

**Report of the Auditor General
of the Ville de Montréal**
to the City Council and to the
Urban Agglomeration Council

For the Year Ended December 31, 2013

5.2

**Monitoring of
Municipal Building
Indoor Air Quality**

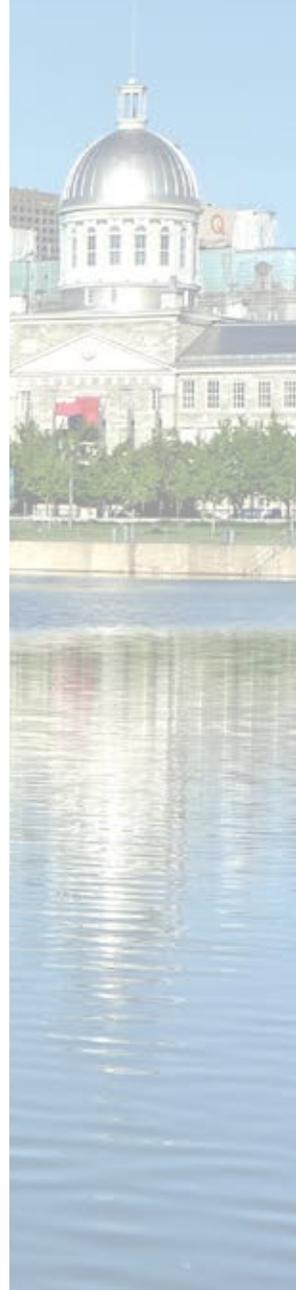


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List of Acronyms

ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers	PMP	preventive maintenance program
CSA	Canadian Standards Association	RBQ	Régie du bâtiment du Québec
DGTE	Division gestion des travaux d'entretien	SCARM	Service de concertation des arrondissements et des ressources matérielles
DI	Direction des immeubles	SIGI	Système intégré de gestion des immeubles
DSTI	Direction des stratégies et transactions immobilières	SIM	Service de sécurité incendie de Montréal
HVAC	heating, ventilation and air conditioning	SPVM	Service de police de la Ville de Montréal
IAQ	indoor air quality		

5.2. Monitoring of Municipal Building Indoor Air Quality

1. Introduction

Ville de Montréal (the city) owns a major building inventory (1,338 buildings¹); these buildings service both Montrealers and municipal employees. This inventory is comprised of buildings of several types such as sports and leisure centres, community centres, administrative offices, municipal workshops as well as police and fire stations. Thousands of citizens and city employees use these buildings on a daily basis.

When it comes to property management, maintaining good indoor air quality (IAQ) is an important concern, even an occupational health and safety issue. According to Health Canada, Canadians spend close to 90% of their time indoors, whether at home, at work or in leisure centres. Consequently, IAQ is a critical health factor and moreover figures among the objectives of the Politique de développement durable pour les édifices de la Ville de Montréal [TRANSLATION: Sustainable development policy for Ville de Montréal buildings] adopted by the executive committee on June 9, 2009.

The interaction between various risk factors (see Appendix 6.1) may have an impact on IAQ, among other things on the choice of construction materials, furniture and equipment, the number of occupants and hours spent in a building, occupants' activities as well as sources of external contamination. It may also have an impact on the preventive maintenance of various building components. Below are some of the common causes of indoor air pollution:

- Mismatched comfort parameters (e.g., excessively warm or cool temperatures, excessively high or low humidity rates, abnormal concentrations of carbon dioxide [CO₂]²);
- Presence of biological and chemical contaminants in the indoor air (e.g., chemical substances, dust, mildew or fungi, bacteria, gases, vapours, odours, material and equipment releasing high quantities of volatile organic compounds [VOCs]³ in the air);
- Poor maintenance (e.g., filters in poor condition) and/or inadequately functioning heating and ventilation systems resulting, for example, in an insufficient intake of fresh air or the infiltration of stale air.

¹ Source: Service de concertation des arrondissements et des ressources matérielles (SCARM) – Direction des stratégies et transactions immobilières (DSTI), inventory as at January 2014. Buildings owned by the city, excluding outdoor pools.

² This gas—which is naturally present in the atmosphere—is generated by human breathing. Outdoor air must be brought in to reduce the concentration of CO₂.

³ Volatile organic compounds can be released in the indoor air namely by building materials, janitorial supplies, furniture items, etc. Certain VOCs are toxic but only when they are present in high concentrations in the air.

Although IAQ is an important issue, our research as well as information obtained from the persons met reveal the absence of laws or regulations—whether in Québec or elsewhere in Canada—that deal specifically with IAQ in non-industrial settings such as residential, commercial and institutional buildings (including municipal buildings). However, various legislative sources on standardization set out responsibilities and obligations with respect to IAQ, including the following:

- The *Regulation respecting safety in public buildings*,⁴ enacted under the *Public Buildings Safety Act*,⁵
- The *Regulation respecting occupational health and safety*⁶ enacted under the *Act respecting occupational health and safety*,⁷
- The *Public Health Act*,⁸
- The *Safety Code*⁹ enacted under the *Building Act*,¹⁰
- The *National Building Code (NBC) – Canada 2010* (amended).

For its part, the city adopted the *Building Regulations*¹¹ which stipulate that the aforementioned *National Building Code – Canada 2010* applies to the city along with the amendments (additions) which specify building design and construction requirements and ventilation component installation requirements among other things. At the same time, the Direction des immeubles (DI) implemented a standard titled “Gestion et contrôle de l’énergie dans les bâtiments municipaux,” [TRANSLATION: Management and control of energy in municipal buildings] specifically to standardize air (cooling and heating) and water temperatures in the city’s facilities and buildings while reducing energy consumption and ensuring the wellbeing of building occupants.

Furthermore, with respect to reference sources on good practices, the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), the Canadian Standards Association (CSA) as well as Health Canada figure among the organizations that have established standards, guides and guidelines on IAQ management. The ASHRAE is an internationally recognized engineering association. It regularly publishes and updates ventilation system design, installation and maintenance standards for all kinds of non-industrial buildings. The CSA is an organization that publishes IAQ management guidelines for designers and managers, whereas Health Canada has drafted several building IAQ publications (e.g., *Indoor Air Quality in Office Buildings: A Technical Guide* and the *Humidity*

⁴ GO. Part 2, Vol. 129, No. 49, November 26, 1997, pp. 7314-7315.

⁵ RSQ, chapter S-3.

⁶ GO. Part 2, Vol. 133, No. 29, July 18, 2001, pp. 5020-5024.

⁷ RSQ, chapter S-2.1.

⁸ RSQ, chapter S-2.2.

⁹ GO. Part 2, Vol. 134, No. 36, September 4, 2002, pp. 6065-6068.

¹⁰ RSQ, chapter B-1.1.

¹¹ RRMV, chapter B-1, April 25, 1997.

and Mould in Indoor Air information file). It is important to note that standards such as those of the ASHRAE are voluntary rather than compulsory in nature; they are designed to help building managers ensure an acceptable IAQ with respect to both design and construction methods as well as building and system maintenance (e.g., heating and ventilation systems). Also, manufacturers themselves produce guides on using the equipment.

During the building design and heating, ventilation and air conditioning (HVAC¹²) system installation phases, there are principles, trade practices and general characteristics that apply to IAQ. However, in the case of existing buildings, it is rather how they are maintained that can adversely affect IAQ. This requires the establishment and implementation of a periodic maintenance and inspection program for all building components, specifically with respect to HVAC systems. Indeed, according to many studies and publications, a host of IAQ issues stem from inefficient ventilation or deficient HVAC component management practices.

In this sense, it is important to rigorously manage building IAQ in order to prevent, detect, assess and correct most air quality problems at the source.

2. Purpose and Scope of the Audit

The objective of the audit was to ascertain the existence and implementation of a preventive maintenance program (PMP) of all equipment susceptible of compromising the IAQ of the city's buildings and to verify the existence of periodic IAQ monitoring mechanisms for these buildings.

Although there are many aspects that need to be considered when it comes to building IAQ, the scope of our audit focussed mainly on one influencing factor, i.e., the preventive maintenance of the HVAC systems in the city's buildings. Consequently, the other factors of influence relating notably to buildings' structural condition as well as those related to building and system (e.g., HVAC) design were not examined as part of this audit.

Our audit dealt mainly with 2012 and 2013, but we also took into account information that we received up to January 2014. For certain aspects, data on years prior to 2012 and 2013 were also considered. The audit involved the following three business units:

¹² HVAC (heating, ventilation and air conditioning) is an acronym used to designate all air systems designed to ensure a safe and secure environment as well as occupant comfort.

- Service de concertation des arrondissements et des ressources matérielles (SCARM)¹³:
 - DI – Division gestion des travaux d’entretien (DGTE),
 - DSTI;
- Saint-Laurent borough:
 - Direction des travaux publics – Division de la mécanique des bâtiments et de l’éclairage des rues;
- LaSalle borough:
 - Direction des services techniques – Division édifices et équipements.¹⁴

3. Summary of Findings

Our audit work revealed sectors where improvements are required. The following sections of this audit report highlight deficiencies with respect to:

- The building inventory (Section 4.1.1):
 - The DSTI, responsible for updating the inventory of city buildings on an ongoing basis, has no formal communication mechanism in place to enable the city’s various business units to systematically inform it of changes to the inventory of buildings for which they are responsible.
- The inventory of HVAC system components (Section 4.1.2):
 - The audited business units¹⁵ do not necessarily keep a complete and up-to-date inventory of the HVAC system components that they are responsible for maintaining,
 - The DI has no structured and standardized mechanism for communicating inventory component update requests in the Système intégré de gestion des immeubles (SIGI) that are sent to it by the various concerned stakeholders within the maintenance sections.
- The establishment and integrity of the preventive maintenance programs (Section 4.2):
 - Direction des immeubles (Section 4.2.1):
 - The PMPs do not necessarily cover all HVAC system components that require maintenance. Also, they are incomplete and outdated with respect to maintenance activities and tasks, standard maintenance timelines as well as scheduled maintenance frequencies and periods during the year,

¹³ Name of the department at the time of our audit. Effective May 1, 2014, the department is known as the Service de concertation des arrondissements.

¹⁴ This division is now named the “Division immeubles et matériel roulant” and reports to the Direction des travaux publics.

¹⁵ The DI as well as the Saint-Laurent and LaSalle boroughs.

- The HVAC systems' PMPs were reviewed a few years ago but have still not been incorporated into the SIGI,
- In operational terms, the planned PMPs regarding a single building's components are not always optimized to foster the efficient management of maintenance activities;
- Saint-Laurent borough (Section 4.2.2):
 - The content of the PMP developed by the borough using the SIGI is not necessarily complete or up to date,
 - In operational terms, the activities planned in the PMP regarding a single building's components are not always optimized to foster the efficient management of maintenance activities;
- LaSalle borough (Section 4.2.3):
 - PMPs that are to be planned and developed by firms specializing in maintenance contracts are not sent to the persons in charge of the borough for the purpose of having them verify that each building and its individual components are covered by an adequate maintenance program that meets city requirements and good industry practices and of ensuring follow-up of scheduled maintenances,
 - The process to renew the awarding of maintenance contracts is not always triggered sufficiently in advance. As a result, the maintenance of certain equipment such as HVAC system components is neither planned nor carried out.
- The evaluation of the implementation of the preventive maintenance programs (Section 4.3):
 - Direction des immeubles (Section 4.3.1):
 - Implementation and follow-up of the PMPs – internally (Section 4.3.1.1):
 - The absence of reliable information in the SIGI makes it difficult to generate a reliable portrait of the actual number of PMPs implemented compared to what was initially planned,
 - Implementation and follow-up of the PMPs – on a contract basis (Section 4.3.1.2):
 - The tendering documents prepared for the awarding of building component maintenance contracts include PMP files that are not necessarily up to date,
 - The absence of a rigorous mechanism used on an ongoing basis and documented to follow up on maintenance work entrusted to external firms makes it difficult to evaluate the implementation rate for planned PMPs;
 - Saint-Laurent borough (Section 4.3.2):
 - Optimal use is not made of the SIGI. Consequently, the borough cannot extract information from the system that would enable it to track and evaluate the PMP implementation rate that was entered into the system;

- LaSalle borough (Section 4.3.3):
 - No formal, structured and documented mechanism to track and evaluate the implementation of the planned PMPs has been put into place.
- The establishment and implementation of PMPs for water cooling towers (Section 4.4):
 - Direction des immeubles (Section 4.4.1):
 - All of the water cooling towers are not necessarily associated with the corresponding PMPs in the SIGI,
 - The maintenance records are not necessarily available on site where the water cooling towers are located and they do not meet the requirements of the new regulation,
 - In the case of the water cooling towers under the responsibility of the Section des travaux d'entretien à contrat, there exists no systematic compilation process to ensure that external firms to which maintenance contracts have been awarded fully completed the maintenance provided under the PMP for the component in question;
 - Saint-Laurent borough (Section 4.4.2):
 - Although it is not a regulatory obligation, the new PMP implemented for the water cooling towers does not include bacterial analyses of the water for the purpose of detecting *Legionella* bacteria;
 - LaSalle borough (Section 4.4.3):
 - In the case of one of the two water cooling towers, neither an individualized PMP nor a maintenance record were implemented to meet the new regulatory requirements,
 - In the case of the other tower, the maintenance record that was implemented does not comply with all of the new regulatory requirements,
 - No tracking mechanism has been implemented to document maintenance activities carried out by external firms.
- The IAQ tracking mechanisms (Section 4.5):
 - Gas sensing probes (Section 4.5.2):
 - Direction des immeubles (Section 4.5.2.1):
 - We were not able to obtain any documentary evidence confirming that the gas sensing probes of the buildings that are under the responsibility of the DI are periodically maintained and calibrated to ensure they function properly,
 - Saint-Laurent borough (Section 4.5.2.2):
 - For one type of gas sensing probe, we were not able to obtain any documentary evidence confirming periodic maintenance and calibration to ensure the probes' proper functioning,

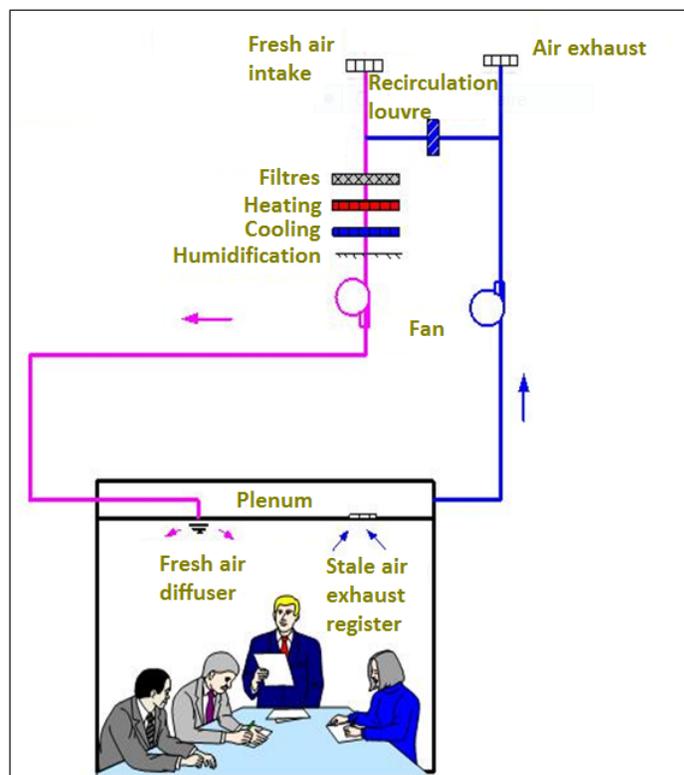
- LaSalle borough (Section 4.5.2.3):
 - We have still not obtained documentary evidence confirming that all gas sensing probes were periodically maintained and calibrated to ensure their proper functioning;
- Complaint management (Section 4.5.3):
 - Direction des immeubles (Section 4.5.3.1):
 - Under the process implemented to manage complaints, it is not mandatory to document the diagnosis or measures taken to correct the problems having given rise to the complaints in the first place,
 - Saint-Laurent borough (Section 4.5.3.2):
 - The process implemented to manage complaints does not require documenting the diagnosis or measures taken to correct the problems having given rise to the complaints in the first place,
 - LaSalle borough (Section 4.5.3.3):
 - The borough has no structured mechanism in place to compile and document complaints lodged by the occupants of buildings under its responsibility and therefore has no way of creating complaint histories, tracking complaints over time and accounting for complaints.
- Accountability (Section 4.6):
 - Direction des immeubles (Section 4.6.1):
 - There is no accountability mechanism in place for boroughs that have the preventive maintenance of their buildings' HVAC system components carried out by the DI,
 - No accountability mechanism has been implemented for the Section des travaux d'entretien à contrat to evaluate the extent to which external firms carry out the scheduled PMPs;
 - Saint-Laurent borough (Section 4.6.2):
 - The accountability mechanisms in place do not provide information on the extent to which the PMP regarding HVAC systems has been implemented;
 - LaSalle borough (Section 4.6.3):
 - No accountability mechanism has been implemented to evaluate the extent to which the external firms carry out the scheduled PMPs within the borough's buildings.

4. Detailed Findings and Recommendations

Essentially, sealed buildings¹⁶ are constructed for energy-saving reasons. To ensure adequate air exchange, these buildings are equipped with HVAC systems designed to provide occupants with indoor air that meets thermal comfort, health and safety standards.

These systems comprise a wide variety of components (e.g., motorized louvers, filters, air supply ducts, humidifiers) that may vary from one building to the next depending on building design and operation. Generally, HVAC systems are designed to provide fresh air to the building and evacuate stale air from the building. These systems distribute air that is a mixture of fresh outdoor air and recycled indoor air. This air mixture is first filtered, heated or cooled and humidified or dehumidified before being released by the central unit to the air ducts and distributed to the occupied spaces, as shown in Figure 1.

Figure 1 – Characteristics of a Ventilation System



Source: "Hygiène industrielle et qualité de l'air." Presentation made by Jacques Saindon Eng., M. Sc. A ROH on May 4, 2010 at a seminar of the Canadian Union of Public Employees (Québec).

¹⁶ Sealed buildings feature windows that cannot be opened by the occupants.

HVAC systems therefore have a direct impact on occupants and it is important to make sure that their components operate properly. Also, in accordance with good IAQ practices, a PMP must be implemented to maintain good air quality. This includes periodic verifications of the HVAC system components.

In fact, this preoccupation was clearly defined by the city in its equipment and infrastructure policy,¹⁷ which states the necessity to draw up an adapted PMP that provides specific information on the work required to protect the assets and extend their useful life.

With respect to the distribution of roles and responsibilities regarding the maintenance of city buildings, we note that the *Charter of Ville de Montréal* does not address this aspect in explicit terms. However, as stipulated, we understand that the city (Section 84) or a borough (Section 130) can exercise its powers and must fulfil its obligations in respect of buildings operated to provide the services that fall under its respective jurisdiction. Thus, (routine and preventive) maintenance falls under the jurisdiction of the boroughs with respect to their territory's building inventory.

In light of the information obtained, we note that the responsibility for managing the maintenance of city buildings is made more complex by the involvement of various stakeholders depending on whether the building is included in the central or local inventory (see Appendix 6.2). Thus, as illustrated in Table 1 below, the responsibility for carrying out routine and preventive maintenance of the city's buildings lies in part with the DI,¹⁸ in part with the boroughs created from former suburban municipalities and in part with the central departments responsible for the buildings, in accordance with each stakeholder's specific mode of operation (internally or by contract). From the outset, we were forced to use data partially extracted from the city's building inventory (1,130 buildings) provided by the DSTI. Indeed, despite repeated requests made to the persons in charge, we only managed to obtain the current number of inventoried buildings, i.e., 1,338 buildings belonging to the city, whereas we were not provided with the information required to determine, for example, how the responsibility for their maintenance was distributed. Consequently, for the purposes of this audit report and Table 1, the data pertaining to an inventory of 1,130 buildings were used.

¹⁷ This policy—which has since been updated more than once—was adopted by the city council at the time the budget of the three-year capital expenditures program was studied in December 2004.

¹⁸ It must also be noted that the DI can intervene in the management of buildings rented by the city when stipulated in the applicable lease documents.

Table 1 – Responsibility for the Maintenance of City Buildings

Responsibility for the maintenance of buildings	Maintenance mode	Number of buildings	Total	Proportion
DI	Internally	443	511	45%
	Under contract	68		
Boroughs created from former suburban municipalities or other central departments	Internally or under contract	619	619	55%
Total		1,130	1,130	100%

Source: DSTI, data extracted from the inventory dated June 23, 2013.

More specifically, the Division gestion des travaux d'entretien (DGTE), which reports to the DI, is responsible among other things for providing and carrying out planned (preventive) and corrective maintenance as well as minor maintenance work on all architectural (e.g., buildings' roofs or envelopes), electrical and mechanical (e.g., HVAC systems) systems of the 511 (45%) municipal buildings located on the territory of the nine boroughs of the former Ville de Montréal and of some buildings included in the central departments' inventory (e.g., fire stations of the Service de sécurité incendie de Montréal [SIM] and neighbourhood police stations of the Service de police de la Ville de Montréal [SPVM]).

At the time of our audit, to carry out its mission, the DGTE relied on personnel¹⁹ distributed among three sections, i.e.:

- **Section d'entretien Est:** Ahuntsic-Cartierville, Villeray–Saint-Michel–Parc-Extension, Rosemont–La Petite-Patrie, Mercier–Hochelaga-Maisonneuve and Rivière-des-Prairies–Pointe-aux-Trembles boroughs;
- **Section d'entretien Ouest:** Le Plateau-Mont-Royal, Ville-Marie, Côte-des-Neiges–Notre-Dame-de-Grâce and Le Sud-Ouest boroughs;
- **Section des travaux d'entretien à contrat.**²⁰

The first two sections are responsible for maintenance work that is carried out internally (by blue collar workers), where the Section des travaux d'entretien à contrat is responsible for managing planned maintenance that is contracted out to specialized external firms.

To manage building maintenance, the DI uses the SIGI (a computerized application). This application makes it possible to compile and track the inventory of buildings, facilities (e.g., outdoor pools, wading pools and water play parks) and components (e.g., HVAC systems). The application can also be used to collect the data needed to plan, manage and carry out maintenance work under PMPs.

¹⁹ Approximately 201.7 person-years according to the 2013 budget documents.

²⁰ In 2014, the DI's organizational structure was revised and the Section des travaux d'entretien à contrat now reports to the Division soutien et exploitation.

As far as the buildings that are under the responsibility of the boroughs created from former suburban municipalities or central departments²¹ are concerned, which account for 55% (619/1130 – according to Table 1) of city buildings, the preferred mode of maintenance (internal or under contract) varies from one business unit to the next. It is however important to note that the DI may be asked to see to maintaining some of these buildings' components (e.g., arenas' refrigeration systems in the Montréal-Nord borough). In cases where the responsibility for maintenance is shared, the DI signs service agreements with the concerned business units.

With respect to the two boroughs created from former suburban municipalities that were the object of the present audit, namely Saint-Laurent and LaSalle, their mode of operation is described below.

Saint-Laurent Borough

The Division de la mécanique des bâtiments et de l'éclairage des rues has the buildings on its territory maintained by blue collar workers. According to the information obtained from the individuals with whom we met, the team in charge of HVAC systems is comprised of forepersons, plumbers, refrigerationists, electricians and building service technicians. During busy periods, day employees are added to the regular team. In general, the Saint-Laurent borough operates without the intervention of the DI. However, the borough may call upon the DI's expertise in particular situations.

As in the case of the DI, the Saint-Laurent borough uses the SIGI to manage the inventory of buildings on its territory as well as their components and to plan and implement the maintenance work described in the PMPs.

LaSalle Borough

The Division édifices et équipements entrusts the maintenance of the HVAC systems of the buildings on its territory to different specialized external firms. Namely, contracts varying from one year to five years in duration were awarded to three specialized firms to ensure the maintenance of the different groups of components making up the HVAC systems of the borough's buildings (e.g., the maintenance of gas heating equipment, the inspection and preventive maintenance of HVAC systems, the maintenance of HVAC system regulation components).

²¹ See Appendix 6.2.

The employees in charge of this borough's HVAC systems include a foreperson and a building service technician. Among other duties, they are required to follow up on the work carried out by the external firms under contract and update the tendering documents for the renewal of maintenance contracts.

4.1. Inventory of Buildings and their Air-Related Components

PMPs must be planned and implemented in accordance with a full inventory of the city's buildings. As assets change and evolve (lease ends, new leases, new buildings, sales, purchases, demolitions, etc.), this inventory will need to be updated.

Knowledge of these buildings' systems and components is also a crucial prerequisite for developing and implementing a complete PMP designed to ensure the proper operation of all these systems over the long term (return on investment).

Our audit work was intended first and foremost to evaluate the extent to which the city's inventory of buildings and HVAC components was complete and up to date.

4.1.1. Building Inventory

4.1.1.A. Background and Findings

Under the direction of the SCARM, the DSTI is the administrative unit responsible for managing all property data on every building and facility (e.g., outdoor pools, wading pools, water play parks) belonging to the city. These data are managed using the SIGI, which contains an inventory database developed jointly by the DSTI and the DI. According to the information obtained from the DSTI, the SIGI's inventory accounts for 1,130 buildings²² belonging to the city, 339 of which are equipped with HVAC systems for a total of a little over 5,200 components (e.g., air conditioners, fans, filters, water cooling towers).

In order to determine if the building inventory was complete and up to date, we proceeded on the basis of surveys. Thus, we obtained from the two boroughs that are the object of this audit (Saint-Laurent and LaSalle) the list of buildings for which they are responsible and then verified if each building was included in the inventory kept by the DSTI using the SIGI. The results of this comparative analysis are presented in Table 2.

²² This figure does not include facilities such as outdoor pools, wading pools and water play parks.

Table 2 – Comparative Analysis of the Boroughs’ Building Inventories and the DSTI’s Inventory

Borough	Number of buildings accounted for in the borough’s inventory ^[a]	Number of buildings accounted for in the DSTI’s inventory	Difference
Saint-Laurent	45	45	0
LaSalle	34	34	0

^[a] It must be noted that we did not include in the inventories provided by the boroughs facilities such as outdoor pools, wading pools and water play parks.

Given the scope of the city’s building inventory and the fact that it is not possible for us to validate its integrality with absolute certainty, the results of the survey conducted—although conclusive—did not provide us with a reasonable level of assurance as to the completeness of the building inventory. Moreover, one of the managers in charge at the DSTI pointed out to us that it was possible that the building inventory kept by the DSTI was not fully up to date (e.g., in the case where boroughs built or demolished buildings on their respective territories without having notified the DSTI of such). To this effect, it would appear that no formal reporting mechanism has been implemented for the purpose of first systematically informing the DSTI of any change and then updating the building inventory in the SIGI’s database.

In our opinion, the city has a legitimate interest in knowing how many assets it owns at any given moment. Moreover, the objectives set out in the city’s equipment and infrastructure policy state that [TRANSLATION] “*Ville de Montréal must keep a full and permanent inventory of its real estate assets.*”

Considering how roles and responsibilities are distributed with respect to building maintenance, we are aware that the DI is not responsible for intervening in all of the buildings on the city’s territory. In that sense, changes made to the building inventory in the SIGI, for which other business units are responsible for routine and preventive maintenance, have no impact on how operations are managed in the SIGI. However, among other things, the DI sees to the routine and preventive maintenance of the buildings under the responsibility of the boroughs of the former Ville de Montréal. As a result, it is in our opinion highly relevant to implement formal reporting mechanisms for the purpose of updating the building inventory in the SIGI. Indeed, it is based on this inventory that the PMP may be planned and carried out for the buildings on these boroughs’ territories.

4.1.1.B. Recommendation

We recommend that the Direction des stratégies et transactions immobilières take the necessary measures to implement a formalized reporting mechanism to enable the different business units to systematically notify the city each time changes are made to the building inventory for which they are responsible, for the purpose of keeping the city's building inventory up to date on an ongoing basis.

Business unit's response:

[TRANSLATION] In accordance with the recommendation, the DSTI plans to carry out the following actions:

- *Provide each of the concerned business units with a list of the buildings considered to be under its responsibility according to the SIGI. The business units shall be required to validate the lists and convey any required changes thereto in accordance with the applicable procedure in order to systematically report changes with respect to individual buildings. (Planned completion: July 2014)*
- *Upon receipt of the validated lists and other updated information, the DSTI shall update the data in the SIGI on an ongoing basis. An annual update is scheduled for November. (Planned completion: November 2014)*

4.1.2. Inventory of Heating, Ventilation and Air Conditioning System Components

4.1.2.A. Background and Findings

For each of the buildings entered, the SIGI's database also enumerates its inventory of components. It should be noted that the inventory contained in the SIGI lists 1,130 buildings, 339 of which are equipped with HVAC systems comprising a little more than 5,200 components (e.g., air conditioners, fans, water cooling towers). In accordance with the applicable distribution of roles and responsibilities (see Appendix 6.2), the HVAC system components in these 339 buildings are maintained by the DGTE, under the direction of the DI, the boroughs created from former suburban municipalities or other central departments entrusted with this responsibility.

The DI uses the SIGI to manage the inventory of building components in buildings on the territories of the boroughs of the former Ville de Montréal. Based on the information obtained from the persons with whom we met, since 2009, the inventory of these buildings' components is kept up to date following visits and inspections conducted under a five-year professional service contract (ending in 2014) awarded to an external firm by the DSTI. Among other things, this firm is mandated to determine the condition of municipal buildings as well as their major components. This mandate is carried out from an "ownership"

perspective and is basically intended to evaluate the investment deficit of municipal buildings and required maintenance operations. For this purpose, the initial intention was to draw up a portrait of the buildings belonging to the city and take stock of their most important components on the basis of 20% of the building inventory inspected per year over a five-year period.

In the opinion of the persons with whom we met within the DI, the asset review carried out as part of this mandate was about 80% completed in 2013. However, the data stemming from this enumeration since 2009 regarding building components had not yet been fully integrated into the SIGI's inventory at the time of our audit work. In fact, these same individuals estimate that only 40% of the data generated until the beginning of 2013 have been entered into the SIGI. The lack of personnel was mentioned to justify the delays in entering the data into the SIGI.

Also, during the course of the interviews, various stakeholders who were met raised a doubt as to this mandate's actual contribution to a full updating of the component inventory. Indeed, the persons in charge pointed out that the data obtained pursuant to this mandate are not detailed enough for the PMP planning purposes. They estimate that, using the data obtained pursuant to another project, i.e., the project with respect to equipment lockout²³ program activities, would have been much more appropriate seeing as it required a more accurate and rigorous overview of the inventory of all system components.

In addition, the persons with whom we met pointed out that the DI's updating of the component inventory could also be driven by requests made directly by stakeholders within the Section d'entretien Est and Section d'entretien Ouest. Notably, when a change arises within a building (e.g., a component is installed or replaced), a note is sent via facsimile or email to the DI to request that the change be entered into the SIGI. To this effect, our audit work indicated that neither these update requests nor their subsequent processing by the DI are adequately structured. Indeed, there exists no standard form to adequately document update requests in a standardized manner. This makes them long and tedious to process, especially when all of the information required to enter the changes into the SIGI were not adequately communicated to the DI. The lack of reliability of the SIGI's component inventory,

²³ The equipment lockout program, which was approved by city authorities in April 2009, is intended to establish a process and procedure to eliminate or minimize the risk of exposure to hazardous energy sources even before an authorized person proceeds with one or the other of prescribed activities on machines, systems or equipment at risk of powering or starting up unexpectedly or of suddenly releasing stored energy and causing injury. This project requires a detailed and complete inventory of all city building components and equipment among other things. The implementation of this project will ensure the city's compliance with its requirements under the *Act respecting occupational health and safety* and the relevant regulations.

caused by delays in processing these requests, was mentioned by the various stakeholders met as yet another problem.

With respect to the Section des travaux d'entretien à contrat, the stakeholders with whom we met informed us that the inventory of the building components under their responsibility was taken between 2003 and 2009 by a private firm and then validated internally by the DI. Since then, they have pointed out that they update the component inventory by including, in the maintenance contracts awarded, inventory forms that the awarded contractors are required to fill out according to a specific timeline. The persons in charge of the Section des travaux d'entretien à contrat then consult these forms to complete or update the component inventory in the SIGI. Although this practice appears appropriate to us, we have not been able to validate it.

Furthermore, the persons met within the DI all agree that the inventory of 5,200 components—a portion of which is under the responsibility of the boroughs created from former suburban municipalities or other central departments—would not necessarily be complete and up to date. Indeed, it should be noted that, with some exceptions, the DI does not intervene in these business units to carry out the maintenance of buildings for which they are responsible. Also, these units are free to opt for the maintenance mode of their choice (e.g., internally or under contract) as well as their own maintenance program and management system. Consequently, only the portion of components within the buildings on the territory of the nine boroughs of the former Ville de Montréal and buildings of certain central departments under the responsibility of the DI continues to be updated in the SIGI's database managed by the DI.

However and exceptionally, the Saint-Laurent borough uses the SIGI to manage the maintenance of the 45 buildings under its responsibility (including 19 with HVAC systems). The underlying database is updated by the borough's personnel, who also update this same inventory in another application used for the equipment lockout program.

As for the LaSalle borough, which is responsible for 34 buildings (including 9 with HVAC systems), it does not keep a computerized inventory of its buildings and their components. It should be noted that the LaSalle borough awards maintenance contracts to specialized external firms for the buildings on its territory. A computerized list of its building inventory and a list of each building's components serve as inventories. These lists of components per building are included with the tendering documents for the purpose of awarding maintenance contracts. For example, the tendering documents provide that the successful contractor is required to update the inventory lists on a yearly basis and provide them to the borough's

designated person for approval purposes. We obtained and examined these lists for years 2012 and 2013. The results of that examination are presented further on in this section.

That being said, in order to evaluate if the SIGI's component inventory was complete and up to date, we carried out a test on one type of HVAC system component, namely water cooling towers.²⁴

In light of the information obtained from the persons contacted, we learned that 33 such towers were installed in 29 of the buildings on the city's territory. We therefore compared the information thus obtained to the information contained in the component inventory of the SIGI's database. The results of that comparative analysis are presented in Table 3.

Table 3 – Validation of the Water Cooling Tower Component Inventory in the SIGI

Business units	Inventory according to units	Inventory according to the SIGI (January 2013) ^[a]	Inventory according to the SIGI (July 2013) ^[b]
DI – Section d'entretien Est	10	7	10
DI – Section d'entretien Ouest	7	3	7
DI – Section des travaux d'entretien à contrat	6	5	6
Subtotal (DI)	23	15	23
Saint-Laurent borough	2	2	2
LaSalle borough	2	0	0
Other	6 ^[c]	0	0
Total	33	17	25

^[a] Inventory initially obtained from the DI at the beginning of our audit work.

^[b] Inventory updated following the work carried out by a person designated by the DSTI to ensure the city's compliance with the new requirements of the *Safety Code* of the *Building Act* regarding the maintenance of water cooling towers.

^[c] Components for which business units other than the DI and the Saint-Laurent and LaSalle boroughs are responsible. Information obtained from a representative of the DSTI in charge of identifying "water cooling tower" type components on the Montréal territory.

First of all, we note that the Section d'entretien Est and Section d'entretien Ouest as well as the Section des travaux d'entretien à contrat identify 23 "water cooling tower" type components within the buildings under their responsibility. As of January 2013, the SIGI's inventory listed 15 cooling towers, two of which in fact corresponded to former equipment that no longer existed and should have been removed from the inventory. Thus, only 13 of

²⁴ According to the information obtained, it must be noted that this type of component includes water cooling towers, evaporative condensers and fluid coolers.

the 23 existing towers (57%) were listed in the SIGI's inventory at the beginning of our audit work.

Following efforts made by the DI to update the inventory of this component type, the SIGI's inventory indicated 23 water cooling towers in July 2013. That means that, at least until the middle of 2013, the PMPs generated from the SIGI for buildings under the responsibility of the DI were based on an incomplete and inaccurate inventory for this type of component. Indeed, PMPs could only be planned for 15 water cooling towers (including 2 that no longer existed) rather than for 23.

We managed to locate the two water cooling towers under the responsibility of the Saint-Laurent borough in the SIGI's inventory.

As for those under the responsibility of the LaSalle borough (2) and those under the responsibility of other central departments (6), they were not included in the SIGI. That can be explained by the fact that their maintenance is decentralized and confirms the information obtained according to which the inventory of components for which the DI is not responsible for maintenance is incomplete in the database generated by the SIGI. However, we were able to retrace the LaSalle borough's two water cooling towers in the inventory kept by the borough. As more specifically concerns the LaSalle borough, we noted upon examination of the lists containing the inventory of components prepared by the successful contractor in 2012 and 2013 that they were incomplete and not necessarily up to date. Furthermore, this was confirmed by the manager contacted in this borough, who mentioned that the necessary corrective actions were already under way to ensure that the component inventory was adequately kept, documented and updated on an ongoing basis.

Moreover, apart from the water cooling towers, representatives of the Section d'entretien Est and Section d'entretien Ouest pointed out to us that the SIGI's inventory of other types of components was inaccurate.

Under the circumstances, we concluded that the unreliable information contained in the SIGI's component inventory encouraged the responsible persons within the DI's Section d'entretien Est and Section d'entretien Ouest to develop—in parallel to the SIGI—a manual maintenance management mode. According to the information obtained, certain sections thereby developed their own inventory lists to ensure that PMPs were planned for all existing components, on the one hand, and to effectively purchase the necessary replacement parts for these systems. Indeed, because the inventory of these components is not necessarily up to date in the SIGI, the concerned stakeholders are faced with the risk that:

- Replacement parts (e.g., filters, belts) that no longer correspond to the specifications of the existing facilities are purchased and useless expenses are incurred to keep an inventory of unnecessary parts;
- Employees responsible for equipment maintenance show up at buildings with the wrong parts.

Some representatives even admit that they use the SIGI more as a guide to avoid omitting buildings and place greater trust in a manually kept inventory.

In short, the completeness of the component inventory is very important, especially when it comes to planning PMPs to ensure IAQ. We note that this inventory contained in the SIGI and the inventory kept by the LaSalle borough are incomplete and contain data that are not necessarily up to date. In our opinion, these shortcomings raise questions as to the possibility that equipment did not benefit from all preventive maintenance when required. This situation also sheds doubt as to the completeness of the inventory of all building components (other than HVAC systems) and the risks that this situation could pose for maintenance planning.

4.1.2.B. Recommendation

We recommend that the Direction des immeubles take the necessary measures to keep a complete and up-to-date inventory of the heating, ventilation and air conditioning system components installed in the buildings under its responsibility such as to enable the various stakeholders to fully plan and implement preventive maintenance programs.

Business unit's response:

[TRANSLATION] The computerized technical files used to account for PMP components and incorporated in the SIGI are used as part of the audit of the buildings piloted by the DSTI and sent to the DI once completed:

- *The Division du soutien et de l'exploitation now updates the components in the SIGI and its mobile application, "SIGI-Mobile" (electronic tablets and cellular phones) on an ongoing basis as the files are made available by the persons in charge of conducting the audit. The delays have been eliminated, whereas the DI is up to date with the delivery by the DSTI of the audit data incorporated in the SIGI. The next two deliveries of audit files are scheduled in 2014 and 2015 respectively. That is when the DI will start entering the information regarding each delivery. **(Completed since February 2014 [ongoing since])***
- *The DI shall send a notice to all persons in charge of implementing the projects of the DSTI and other business units in order to systematically obtain the inventory files completed by the various service providers when major work is carried out. **(Planned completion: September 2014)***

- *Using the lockout program, the DI shall use this team to improve the current inventory-taking activities. (Planned completion: December 2014)*

4.1.2.C. Recommendation

For the same reason, we recommend that the Direction des immeubles take the measures it deems appropriate either to accelerate and complete the entry in the *Système intégré de gestion des immeubles* of the list of the main components following the visits and inspections carried out as part of the mandate awarded to an external firm or to evaluate the relevance of using, for this purpose, the data contained in the inventory of components produced during the implementation of the equipment lockout program.

Business unit's response:

[TRANSLATION] The DI has already undertaken the following actions to accelerate and complete the entry of information in the SIGI:

- *Updates of the components identified by the audit and the association of the components of the PMP 2000 (mechanical ventilation systems) are now done on an ongoing basis. (Completed)*
- *The DI and the DSTI shall align the inventory records completed as part of the lockout program and the audit. Thus, once the DSTI's audit team has passed, the team responsible for the lockout program shall validate the information in the SIGI. Both teams shall exchange their respective visit schedules. (Planned completion: September 2014)*
- *Considering the significance of the efforts required to efficiently manage the inventory, the DI shall evaluate the required resources and, if applicable, present a development plan as part of the 2015 budgetary exercise. The DI shall have recourse to the lockout team to track the inventory of electromechanical systems. (Planned completion: December 2014)*

4.1.2.D. Recommendation

We recommend that the Direction des immeubles establish a structured and standardized reporting mechanism for requests to update components in the inventory of the *Système intégré de gestion des immeubles* by implementing a standard form to be used by all concerned stakeholders to facilitate the entry of the information in the database of the *Système intégré de gestion des immeubles* and reduce processing delays.

Business unit's response:

[TRANSLATION] A procedure aimed at improving data retrieval and processing shall be provided to the persons in charge of the buildings that are maintained internally and

under contract to have them complete the technical files incorporated in the SIGI when they replace components. **(Planned completion: September 2014)**

The DI shall implement a tracking mechanism to ensure compliance with this procedure. **(Planned completion: December 2014)**

The DI produced owner specifications with respect to the lockout procedure that serve to number and identify components. This document was sent to the DSTI to be incorporated in the contractual agreements. **(Planned completion: November 2014)**

The DI shall send a notice to the persons in charge of implementing the projects of the DSTI and other business units to ensure compliance with the procedure for updating the inventory records that are to be completed by the various service providers. **(Planned completion: May 2014)**

4.1.2.E. Recommendation

We recommend that the Saint-Laurent and LaSalle boroughs continue their efforts to ensure that the inventory of the equipment components installed in their buildings, including HVAC systems, is kept complete and up to date on an ongoing basis.

Business units' response:

SAINT-LAURENT BOROUGH

[TRANSLATION] Our buildings' mechanical facilities are frequently inspected by our technicians to ensure the proper functioning of the equipment (PMP).

The component inventory is and shall be updated as new equipment is installed.

The lockout program accounts for the full inventory of electrical and electromechanical equipment in the mechanical equipment rooms, on the rooftops and in the electrical equipment rooms of our buildings.

Lockout records for each piece of equipment (valve, pump, fan) were developed, printed and inserted in the binders placed at the disposal of our blue collar workers in the mechanical equipment rooms. Each record clearly describes the applicable safety procedure to be followed before carrying out an intervention on equipment.

*Updating the lockout records also makes it necessary to update the inventory of equipment in the SIGI. **(Completed)***

LASALLE BOROUGH

*[TRANSLATION] A reminder shall be sent to the suppliers (three firms) asking them to update the list of equipment, as set out in the contract. **(Planned completion: June 2014)***

Verification of the lists with the suppliers with respect to the components and the level of detail that needs to be provided in said lists following the inspections scheduled in June and September 2014. (Planned completion: October 2014)

The lists shall be updated and validated by the borough on an annual basis for the three suppliers. (Planned completion: October 2014)

4.2. Development and Integrity of Preventive Maintenance Programs

It is necessary to develop and implement PMPs for buildings' HVAC systems to efficiently maintain these systems. Indeed, a structured and complete PMP contributes to optimizing the operation of the entire system, extending the useful life of equipment, reducing long-term operating costs by preventing major failures and creating a comfortable and safe environment for occupants.

It has been demonstrated that the absence of a PMP or adequate maintenance for a ventilation system not only decreases the system's efficiency but also negatively affects the building occupants' living environment. HVAC systems must therefore be maintained in optimal operating condition to ensure an adequate IAQ within buildings.

As we pointed out earlier in this report, a good IAQ is an integral part of the Politique de développement durable pour les édifices de la Ville de Montréal [TRANSLATION: Sustainable development policy for Ville de Montréal buildings] adopted by the executive committee on June 9, 2009, which gave rise to a three-year action plan²⁵ for city and borough buildings. This action plan describes the different axes of intervention including, with respect to air quality management, ensuring a healthy and safe environment for building occupants. To achieve this objective, the action plan provides for the implementation of a PMP for the HVAC systems of all buildings over a three-year period.

The implementation of a PMP requires that a series of tasks and actions be carried out for each system component at a given frequency, in accordance with manufacturers' recommendations and good practices. The way the PMP is planned and structured determines the systematic work required on all equipment. The PMP also sets the maintenance calendar and the procedure for describing maintenance activities and tasks, among other things.

²⁵ Plan d'action en développement durable pour les édifices de la Ville de Montréal [TRANSLATION: Sustainable development action plan for Ville de Montréal buildings] (2009-2010-2011), June 2009.

According to good practices, a PMP must be modulated based on where the buildings are located, the activities that are practiced in these buildings and the types of HVAC systems installed. This implies that certain facilities could require more maintenance than the minimum recommended in the good practices.

The PMP also provides preventive measures such as periodic verifications of the components, the presence of contaminants and humidity as well as any malfunction that could have an impact on system efficiency. Among other things, the entire HVAC system must undergo a general inspection to ensure its compliance with design parameters. Finally, all PMP activities must be documented once they have been implemented.

4.2.1. Direction des immeubles

4.2.1.A. Background and Findings

The DI, which is responsible for the maintenance of a good portion of the city's building inventory, has developed PMPs for the different systems installed in the city's buildings and entered them in the SIGI. A DI engineer developed these PMPs in the 1990s. During our audit, we focussed on the following main PMPs regarding HVAC systems:

- PMP 2000 – Mechanical ventilation systems. This PMP covers most maintenance activities on HVAC system components, with the exception of filters that are covered by a separate PMP;
- PMP 2200 – Filters. This PMP lays out specific activities for inspecting and replacing HVAC system filters;
- PMP 1700 – Skating rink refrigeration systems. This PMP lays out a set of maintenance activities for the systems installed in arenas, including the water cooling towers used to cool the ice. This component type is covered in the chapter on HVAC systems.

It should be noted that each of the DI's maintenance sections uses the PMPs developed to manage the maintenance of the HVAC systems within the buildings for which they are responsible. Namely, in its tendering documents for the award of maintenance contracts, the Section des travaux d'entretien à contrat includes the SIGI's PMP files regarding each component that the contracting external firm will be required to maintain.

For each category of components (e.g., fans, air conditioners, humidifiers), the PMPs included in the SIGI provide one file per maintenance activity (e.g., maintenance of motorized louvers, annual resetting of the chiller) that lists the required tasks and inspections as well as their frequency, the period of the year during which they are to be carried out and the time normally required by the designated employees (blue collar workers) to carry them out.

Each component of the inventoried buildings' HVAC systems is associated with one or more PMP activities. This enables the SIGI to automatically plan the activity-based maintenance work over 13 four-week periods (52 weeks in total), in accordance with the frequency and time of the year planned for each activity (e.g., once a year, once a week).

Once this automated planning is complete, work orders are periodically generated for each building and assigned to blue collar workers responsible for completing the work. In light of the information obtained from the persons with whom we met, although forepersons may use the system to automatically plan PMPs, in practice, they use their judgment and knowledge of the buildings under their responsibility to generate the work orders. To this effect, the forepersons mention different shortcomings and point out that the PMPs planned by the SIGI are not always appropriate.

First of all, it was mentioned to us that the SIGI uses a component inventory that is neither complete nor up to date to plan the PMPs. Thus, the SIGI plans and generates work orders for maintenance activities on components that sometimes no longer exist whereas maintenance activities are not necessarily planned for existing components. As we mentioned in the previous section of this audit report, the fact that the information entered into the SIGI is neither complete nor up to date forces forepersons to resort to other management tools in parallel with the SIGI to plan the maintenance of certain components. Moreover, the persons met pointed out that they sometimes need to carry out maintenance activities and tasks in addition to those set out in the SIGI. This would be the case of water cooling towers,²⁶ which require more elaborate maintenance work carried out by blue collar workers than the work described in the PMP. In the case of certain components, we were told that the frequency and period of the year according to which maintenance activities are scheduled in the PMP are not always appropriate (e.g., replacing heating system filters during the summer when the systems are not operating).

Next, we note that preventive maintenance activities may also be carried out sporadically. Indeed, following a visual inspection or a service call, for example, a blue collar worker working in a building may come to the conclusion that certain unplanned maintenance activities are required. Moreover, in the interest of operational efficiency, the persons in charge with whom we met added that certain maintenance activities carried out on a single building's different components should all be planned at the same time.

²⁶ This activity was added to the PMP 2000 at the time we conducted our audit.

Thus, the difference between the PMPs and the reality on the ground requires them to manually adjust their planning by:

- adding activities that are missing from the PMPs;
- adjusting the frequency of the work to be carried out on certain components;
- modifying the period during which certain activities are scheduled.

As for the standard times (in hours) required to carry out the maintenance activities set out in the PMPs, the information obtained from the persons with whom we met reveals that they are not always realistic and would need to be revised to take into account certain factors such as the age of the buildings and their systems. This would mean adjusting upward or downward the frequency or time required with respect to what had been initially planned.

Inevitably, all of these factors have an impact on how the work is planned. As such, the persons in charge of maintenance within the Section d'entretien Est and Section d'entretien Ouest consider that the PMP 2000 (mechanical ventilation systems)—which covers most of the maintenance work carried out on HVAC systems—requires further development. They believe that this PMP would need to be updated not only because it is incomplete but it also contains too many elements, making it difficult to follow up on and carry out.

The persons met at the DI concur and point out that they revised the HVAC systems' PMPs in 2009 and 2010 in accordance with the industry's new maintenance standards. However, to date, these new revised PMPs are not always used because they have not yet been entered into the SIGI. According to the persons in charge, it will not be possible to enter these new PMPs into the SIGI until the full inventory of building components has been completed and entered into the system. The work will then be planned to reflect the updated maintenance activities required for all existing components and systems. In the meantime, it must be noted that the DI continues to plan the maintenance of the buildings for which it is responsible using the former PMPs and an incomplete and outdated component inventory.

In this regard, during our interviews within the Section des travaux d'entretien à contrat, the persons met confirmed to us that they had not been informed of this review of the HVAC systems' PMPs. Consequently, since 2009, the section continues to award maintenance contracts for buildings under its responsibility on the basis of the former PMPs. Although the updated PMPs have not yet been entered into the SIGI, we believe that they should have nevertheless been included with the tendering documents to enable the awarding external firms to use them. That is all the more relevant since the persons in charge with whom we met themselves point out the current PMPs' shortcomings, namely with respect to maintenance frequencies that are deemed inappropriate.

To evaluate the relevance of the PMPs with respect to keeping the equipment in good operating condition and maintaining the efficiency of the HVAC systems and their compliance with the industry's good practices, we referred to the documents on the subject and attempted to retrace, in the PMPs implemented by the DI, the existence of a scheduled maintenance for its 11 components. The results of the comparative analysis conducted (see Appendix 6.3) allow us to conclude that the PMPs do not provide for the maintenance of certain components. Although we are not in a position to determine the integrity and reliability of each PMP, the facts as found lead us to question the compliance of the implemented programs, with respect to both the components that require maintenance and the applicable activities and tasks. Moreover, the findings presented in the previous section relative to the incompleteness of the SIGI's component inventory and the parallel use of management tools raise doubts as to the less than optimal planning and eventual implementation of the PMPs. Under the circumstances, there remains a risk that certain components do not receive the preventive maintenance they require. Ultimately, this could compromise the proper functioning of the systems and—consequently—the IAQ of the city's buildings.

4.2.1.B. Recommendation

We recommend that the Direction des immeubles, to ensure that the buildings under its responsibility and each of their components are covered by a complete preventive maintenance program that complies with the city's requirements as well as industry standards, take the necessary measures to:

- **update the content of the preventive maintenance programs with respect to the applicable components, maintenance activities and tasks, standard maintenance time requirements and the periods of the year when maintenance activities are scheduled;**
- **accelerate the entry in the Système intégré de gestion des immeubles of the revised preventive maintenance programs by making sure to associate all components requiring maintenance with the system;**
- **distribute the updated and revised preventive maintenance programs to all concerned stakeholders;**
- **in operational terms, optimize the ties between the scheduled preventive maintenance programs for the components of a single building to ensure a more efficient management of maintenance activities.**

Business unit's response:

[TRANSLATION] Updating and integration of the PMPs:

- *The PMP 2000 (mechanical ventilation systems) is being entered and implemented. This includes the inventory and entry of components such as mixing boxes and stale air exhaust registers. (Planned completion: December 2014)*
- *The implementation of the second phase of the SIGI-Mobile for the purpose of managing PMPs shall make it possible to determine with greater accuracy the time spent on maintaining buildings' individual mechanical components. (Planned completion: November 2015)*
- *Following the implementation of the second phase of the SIGI-Mobile, the standard PMP times shall be corrected in accordance with actual times and historical data. (Planned completion: May 2016)*

Provide the revised PMPs to the persons concerned:

- *The list of revised PMPs was provided to the teams that carry out maintenance internally and under contract. (Planned completion: March 2014)*

Optimization:

- *The revised PMP 2000 (mechanical ventilation systems) is being integrated. All components entered in the SIGI as of April 30, 2014 shall be linked to their respective maintenance activities. (Planned completion: June 2014)*
- *The computerized work order of the PMP 2000 (mechanical ventilation systems) shall be modified to group all building components concerning a same maintenance activity on the same work order. (Planned completion: June 2014)*

4.2.2. Saint-Laurent Borough

4.2.2.A. Background and Findings

For the preventive maintenance of its HVAC systems, the Saint-Laurent borough uses a program titled "PMP 99003 – Ventilation", which is part of the SIGI and managed through the SIGI. Although it is similar to the PMPs used by the DI, based on the information with which we were provided, this PMP was developed specifically by the borough. According to the information obtained from the persons met, tasks and scheduled activities are updated on an ongoing basis according to determined building requirements.

In the case of certain HVAC system components, maintenance activities are planned in the borough's PMP. Each activity details the required tasks and inspections, their frequencies, the periods of the year during which they must be carried out as well as the standard times required to complete them. The SIGI makes it possible to automate the planning of these activities for the entire component inventory, according to the frequency and target period of the year provided in the PMP. Work orders (PMP) detailing the required maintenance activities for each building may be periodically generated by the SIGI.

However, according to the information obtained from the persons met, it would appear that the maintenance activities planned on the basis of the borough's PMP are not systematically carried out. Indeed, it is instead the foreperson responsible for implementing the PMP that schedules the maintenance work and assigns work orders corresponding to the tasks that need to be carried out by the blue collar workers. Thus, the person in charge adapts the frequency and planning of the maintenance activities generated by the SIGI at his/her discretion, using his/her judgment and knowledge of the work carried out with respect to what is required. For example, with respect to replacing filters, we were told that the borough replaces them more or less four times a year as provided under the PMP, depending on the condition of the filters. We also found, following a review of the forms used to record the results of water quality tests carried out on cooling towers, that these tests are conducted on a weekly basis whereas the PMP stipulates that they are to be conducted twice a year. We therefore conclude that the SIGI's planning of the PMP does not necessarily reflect the maintenance that is actually required.

Also, we were told that preventive maintenance may be carried out sporadically. Indeed, a blue collar worker working in a building, whether in response to a service call or to carry out the maintenance activities assigned to him/her under the PMP, may carry out a part of the preventive maintenance on one or several system components even though these tasks are not scheduled during this period.

These claims raise questions concerning the reliability and relevance of the PMP developed by the borough. Indeed, the systematic modulation of the maintenance frequencies and periodic planning of the work generated by the SIGI tends to show that the PMP is not optimal. Furthermore, the comparative analysis that we conducted on a sample of 11 HVAC system components to evaluate the compliance of the borough's PMP with good practices led us to conclude that this PMP did not cover the maintenance of certain components (see Appendix 6.3).

Also, upon closer review of the content of the PMP implemented by the borough, we noted that the HVAC system components present in certain buildings are in no way associated with the PMP. Indeed, of the 19 buildings with components impacting air quality among the 45 buildings under the borough's responsibility, the components impacting air quality of only five buildings are covered by the PMP. According to the information obtained from the persons we contacted to confirm these findings, in reality, all of the components would be maintained by the employees assigned for this purpose. However, only the most important HVAC systems are associated with the PMP entered into the SIGI.

In conclusion, our findings emphasize the inadequacy of the PMP that can be generated from the SIGI. This could explain—at least in part—why the persons in charge do not really follow the PMP to manage preventive maintenance. However, the fact remains that the borough's current mode of operation poses the risk that certain components do not receive the preventive maintenance they require, that the maintenance activities carried out from one building to the next is not consistent or compliant with industry standards or that priority maintenance activities are not carried out. That could ultimately compromise the proper functioning of the systems. Consequently, it is our opinion that the borough should re-evaluate the content of the PMP entered into the SIGI and update it as required.

4.2.2.B. Recommendation

We recommend that the Saint-Laurent borough take the necessary measures to re-evaluate the content of the preventive maintenance program entered into the Système intégré de gestion des immeubles and update it as required for the purposes of:

- **providing the concerned stakeholders with a management tool that is complete, structured and compliant with good industry practices to ensure an optimal operational management of the heating, ventilation and air conditioning system components within the buildings under their responsibility;**
- **in operational terms, optimizing the scheduled preventive maintenance activities for a single building's components to manage the required maintenance more efficiently.**

Business unit's response:

[TRANSLATION] Optimize the calendar of PMPs in collaboration with the blue collar workers and forepersons.

Revise the PMPs on an ongoing basis.

Print out the PMPs to be carried out in accordance with the established planning and provide them to the blue collar workers for completion.

Make the necessary corrections to the PMPs once the inspections have been carried out.

*Document the completion of the PMPs and corrected PMPs. **(Planned completion: December 2014)***

4.2.3. LaSalle Borough

4.2.3.A. Background and Findings

We should first recall that the LaSalle borough signs contractual agreements with three external firms to have its buildings maintained. According to the information obtained from the persons with whom we met, the borough has not developed any PMP per se and the contracting external firms are fully responsible for planning the maintenance work on the borough's inventory of HVAC system components.

However, the borough includes in its tendering documents a list in narrative form of the maintenance activities that need to be carried out on the components that equip the buildings for which maintenance contracts are awarded. The included specifications stipulate, among other requirements, the implementation of a maintenance plan by qualified personnel, with maintenance activities and their frequencies based on industry standards including those of the ASHRAE and those recommended by manufacturers.

It is the opinion of the persons met that the requirements described in the specifications take into account all of the good practices in terms of HVAC system maintenance.

According to the information obtained, it is not before a meeting that follows the awarding of the contract that the persons in charge for the borough and the external firm agree on the recommended mode, namely with respect to planning the PMPs. We received no evidence of such planning seeing as there is no documentation to this effect (e.g., a detailed program calendar, meeting minutes).

Since the maintenance activities included in the tendering documents are described in rather general narrative terms and no planning is prepared by the borough, we would have expected the maintenance activity programs developed by the external firms to be systematically forwarded to the persons in charge within the borough. Indeed, these persons in charge would then have been in a better position to adequately plan the PMPs for all of the borough's HVAC system components and ultimately follow up on the carrying out of the scheduled maintenance work. But the borough did not receive plans or PMPs from these external firms. Under the circumstances, we cannot confirm that the PMPs are adequately planned for the borough, particularly since our audit work revealed that one of the maintenance contracts²⁷—of a one-year term, which was awarded to one of the three external firms and expired in 2011—had not been submitted to a new tender process and that a new contract was awarded only in September 2013, i.e., almost two years later. This situation raises questions as to the

²⁷ This contract covers the HVAC systems' regulating devices (e.g., probes, thermostats).

possibility that the maintenance required on the equipment (e.g., maintenance and calibration of gas sensing probes) may have not been carried out during this period of uncertainty with respect to the awarding of the related contract. We cover this aspect in Section 4.5.2 (“Gas Sensing Probes”) of this audit report.

Furthermore, as we did in the case of the other business units audited, we proceeded with a comparative analysis of the scheduled maintenance described in the tendering documents with respect to good industry practices to evaluate their integrity and compliance. For the purpose of this comparative analysis, we used a sample of 11 HVAC system components (see Appendix 6.3). The results we obtained raise questions. In the case of certain components, we were not able to find evidence that the scheduled maintenance activities had been carried out.

4.2.3.B. Recommendation

We recommend that the LaSalle borough take the required measures to obtain from the contracting specialized firms the planning and content of the applicable preventive maintenance programs to ensure that each building and its individual components are adequately maintained, in accordance with the requirements set out by the city and good industry practices, and to ultimately enable follow-up of the scheduled maintenance carried out.

Business unit’s response:

[TRANSLATION] Firm 1: A representative of the firm was met March 19. Request was made to the firm to provide us with the PMP and required tracking tools prior to the inspection scheduled for June 2014. (Planned completion: May 2014)

Firm 2: The record of preventive maintenance, the list of equipment and the list of tasks are already in place within each building. The tasks and the frequency with which they must be carried out are described in the contract. (Completed)

Firm 3: A meeting shall be held in April for the purpose of providing a PMP as well as the required tracking tools prior to the inspection scheduled for June 2014. (Planned completion: May 2014)

The verification and validation shall be carried out by the borough after the inspections scheduled for June and September 2014. (Planned completion: October 2014)

4.2.3.C. Recommendation

We also recommend that the LaSalle borough plan sufficiently ahead of time the process leading to the awarding of contract renewals to ensure the preventive maintenance of the equipment, including the heating, ventilation and air conditioning systems.

Business unit's response:

[TRANSLATION] This is an exceptional situation because we revised the tendering concept for these contracts to include parts and minor repairs.

A contract tracking table is currently being developed. (Planned completion: May 2014)

4.3. Evaluation of the Implementation of Preventive Maintenance Programs

The PMP, which establishes the work that needs to be systematically carried out on all HVAC system components, must provide a schedule of maintenance activities as well as a process for verifying that they were carried out. The implementation of the PMP will make a positive contribution to various issues, including the following:

- occupant safety;
- compliance with standards and legal obligations;
- mitigation of the risks of premature equipment wear;
- optimization of maintenance program resources;
- informed budgetary and strategic decision making.

It is essential to follow up on the implementation of the PMPs to enable the persons in charge to make sure that the maintenance work is carried out diligently in all facilities. Moreover, it is of the highest interest to follow up on the implementation of the PMPs regarding HVAC systems because they are more likely to have an impact on IAQ.

Indeed, it is in the interest of the persons in charge of building maintenance to implement an administrative process enabling the ongoing and rigorous follow-up of the planning and carrying out of scheduled maintenance work from one period to the next, namely to:

- facilitate the establishment of an overall portrait of the carrying out of the PMPs for the purpose of reporting to the authorities responsible for the proper functioning of the operations (e.g., the DI, borough managements);

- make it possible to evaluate the impact of the maintenance operations on the proper functioning of the equipment over its useful life;
- make it possible to consult a documented maintenance history for the purpose of assessing the situation in cases where problems were reported or complaints made;
- make it possible to compare performance levels to the objectives established from one year to the next;
- conduct analyses to, among other purposes, determine the maintenance activities that may be causing problems;
- be able to justify needs in terms of human and financial resources in order to achieve the established objectives.

Thus, for each of the business units audited, we examined the extent to which the PMPs within these business units had been implemented and their carrying out had been adequately tracked.

4.3.1. Direction des immeubles

4.3.1.1. Implementation and Tracking of the Completion of the Preventive Maintenance Programs – Internally

4.3.1.1.A. Background and Findings

The forepersons of the Section d'entretien Est and Section d'entretien Ouest use the activities planned in the various PMPs entered into the SIGI (e.g., PMP 2000 – Mechanical ventilation systems, PMP 2200 – Filters) to periodically generate work orders (hard copies) for each building. These work orders specify the work that needs to be carried out (tasks) for each activity. The PMP implementation process provides that these work orders are then assigned to blue collar workers responsible for carrying out the required maintenance work. Once they have carried out the work, the blue collar workers must complete and sign the work orders that are first remitted to the foreperson, then to an office clerk who will enter them into the SIGI to confirm the completion of the work. It should be noted that the actual hours worked as they appear on blue collar workers' time sheets must also be entered and allocated to the maintenance activities carried out in each building.

According to the information obtained, when the forepersons periodically generate the list of work orders, only the interventions provided in the PMP for a given period are generated. However, the work orders of previous periods that have not yet been confirmed in the SIGI as having been carried out remain active in the system. Consequently, the forepersons are

required to closely monitor a large quantity of work orders issued from one period to the next to ensure that the planned PMPs have been carried out in full.

To monitor the carrying out of the PMPs within the buildings, the forepersons of the Section d'entretien Est and Section d'entretien Ouest may use a report titled "Résumé des listes de travail par ouvrage/composante" [TRANSLATION: Summary of work list per structure/component] contained in the SIGI. For each building and its components, this report lists all of the maintenance work planned for a specific PMP (e.g., PMP 1700) over a given period. For each maintenance activity, the report also indicates the start and end dates of the work carried out by blue collar workers as well as, if applicable, comments entered with respect to the reasons explaining why work was cancelled (e.g., postponement to the next maintenance period). The absence of dates or comments indicates to the foreperson that the planned maintenance work has still not been carried out and remains "active" in the system.

Although the forepersons may use this report to monitor the implementation of the PMPs, it would appear that it is not reliable. Some of them have even stopped using it. Indeed, the various persons with whom we met within the Section d'entretien Est and Section d'entretien Ouest claimed that the information contained in the SIGI is not always accurate because of the many shortcomings around managing the implementation of the PMPs from an operational standpoint. The comments we received include the following:

- The work orders generated by the SIGI are not all filled out and returned once the work has been completed for the purpose of being entered in the system. Indeed, although the work may have been carried out, in certain cases, work orders are lost or were not adequately filled out. This risk inevitably increases when a high number of work orders (hard copies) are handled;
- Maintenance work may be carried out sporadically when required (e.g., during an intervention stemming from a service call) without a corresponding work order being issued. The maintenance work carried out for activities that could be planned in the SIGI for a later period is not entered into the system, which renders the program less reliable;
- The completed work orders may be entered late or partially, which inevitably affects the information contained in the SIGI database and the reliability of the reports generated as a consequence. It should be noted that the planned maintenance activities remain active in the system until they have been completed or officially cancelled. The stakeholders we met mentioned that they were unable to differentiate missing work orders from those that had not yet been entered in the system.

Under the circumstances, it is clear that because of these shortcomings around managing the implementation of the PMPs and the resulting lack of reliable information, the users are losing confidence in the SIGI and therefore turn toward other tools developed in parallel with

the SIGI to track the required maintenance work. We did not examine the efficiency of these parallel tracking tools; nevertheless, in our opinion, to be able to efficiently track the implementation of the planned PMPs in the SIGI, the persons in charge should take the necessary measures to ensure that the completed work orders are entered into the system more rigorously.

In this regard, we were informed of the implementation of a new application called “SIGI-Mobile” within the DI at the end of November 2013. This application is to be used by the DI’s forepersons and blue collar workers and makes it possible to automate the electronic processing (using handheld computers) of maintenance requests for the buildings under the DI’s responsibility (e.g., a service call or complaint). Since our audit had been completed by the time this information was provided to us, we did not examine the SIGI-Mobile application. Nevertheless, the information obtained reveals that the electronic processing and automated entry of the required maintenances eliminate the need for hard copy versions of the requests. This should contribute to making the work teams more efficient. According to this same information, it is expected that, during a subsequent stage of the development of the application, it will include the planned maintenance activities (PMPs) and the activities of the equipment lockout program.

That being said, we nevertheless observed that the DI developed a management report to determine the rate of completion of PMPs by the Section d’entretien Est and Section d’entretien Ouest. This report titled “Bilan des PEP” [TRANSLATION: PMP summary] presents the rate of completion of all work scheduled in the PMPs, including the work on the HVAC systems for each of the year’s 13 periods.²⁸

The results included in the summaries prepared by the Section d’entretien Est and Section d’entretien Ouest for 2012 are presented in Table 4 below.

²⁸ Note that the maintenance activities planned in the PMPs are spread out over 13 four-week periods (52 weeks).

Table 4 – Rate of Completion of the HVAC System PMPs (2012)

PMP	Goal	Section d'entretien Est		Section d'entretien Ouest		Total – Internally	
		Percentage completed ^[a]	AT/ST ratio ^[b]	Percentage completed ^[a]	AT/ST ratio ^[b]	Percentage completed ^[a]	AT/ST ratio ^[b]
PMP 1700 – Staking rink refrigeration systems	50%	27%	0.38	84%	1.87	42%	1.16
PMP 2000 – Mechanical ventilation systems	50%	22%	1.28	72%	2.74	41%	2.01
PMP 2200 – Filters	50%	41%	1.11	97%	0.5	63%	0.71

^[a] Represents the percentage of maintenance work completed.

^[b] Represents the actual time spent to complete the work divided by the standard time planned to complete the work.

Source: Summary prepared by the Section d'entretien Est and Section d'entretien Ouest for the period from December 29, 2011 to December 28, 2012.

Thus, at first view, the results presented in this summary tend to show that a high percentage of PMPs are not completed, especially as far as the Section d'entretien Est is concerned. However, in light of the information obtained on how maintenance work is managed in the field, it is our understanding that these results cannot currently be relied on and that it is not possible to accurately evaluate the percentage of PMPs that are carried out by the Section d'entretien Est and Section d'entretien Ouest in accordance with the established planning.

Indeed, it is our opinion that it is laudable, even necessary, to implement such a summary to be able to evaluate the extent to which the implemented PMPs are completed and then determine the sections where improvements are required. However, we are forced to note that the reliability of the current summary may be questionable since it is prepared from a database (SIGI) afflicted by non-negligible shortcomings including the following:

- Earlier in this audit report, we first observed that the inventory of buildings and their components was not necessarily complete and up to date. This situation forces forepersons to review how maintenance is planned by the SIGI and use parallel tracking tools. Among other things, it appears that certain maintenance activities are planned for components that are no longer used or that the maintenance frequency planned for other components is not appropriate. Consequently, the PMP summary presents the ratio of maintenance activities carried out over a maintenance program that is not systematically followed. As a result, it is possible that more maintenance work than scheduled was carried out in buildings whereas other maintenance work was neither planned nor carried out;
- Next, the persons in charge with whom we met stated that it is now more complex to track the work orders generated by the SIGI. There is a considerable quantity of work orders for a single building and the paper versions are handled by several people. Namely, work orders can be lost and data entry errors are possible during the processing of work orders, which increases the risk of erroneous data in the SIGI;

- Finally, as we will set out below, both the actual time taken to carry out the maintenance work and the standard times established do not necessarily reflect reality.

According to the information obtained from the persons met, these summaries are generated on a monthly basis and sent to the managers in charge of maintenance activities for information purposes. Furthermore, there is no other mechanism in place for tracking the implementation of the PMPs.

Moreover, we note that the objective for completing the PMPs is set at 50%. However, a PMP is supposed to detail the work that must systematically be carried out on all (100%) equipment to ensure its proper functioning.

This situation leads us to the question of the relevance of the maintenance activities set out in the PMPs and, especially, of their respective levels of priority. However, nothing seems to indicate that the work that is not carried out is of a lesser priority than the work that is completed. That is of particular concern given the fact the persons in charge point out that all of the work scheduled in the PMPs is required. The objective therefore appears to be based on operational constraints regarding the completion of the PMPs rather than on actual needs.

Furthermore, in light of the information provided in the previous summary (see Table 4), we note that a wide gap sometimes separates the actual time taken to complete the maintenance work from the standard times established. Indeed, the standard time is often exceeded, specifically in the case of PMP 2000, for which twice as many hours (AT/ST ratio: 2.01) were entered in total by both the Section d'entretien Est and Section d'entretien Ouest. Moreover, the AT/ST ratios presented in the summary of the PMPs all raise doubts as to how realistic the established standard times are. To this effect, the persons with whom we met mentioned that, in the case of certain maintenance activities, the standard rates had been established rather arbitrarily and were not necessarily fully representative of the actual time needed to complete the activities.

Similarly, it was also pointed out to us that the AT/ST ratio may be biased by a lack of rigour in the allocation of actual hours worked by blue collar workers to each maintenance activity. Indeed, the hours taken to complete the maintenance work is not necessarily allocated fully or specifically to the applicable work. For example, during a scheduled maintenance, blue collar workers may take advantage of their presence in a building to carry out other work or repairs. The time worked is sometimes allocated in full solely to the planned activity whereas, in other cases, no time may be entered for these activities. Thus, errors and omissions in the entry of the actual time worked can warp the comparison of standard hours with actual hours. This is not necessarily representative of the reality and makes the figures that much less

useful for management purposes. Finally, seeing as Table 4 above highlights major shortcomings, in our opinion, it would be necessary to know the specific causes to be able to make the required corrections.

Our findings do not point to an efficient and prudent management of the planned maintenance activities because it is more difficult to obtain the assurance that all preventive maintenance planned for building components was actually carried out as scheduled. This situation could negatively affect the health and safety of building occupants, accelerate equipment wear and consequently increase equipment repair or replacement costs. In addition, the lack of reliable information in the SIGI deprives managers of relevant management information for making decisions. In our opinion, the PMPs absolutely must be implemented and their completion must be tracked. Consequently, it would be highly desirable that the necessary measures be taken to use the existing management system to its full potential for the purpose of tracking the implementation of the PMPs and ultimately accounting for the results obtained with respect to the objectives initially established.

4.3.1.1.B. Recommendation

We recommend that the Direction des immeubles implement the necessary measures to optimize the management and implementation of the preventive maintenance programs carried out internally (by blue collar workers) in order to be in a position of rigorously planning and fully carrying out the maintenance work on all components involved in interior air quality.

Business unit's response:

*[TRANSLATION] The DI favours the use of a single computerized system in real time, i.e., the SIGI and the SIGI-Mobile application, for managing the inventory and completing both corrective and preventive maintenance work. The goal is to produce consistent results and achieve enhanced accountability. Thus, it shall encourage forepersons to use the SIGI and its SIGI-Mobile application by disseminating a procedure aimed at improving data retrieval and processing. **(Planned completion: December 2014)***

*The DI shall evaluate the necessary resources and, if necessary, present a development plan as part of the 2015 budgetary exercise to enable the full completion of the various PMPs. **(Planned completion: May 2015)***

4.3.1.1.C. Recommendation

We recommend that the Direction des immeubles take the required measures to improve the reliability of the information entered into the existing computerized management system and optimize the use of said information for the purpose of evaluating the extent to which the planned preventive maintenance programs were carried out diligently in all facilities.

Business unit's response:

[TRANSLATION] All PMPs are now periodically tracked. The PMP 2000 (mechanical ventilation systems) is currently being revised and shall be implemented and tracked once completed. (Planned completion: December 2014)

In the coming months, significant efforts shall be made to validate the inventories and update the information in the SIGI. Systematic inventory taking and updating of components and systems that have an impact on energy savings are under way (ventilation system steam traps and heating coils). (Planned completion: November 2014)

The lockout team shall be used to make the information contained in the SIGI more reliable. (Planned completion: December 2014)

The DI favours the use of a single computerized system in real time, i.e., the SIGI and the SIGI-Mobile application, for managing the inventory and completing both corrective and preventive maintenance work. The goal is to produce consistent results and achieve enhanced accountability. Thus, it shall encourage forepersons to use the SIGI and its SIGI-Mobile application by disseminating a procedure aimed at improving data retrieval and processing. (Planned completion: December 2014)

4.3.1.2. Implementation and Tracking of the Completion of the Preventive Maintenance Programs – Under Contract

4.3.1.2.A. Background and Findings

During our audit, among the buildings for which the DI is responsible, 68 were maintained under contract by four specialized external firms. As previously mentioned, the PMP forms developed by the DI are attached to the maintenance contract tendering documents and the contracting external firms must use them to schedule the planned maintenance in their own maintenance management systems. It is also important to note that the Section des travaux d'entretien à contrat has been using the former HVAC system PMPs rather than those updated by the DI in 2009 and 2010 since the first call for tenders launched in 2009 and subsequently year after year.

The PMP implementation process sets out that these firms must send their annual planned maintenance program for each building and each of their components within a specific timeframe to the person in charge of the Section des travaux d'entretien à contrat. Although we were unable to validate this information, the annual maintenance program—which takes the form of an electronic spreadsheet—is then validated internally by the Section des travaux d'entretien à contrat to make sure that it accounts for all PMP activities according to the appropriate maintenance frequencies and periods.

The contract provides that, once each planned activity has been completed, the specialized firms' technicians must send the work orders certifying the completion of the work to a representative of the Section des travaux d'entretien à contrat (electronically). We note that the selected contractor did not produce a summary or portrait illustrating the implementation of the work planned in the PMP. Furthermore, the Section des travaux d'entretien à contrat does not enter the work orders it receives in the SIGI. If they were entered, the system could calculate the percentage of the PMPs implemented.

However, until 2012, the Section des travaux d'entretien à contrat used a mechanism by which the work orders it received were analyzed to then manually associate the maintenance activities in question with those contained in the annual planning spreadsheets prepared by the external firms. According to the information obtained, this was a very painstaking task that was carried out for firms suspected of inadequate performance before undertaking procedures to fine the firms in question. Although the persons met claimed that such measures were taken with certain firms, we did not focus on this aspect during our audit.

We examined the content of the electronic files accounting for this compilation and noted that they only presented an approximate visual overview of the completed work; no completion rate has been calculated. Furthermore, this compilation of information provided by the external firms gives no assurance whatsoever that the work was actually completed in the buildings. Also, since 2013, it appears that the Section des travaux d'entretien à contrat counts on an increased presence of its technical agents in the buildings under its responsibility for tracking the completion of the scheduled maintenance work.

According to the information obtained from these same persons, the objective set by the Section des travaux d'entretien à contrat would be to have between 80% and 90% of PMPs implemented. Although we were provided with no document whatsoever to prove it, these same persons estimate that, on an annual basis, between 60% and 70% of PMPs are actually implemented and they consider that percentage acceptable. We are surprised by both the objective and estimated rate of completion given the fact that, under the contracts awarded,

the external firms are required to complete all (100%) of the preventive maintenance work on the equipment.

Under the circumstances, with the objective of being able to better evaluate the percentage of PMPs implemented within this section, on a sample of six buildings, we calculated the rate of completion of the scheduled maintenances based on the information entered in the electronic files created by the section for the purpose of tracking the work completed by the external firms. Given the lack of more recent tracking files, we focussed on those created for 2010, 2011 and 2012. The results of our audit are presented in Table 5.

Table 5 – PMP Completion Rate for a Sample of Six Buildings Under the Responsibility of the Section des travaux d’entretien à contrat

Building	Contracting external firm	Period concerned ^[a]	Number of scheduled maintenance activities as planned by the external firm	Number of activities completed according to the work orders provided by the firms	PMP completion rate
1	A	2010–2011	N/A		
2	A	2010–2011	N/A		
3	B	2011–2012	111	45	41%
4	B	2011–2012	67	27	40%
5	C	2010–2011	53	24	45%
6	D	2011–2012	390	188	48%
Total			621	284	46%

^[a] Corresponds to the maintenance calendar spread out over 52 weeks. This period may overlap two calendar years.

Thus, in the case of two of the six buildings (buildings 1 and 2), we were unable to calculate a PMP completion rate given that the mechanism implemented by the section to associate the maintenance activities on the work orders with those provided by the external firms in their annual planning had not been used for these buildings.

As for the other four buildings making up the sample (buildings 3 to 6), our audit revealed that the completion of PMPs is confirmed in a proportion that varies from 40% to 48% (46% on average). We are aware that, for various reasons (e.g., missing work orders, compilation errors), the results of our audit may not accurately reflect the work actually completed by the external firms. We nevertheless note that these results differ considerably from the estimates prepared by the persons in charge with whom we met and, may we recall, mentioned that between 60% and 70% of PMPs were completed.

In short, these findings highlight the fact that, in the absence of a rigorous tracking mechanism that is used on an ongoing basis and is well documented, it becomes more difficult to proactively detect when maintenance is deficient or does not comply with the planned maintenance in the PMPs for the purpose of intervening promptly with contractors who do not meet the terms and conditions of their contract.

4.3.1.2.B. Recommendation

We recommend that the Direction des immeubles take the required measures to incorporate, if applicable, the preventive maintenance program's most up-to-date maintenance files in the tendering documents prepared for awarding preventive maintenance contracts for the equipment in the buildings under its responsibility to ensure that the maintenance work is carried out in accordance with industry standards and good practices.

Business unit's response:

[TRANSLATION] Requirements shall be integrated as contracts are renewed. (Planned completion: December 2014)

4.3.1.2.C. Recommendation

We also recommend that the Direction des immeubles adopt a rigorous, ongoing and well documented mechanism to track the maintenance work awarded under contract to specialized external firms for the buildings under its responsibility in order to ensure that preventive maintenance programs are planned diligently and in accordance with contract terms and conditions.

Business unit's response:

[TRANSLATION] The DI already uses a mechanism to periodically track the administrative and supporting documents provided by contractors to ensure the PMPs are rigorously planned. (Planned completion: August 2014)

To ensure tracking on an ongoing basis, the DI shall evaluate the required resources and, if necessary, present a development plan as part of the 2015 budgetary exercise. (Planned completion: December 2014)

Auditor General's Comments:

At the time of our audit, this mechanism had been used until 2012. It is our understanding that the DI plans to use it once again.

4.3.2. Saint-Laurent Borough

4.3.2.1. Implementation and Tracking of the Completion of the Preventive Maintenance Programs

4.3.2.1.A. Background and Findings

To complement the Saint-Laurent borough's "PMP 99003 – Ventilation," the SIGI can be used to generate work orders for each component type. According to the information obtained, these work orders are assigned to blue collar workers to ensure the required work is carried out. The work orders must then be returned to the foreperson.

It is the opinion of the persons met that, although the forepersons have access to the SIGI's automated planning to ensure the implementation of the PMPs, maintenance work can also be carried out in accordance with requirements detected by blue collar workers while they are present in buildings. Indeed, we were informed that blue collar workers conduct ongoing general inspections of the borough's buildings. Consequently, during these inspections, blue collar workers may decide to undertake maintenance work based on their judgment and knowledge of the maintenance required to ensure the proper functioning of the systems in place, regardless of what the PMP stipulates. Because of the ongoing presence of the blue collar workers in the buildings, the persons with whom we met are confident that the maintenance is carried out correctly and that the equipment functions properly.

We also learned that the paper versions of the work orders generated by the SIGI and assigned to the blue collar workers are not necessarily very rigorously tracked nor is their completion confirmed in the system. Moreover, during our visit in the borough, we examined a few of the work orders returned to the foreperson responsible for HVAC system maintenance and observed that most of them provided no evidence whatsoever that they had been executed by the blue collar workers. It is only in rare cases that we were able to find short annotations (e.g., "OK") indicating that the work had been carried out or that repairs were needed. Thus, since the work orders are not usually kept once the work has been completed and that none of them are entered in the SIGI to confirm that the work was completed, it is not possible to evaluate the extent to which the PMP was implemented based on supporting documentary evidence.

We are aware that the ongoing presence of the blue collar workers in the buildings as well as their knowledge of the equipment in place and the maintenance it requires are factors that contribute to mitigating the risks of major breakdowns or unforeseeable incidents that can negatively affect air quality and compromise occupants' health and safety. Nevertheless, it is

our opinion that the absence of formal and structured mechanisms for tracking the implementation of the PMPs deprives managers of management information that would enable them namely to:

- proactively detect any shortcomings in the completion of work or cases of non-compliance with the planned PMP;
- obtain a historic compilation of the maintenance done to make it possible to analyze problem situations;
- establish an overall portrait of the implementation of the PMP to enable more accurate renderings of accounts.

4.3.2.1.B. Recommendation

We recommend that the Saint-Laurent borough take the required steps to optimize how it uses the Système intégré de gestion des immeubles in place in order to be able to ensure that the planned preventive maintenance program is carried out diligently in all facilities, including those that present a risk with respect to maintaining good air quality.

Business unit's response

[TRANSLATION] Use the SIGI to track PMPs (opening, printing, completion, closure and entry of comments).

Document the completion of the PMPs using the SIGI. (Planned completion: December 2014)

4.3.3. LaSalle Borough

4.3.3.1. Implementation and Tracking of the Completion of the Preventive Maintenance Programs

4.3.3.1.A. Background and Findings

Under the PMP implementation process used by this borough, the three specialized external firms to which the maintenance contracts are awarded carry out the annual programming of the preventive maintenance work planned for all HVAC system components for 10 of the borough's 34 buildings.

It should be noted that the borough does not have access to a computer system for managing preventive maintenance work (e.g., the SIGI). We also note that, contrary to the DI's Section des travaux d'entretien à contrat, the tendering documents do not stipulate that the borough

will validate the successful external firms' annual planning. Indeed, as we indicated in Section 4.2 of this audit report dealing with the establishment and integrity of the instigated PMPs, it is only during a meeting held after a contract has been awarded that the persons in charge of the borough and the external firm agree on the recommended mode of operation, specifically with respect to planning the PMPs. However, we have not found evidence of such planning given the absence of documents to this effect.

That being said, to be able to track the completion of the work described in the contracts, the borough incorporated in the tendering documents of two of the three contracts a clause containing an obligation for the external firm to produce a detailed report (e.g., a work order), after each of its interventions, of the inspection and maintenance activities it carried out on the systems or equipment. Among other things, this report must list the facilities verified, the abnormalities detected, the repairs made and the hours spent completing the work. As for the third contract, the borough requires the production of a detailed monthly report instead. In this regard, we were unable to find any evidence of the production of such a monthly report. In fact, we instead discovered that the firms confirmed the completion of the work with work orders issued after each intervention completed in the facilities.

In light of the information obtained from the persons with whom we met, we observe that the work described on the work orders is not necessarily systematically verified in the facilities. Furthermore, since they do not have the firms' annual planned preventive maintenance programs in their possession, the persons in charge of the borough are not able to compare the work described on the work orders to the work provided in the planned PMPs or to evaluate the extent to which these PMPs were globally completed, based on supporting documents.

In this regard, the persons met argue that the recurring visits of the blue collar workers who carry out minor maintenance work in the borough's buildings represent one of the means taken to ensure that the contracting external firm completes the required maintenance. Indeed, they claim that visual inspections of the facilities make it easy to make an overall assessment as to whether or not the required maintenance (e.g., replacement of filters or belts) has been completed.

Thus, the persons in charge with whom we met feel confident that at least 70% of the preventive maintenance work is carried out on the HVAC systems. However, we were unable to validate if this estimate was founded.

We are aware that the ongoing presence of blue collar workers in the buildings as well as the interventions of the various specialized external firms may contribute to mitigating the risks

of major breakdowns or unforeseeable incidents that can negatively affect air quality and compromise occupants' health and safety. Nevertheless, it is our opinion that the absence of formal and structured mechanisms for tracking the implementation of the PMPs deprives managers of management information that would enable them namely to:

- proactively detect any shortcomings in the completion of work or cases of non-compliance with the planned PMP to then be in a position to intervene promptly with the external firms whose maintenance work is deficient;
- obtain a historic compilation of the maintenance done to make it possible to analyze problem situations;
- establish an overall portrait of the implementation of the PMP to enable more accurate renderings of accounts.

4.3.3.1.B. Recommendation

We recommend that the LaSalle borough, in order to be able to verify that the planned preventive maintenance work was carried out diligently in all facilities, including those that pose a risk with respect to maintaining good air quality, implement a formal, structured and documented mechanism for the purposes of evaluating and tracking the implementation of the planned preventive maintenance programs. Of course, the borough will first be required to obtain from the successful firms their annual program of preventive maintenance work planned on all heating, ventilation and air conditioning system components or implement its own preventive maintenance program.

Business unit's response:

[TRANSLATION] The LaSalle borough shall purchase a preventive maintenance software application.

The PMP and tracking methods provided in advance by the contractors and validated by the borough shall be entered into that application.

*Until then, upon receipt of service reports, the persons in charge shall validate the work completed with respect to the established planning and corrective work shall be planned quarterly. **(Planned completion: December 2015)***

4.4. Establishment and Implementation of the Water Cooling Tower Preventive Maintenance Programs

First let us point out that, according to the information obtained from the persons met, there are 33 water cooling towers²⁹ in 29 buildings located on the city's territory. Of the 33 towers, 27 are maintained under the responsibility of the business units covered by our audit, i.e., the DI (23 towers distributed between the Section d'entretien Est and Section d'entretien Ouest and the Section des travaux d'entretien à contrat), the Saint-Laurent borough (two towers) and the LaSalle borough (two towers) (see Table 3 in Section 4.1.2).

Given the importance of the water cooling towers when it comes to air quality and because of the events that occurred in Québec City in July 2012 (181 people were infected by the *Legionella pneumophila* bacteria propagated by a water cooling tower, of whom 14 died), we deemed it appropriate to specifically examine the development and ultimate implementation of the PMPs planned for this type of component.

Given its functionalities, a water cooling tower is one of the components of a HVAC system. It operates³⁰ as a heat exchanger through direct contact between the water and ambient air. Its efficiency depends on the surface area between the liquid and the air. To maximize this surface area, water droplets are diffused through an air current that crosses the tower in order to evacuate the heat and cool the water. Despite the equipment installed to limit water losses during the operation, a portion of the volume of water that circulates in the tower is evacuated outside of the building. Furthermore, the evaporation that occurs in the tower results in a very high concentration of dissolved or suspended matter in the water: mineral salts, chemicals, organic matter, etc.

Thus, the water cooling towers offer an environment that is conducive to the growth of the *Legionella* species of bacteria, which cause legionnaires' disease. Most of the infections (more than 70% to 80%) would be caused by the *Legionella pneumophila* bacteria. This bacterium grows in a humid environment and thrives at temperatures of between 25°C and 45°C. It is therefore necessary to prevent bacterial growth in the water cooling towers and limit their dissemination by implementing a specific PMP.

²⁹ This type of component also includes evaporative condensers and fluid coolers.

³⁰ Source: *Guide explicatif sur l'entretien des tours de refroidissement à l'eau*, Régie du bâtiment du Québec (RBQ), 2013.

First, under good practices, it is recommended that this type of component be maintained on a preventive basis³¹ according to the frequency specified by the manufacturer. It is also recommended that the maintenance include:

- a water treatment program based on the injection of chemicals (biocides) namely to disinfect the circulating water, control bacterial outbreaks and minimize scale deposits and corrosion;
- regular controls (bacteriological analyses) of the water in the network of cooling towers in order to detect the concentration of the *Legionella* species of bacteria.

It must be noted that a new regulation (modifying the *Safety Code*³²) incorporating provisions on water cooling tower maintenance came into force on May 12, 2013 after it was published in the *Gazette officielle du Québec* on March 27, 2013. Under these provisions, a professional in the field is required to develop a maintenance program that takes into consideration the characteristics and history of the interventions (e.g., major breakdowns, repairs made) in each facility. The program must provide details on the following maintenance activities in particular:

- the regular cleaning of the facility's components;
- the measures taken to verify the facility's mechanical components and equipment;
- the water quality maintenance and decontamination procedures.

The new provisions also provide for the keeping of a register in each facility noting, among other things, the equipment's characteristics, the maintenance programs, the history of the interventions and the names of the designated staff members responsible for the maintenance of the equipment.

We therefore examined the measures taken by the audited business units to ensure the preventive maintenance of this type of component.

4.4.1. Direction des immeubles

4.4.1.A. Background and Findings

At the beginning of our audit, within the DI, the water cooling tower maintenance activities were included in the PMP of mechanical ventilation systems (2000) as well as in the PMP of skating rink refrigeration systems (1700) in the case of the towers used to cool the ice in arenas.

³¹ This maintenance includes a regular cleaning of the cooling tower components as well as a weekly visual inspection of their components to detect signs of malfunction or microbial growth. The PMP must also include the wintering and restarting procedures as well as the shutdown and decontamination procedures.

³² *GO. Part 2*, Vol. 145, No. 13, March 27, 2013, p. 1100-1102.

Following the outbreak of the *Legionella pneumophila* bacteria in the Québec City area in the summer of 2012, the persons with whom we met at the DI pointed out to us that the bacteriological analyses conducted on the water cooling towers under their responsibility (23 towers in total) had been carried out by specialized firms for the purpose of detecting the presence of this bacterium. Thus, based on the information obtained, we were able to track down the reports providing evidence of the analyses conducted in 2012 on 11 of the 17 cooling towers under the responsibility of the Section d'entretien Est and Section d'entretien Ouest. The results of these analyses reveal no bacterial presence whatsoever above the prescribed standards. According to the persons met, it is possible that the water in cooling towers that were not in operation during this period was not analyzed. As for the six cooling towers that the Section des travaux d'entretien à contrat is responsible for maintaining, the persons with whom we met within the section confirmed to us that they had not requested such analyses.

Following the coming into force of the new regulation respecting water cooling tower maintenance, in July 2013, the DI proceeded to review the PMPs in effect and developed a separate PMP for this type of component, i.e., PMP 15680 – Water cooling towers. This new PMP is the one that will be used by all of the sections from now on.

Thus, although we are not able to determine the compliance of this new PMP, we observe that it is nevertheless detailed with respect to the required maintenance activities and tasks. Furthermore, although it is not mandatory under the new regulation, we nevertheless observe that the new PMP provides a very relevant control for evaluating its efficiency, i.e., an annual *Legionella* screening test. In our opinion, this addition with respect to previous PMPs represents a sound and prudent management practice. Also, we were informed that this PMP was developed by a specialized engineer and that each facility now has a maintenance log that is kept on site with the water cooling tower, as required under the regulation. On the basis of surveys, we examined the maintenance logs of three water cooling towers that the Section d'entretien Est, Section d'entretien Ouest and Section des travaux d'entretien à contrat are responsible for maintaining, respectively. A log was found to exist in all three cases, but the information we obtained reveals that the log of the water cooling tower under the responsibility of the Section des travaux d'entretien à contrat was not available on site. Furthermore, we observe that the content of these logs does not fully comply with the requirements of the new regulation in force. For example, we were not systematically able to track down the manufacturer's operating and maintenance manual or the names of the person in charge of the maintenance and the persons assigned to maintenance duties.

That being said, despite a few shortcomings noted, the DI has taken the required measures to comply with the provisions of the new regulation respecting water cooling tower maintenance.

Moreover, with respect to the implementation of the PMPs regarding this type of facility, we must first point out that we examined the former PMPs, i.e., the PMP of mechanical ventilation systems (2000) and the PMP of skating rink refrigeration systems (1700), both of which were used for the purposes of our audit.

We already mentioned that the component inventory is incomplete and outdated and pointed out the fact that certain components may not have been maintained as planned. Both these shortcomings were also observed with respect to “water cooling tower” type components.

Namely, regarding the water cooling towers that are maintained internally by the Section d’entretien Est and Section d’entretien Ouest, following our examination of the planned PMPs generated by the SIGI, we were able to observe that maintenance was planned for only 9 of the 17 water cooling towers under their responsibility.³³ Thus, given the fact these components were not associated with a PMP in the SIGI, the result is that no work order was systematically generated by the application for the purpose of their maintenance. We are aware that it is nevertheless possible that these components were maintained during the various interventions made by the blue collar workers within the building housing said equipment (e.g., in response to a service call or a complaint) or following the implementation of a form of maintenance planning parallel to the SIGI. However, in our opinion, it would be necessary to review the data entered into the SIGI to ensure that all of the water cooling towers are adequately associated with the applicable PMP. This is all the more important since, given the absence of complete maintenance planning in the SIGI, it could be more difficult for the DI to demonstrate that the water cooling towers were adequately maintained, as is the case with the other HVAC system components.

With respect to the six water cooling towers among the 23 that come under the responsibility of the DI and are maintained by the Section des travaux d’entretien à contrat, it was not possible for us to validate that all of the planned maintenance activities had been carried out. Indeed, although these water cooling towers are included in the maintenance programs provided by the contracting external firms, it is very difficult to track the work orders sent by these firms with respect to what had been planned since this section does not dispose of any systematic compilation mechanism.

³³ See Table 3 in Section 4.1.2: “Inventory of Heating, Ventilation and Air Conditioning System Components.”

4.4.1.B. Recommendation

We recommend that, in order to obtain the assurance that all of the water cooling towers under its responsibility were maintained as planned and to be able to demonstrate it, the Direction des immeubles take the necessary measures to:

- adequately associate all of the water cooling towers with the new applicable preventive maintenance program;
- have maintenance logs kept on site with the water cooling towers and in compliance with the requirements of the new regulation respecting this type of equipment;
- have the Section des travaux d'entretien à contrat acquire a systematic compilation mechanism providing it with evidence that the maintenance work carried out by the contracting external firms was completed in accordance with the preventive maintenance program applying to this type of component.

Business unit's response:

[TRANSLATION] All water cooling towers are included in the applicable PMP since September 2013. (Completed)

The maintenance logs are available since September 2013 on sites where water cooling towers are installed, in accordance with the new regulation in force.

Auditor general's comments:

At the time of our audit in January 2014, a log included in our sample was not available on site with the water cooling tower, as specified by the regulation.

The water cooling towers, maintained in the past under contract, are now included in the related PMP and are maintained internally since March 14, 2014. The maintenance logs shall be verified and filed in the mechanical equipment rooms in accordance with the new regulation in force. (Planned completion: June 2014)

4.4.2. Saint-Laurent Borough

4.4.2.A. Background and Findings

From the outset, it must be noted that the Saint-Laurent borough maintains two water cooling towers.³⁴ Following the outbreak of the *Legionella pneumophila* bacterium in the Québec City area in the summer of 2012, the borough did not order *Legionella* screening tests (bacteriological analysis) for these towers.

³⁴ See Table 3 in Section 4.1.2: "Inventory of Heating, Ventilation and Air Conditioning System Components."

According to the information obtained from the borough's persons in charge with whom we met, the publication in March 2013 of the new regulation respecting the maintenance of water cooling towers encouraged the borough to revise the content of its PMP 99003 (ventilation) with the addition of maintenance activities specific to this component type. It would appear that this specific PMP was developed by a specialized engineer in the field. As is the case of the DI, although we are not able to determine the compliance of this new PMP, we observe that it includes the inspections and maintenance tasks that must be carried out. Also, each facility now has a maintenance log that is kept on site with the water cooling tower, as required under the regulation. We examined the log of one of the borough's two water cooling towers and found that it complied with the requirements of the new regulation in force for this type of equipment.

Thus, besides maintaining and verifying the equipment, we note that the revised PMP provides for weekly analyses of water quality parameters. It must also be pointed out that, during the summer of 2013, the borough mandated a specialized firm to conduct a bacteriological analysis of the water contained in the two towers under its responsibility. We observed that the results of these analyses did not reveal the presence of bacteria of the *Legionella* species beyond the prescribed standards. However, upon examination of the new PMP implemented for this component type, we noted that no bacteriological analyses are planned to detect the presence of bacteria of the *Legionella* species. Although such a control is not mandatory under the new regulations, it is nevertheless our opinion that assessing the efficiency of the implemented PMP and ensuring public safety in terms of air quality would represent a sound and prudent management practice.

4.4.2.B. Recommendation

We recommend that the Saint-Laurent borough revise its water cooling tower preventive maintenance program to include, at a frequency that it deems appropriate, bacteriological analyses of tower water to detect the presence of bacteria of the *Legionella* species and confirm or overrule the efficiency of its preventive maintenance program.

Business unit's response:

[TRANSLATION] Particular attention is given to the water cooling tower in terms of the functioning of the mechanical equipment and the water quality within the cooling loop. Indeed, in addition to a visual inspection carried out at least weekly of the water cooling tower and its components, its mechanical components are maintained in accordance with the manufacturer's recommendations.

An automatic chemical injection system is used to treat the water in order to:

- *disinfect the recirculating water;*
- *reduce the buildup of biofilm;*
- *minimize corrosion;*
- *minimize scaling;*
- *minimize fouling.*

Water quality is analyzed weekly to verify product efficiency. (Already in place)

Collected samples will be sent for analysis to determine the concentration of Legionella pneumophila in CFU/L (colony-forming units per litre of water):

- *upon re-commissioning after the wintering period;*
- *at intervals of at most 30 days during the service period;*
- *between two and seven days after the decontamination procedure has been completed. (Planned completion: August 2014)*

4.4.3. LaSalle Borough

4.4.3.A. Background and Findings

Among the buildings under its responsibility, the LaSalle borough is responsible for maintaining two water cooling towers³⁵ used to cool the ice of two arenas. The borough, which contracts out the maintenance of the components within its buildings to external firms, stipulates in its tendering documents that the contracting firm is required to verify the overall operating condition of the refrigeration systems in accordance with manufacturers' instructions. Thus, the successful firm is responsible for the operation, maintenance and necessary adjustments as well as the commissioning of the automatic chemical injection system (biocides) that equips one of the two towers. We note however that the specifications do not set out all of the required maintenance tasks or their frequencies in very specific terms. The borough thereby leaves total latitude for carrying out a PMP adapted to this type of equipment. Since the legionnaires' disease outbreak in the Québec City area in the summer of 2012, the borough did not order any *Legionella* screening tests for its towers.

One of the two cooling towers was installed in 2011. During the one-year warranty period following the equipment's initial commissioning, i.e., in 2012, the tower was maintained directly by the supplier. Subsequently, the tower's maintenance was incorporated into one of the three HVAC system maintenance contracts awarded by the borough. As for the tower's automatic chemical injection system, another specialized firm saw to its proper functioning.

With respect to the second water cooling tower, it is also maintained under one of the three maintenance contracts awarded. This tower is not equipped with an automatic chemical

³⁵ See Table 3 in Section 4.1.2: "Inventory of Heating, Ventilation and Air Conditioning System Components."

injection system. To this effect, we note that the maintenance described in the tendering documents does not stipulate the obligation for the contracting firm to handle the treatment of the tower's circulating water through the injection of chemicals (biocide treatment). Although good practices point to the importance of chemically treating the water in cooling towers, the persons in charge within the borough instead maintain that this tower does not require a biocide treatment since its water is continuously renewed and the tower operates twelve months a year. In this regard, we also note that the tendering documents in no way require the successful firm to carry out bacteriological analyses of the water to detect the presence of bacteria of the *Legionella* species.

Moreover, we wanted to examine the implementation of the maintenance carried out on this type of equipment. Thus, in the case of the cooling water that was maintained by the equipment vendor, we were unable to find any documentary evidence with respect to the maintenance carried out under warranty in 2012. Apart from visiting the facilities, the persons met confirmed that no specific verification in that respect had been made.

As for the other water cooling tower, we wanted the assurance that it had been maintained in accordance with the specifications provided in the tendering documents. In order to achieve this, for 2012, we examined the work orders sent to the borough by the firm responsible for maintaining the tower. Although maintenance may have been carried out, the work orders examined provide no evidence whatsoever of maintenance on this tower. In our opinion, the borough would benefit from implementing a more rigorous and documented tracking mechanism for the maintenance activities carried out under contract by the external firms.

In the winter of 2013, given the coming into force of the new regulation respecting this type of equipment, the borough mandated a specialized firm to conduct bacteriological analyses of the water contained in its two cooling towers. The results indicated the absence of bacteria of the *Legionella* species. However, in the case of the tower that is not equipped with a chemical injection system, the external laboratory having conducted the analyses points out that this situation comes with a greater risk of problems, especially during the summer season.

Following the coming into force of the new regulation respecting the maintenance of water cooling towers, the RBQ inspected the borough's towers in June 2013 to evaluate if they were being maintained in compliance with the regulation. Following its inspection, the RBQ issued a correction notice for one of the two towers, namely the one equipped with an automatic chemical injection system. Under this notice, the borough was ordered to:

- implement a specific PMP for the cooling tower, developed by one or several members of a professional order (Section 402 of the regulation);

- make a log containing all of the required information and documents, including the cooling tower's PMP (Section 406 of the regulation) available for on-site consultation purposes for the entire existence of the building.

According to the information obtained from the persons in charge, steps have since been taken to ensure that the borough complies with the new regulatory requirements. Thus, for the water cooling tower equipped with an automatic chemical injection system, the borough mandated a specialized firm to develop the new PMP. We obtained a copy. As is the case of all of the other business units audited, although we were not in a position to determine the compliance of this PMP, our audit enabled us to conclude that it details the required maintenance activities and their frequencies. Furthermore, although it is not mandatory under the new regulation, the PMP also provides a highly relevant control for evaluating the efficiency of the PMP, namely a monthly *Legionella* screening test. In our opinion, this represents a sound and prudent management practice for ensuring public safety with respect to air quality. We also note that the borough now keeps an onsite maintenance log for this tower. However, upon examination of this log, we noted that it was not in all respects compliant with the requirements of the new regulation in force for this type of equipment. For example, we were unable to trace the manufacturer's operating and maintenance manual or the names of the person in charge of the maintenance and the persons assigned to maintenance.

As far as the second water cooling tower is concerned, by the end of our audit, the borough was still waiting to receive the RBQ's notice regarding the need to develop a PMP and keep a maintenance log in accordance with the new regulatory provisions for this tower.

4.4.3.B. Recommendation

We recommend that, in order to comply with the new regulatory requirements in effect, the LaSalle borough:

- **pursue the necessary efforts to develop a preventive maintenance program specific to the water cooling tower awaiting the issue of a notice by the Régie du bâtiment du Québec and implement said PMP;**
- **incorporate into the maintenance log kept on site all of the items required under the regulation respecting water cooling towers;**
- **implement a documented tracking process for the maintenance activities carried out under contract by external firms.**

Business unit's response

*[TRANSLATION] An engineering firm was mandated to develop the PMP for the water cooling tower at the Dollard–Saint-Laurent. The program is scheduled to be completed and implemented by April 4, 2014, in accordance with the agreement reached with the RBQ. **(Completed)***

The water cooling towers' preventive maintenance programs and logs shall be completed and implemented in accordance with the new regulation in force. The tracking process is documented.

*The logs implemented shall include all of the tasks in accordance with the frequencies specified in the PMP. **(Planned completion: April 2014)***

*An audit report on equipment maintenance shall be drafted and reviewed quarterly. **(Planned completion: June 2014)***

4.5. Interior Air Quality Monitoring Mechanisms

A building's IAQ is closely linked to its physical characteristics and the efficiency of its HVAC systems. Apart from adequate design and regular maintenance of all building components, the industry's good practices recommend air quality monitoring mechanisms to be able to react appropriately to unforeseeable events that could lead to a deterioration of IAQ despite the application of a PMP.

Such mechanisms may include regular visual inspections of buildings and facilities, remote surveillance of facilities and a mechanism for managing occupants' complaints. Aside from seeing to the proper functioning of the HVAC systems, these monitoring activities are also intended to detect unwanted contaminants (e.g., noxious gases present in the air, asbestos) or other potential sources that could have a negative effect on IAQ (e.g., mildew, water infiltrations).

Such monitoring mechanisms must not replace building and equipment PMPs, but rather complement them. Also, they are part of an overall IAQ management plan.

As part of our audit to verify the existence of IAQ monitoring mechanisms, we were able to identify three main mechanisms implemented by the audited business units:

- the remote monitoring of buildings' HVAC system operations;
- the probes that detect noxious gases in the air;
- the management of occupants' complaints.

4.5.1. Remote Monitoring

Remote monitoring is intended to provide the persons in charge with an overall view of the functioning of the equipment installed in buildings and make it possible to monitor the equipment from a distance. For remote monitoring purposes, a computer is equipped with a monitoring software application which is connected through a network to contact points,³⁶ probes³⁷ and automatic control systems.³⁸ These devices collect a large amount of data on the functioning of the equipment and the facilities, which data are relayed to a remote management central, an infrastructure that provides a specific and global knowledge base on real-time equipment operations. All this makes it possible to detect operating problems and optimize interventions when required.

Remote monitoring can be used to manage various types of equipment and facilities, including those that control power supply, lighting, access control, video surveillance and electromechanical systems such as HVAC systems. In the case of electromechanical systems, remote monitoring generates data of various natures, including on operating state (e.g., reaching the target temperature, functioning of ventilation components and motors). The data also trigger alarms in cases of malfunction (e.g., a breakdown or abnormal system shutdown).

With the various indicators and operating data it receives, the remote management central makes it possible to remotely monitor, troubleshoot and control the different systems and subsystems of buildings' electromechanical facilities.

The malfunction of certain equipment, including HVAC systems, or poor maintenance thereof could pose a health risk for occupants. The remote monitoring of buildings is a good practice because it contributes to mitigating the risks of not detecting equipment malfunctions and makes it possible to diagnose malfunctions and react quickly to correct them.

4.5.1.1. Direction des immeubles

4.5.1.1.A. Background and Findings

The DI operates a central building automation system to remotely manage the electromechanical (HVAC) systems in some of the buildings under its responsibility.

³⁶ Contact points are indicators of system operations (opened or closed).

³⁷ Probes are designed for electromechanical use. Some are used to measure a building's conditions that have an impact on system control. Probes are used to detect parameters such as air temperature and the concentrations of airborne gases. Using a relay, the automatic control systems process the data collected by the probes.

³⁸ An automatic control system is used to control equipment based on the data collected by probes.

According to our observations, this system enables users to remotely detect the sources of facility malfunctions and optimize internal interventions (e.g., repairs, replies to service calls). Indeed, when a problem arises, the remote management system detects and displays it and triggers an alarm on the control screen. In certain cases, it is even possible to solve the problem from a distance since the system allows the user to remotely activate, deactivate or modify the set points³⁹ of heating, ventilation and air conditioning equipment.

According to the information obtained, the central building automation system was implemented four years ago. Originally, the goal of remotely managing buildings was to save energy by reducing heating or air conditioning demands during periods of inoccupation (e.g., nights and days of inactivity). Another goal of remote management was to enable the detection of abnormalities which could result in sharp increases in energy costs if they were left unchecked.

Over time, as major repair or renovation projects were implemented, buildings were gradually connected to the central system. To date, according to the information we obtained from the person in charge, 168 out of 511 buildings for which the DI is responsible for maintenance have been connected to the central building automation system for all or part of their facilities. Also, although the central system makes it easier to intervene in the HVAC systems, it is not designed to detect air quality problems. Indeed, the proper functioning of the systems is not monitored on an ongoing basis because the system is used more as a tool to facilitate reactions to triggered alarms displayed on the control screen and to complaints lodged by the occupants.

According to the persons met, decisions regarding the connection of buildings under the DI's responsibility to the remote management system are made by the persons in charge of renovation or building construction projects, at their full discretion. According to the information obtained, despite the absence of a formal policy framework to support decisions on connecting buildings to the remote management system, the main factors taken into account are financial considerations, operational efficiency and energy conservation rather than building IAQ.

4.5.1.2. Saint-Laurent Borough

4.5.1.2.A. Background and Findings

The Saint-Laurent borough also operates a remote management software application that is separate from the central building automation system operated by the DI. This software gives

³⁹ A set point is a reference value that is to be maintained (e.g., a room's ambient temperature).

users real-time remote access to buildings' embedded systems. With respect to IAQ, for remotely managed facilities, different checkpoints are monitored, including the humidity rate to prevent the development of mildew, the temperature and the carbon dioxide (CO₂) level.

Should abnormalities arise (e.g., a ventilation system shuts down or systems are not triggered at programmed set points), the remote management software triggers alarms that are sent directly to the designated persons in charge, who then analyze the abnormalities detected and intervene as required to correct the problems detected.

According to the information obtained from the persons met, decisions to connect buildings to the central system are made based on the relative importance of each building and its facilities (e.g., high traffic, nature of the activities in the building) as well as the cost/benefit ratio of the required investment. In this respect, we were informed that 9 of the 45 buildings making up the borough's building inventory had been found to be important enough to justify their connection to the remote monitoring system.

4.5.1.3. LaSalle Borough

4.5.1.3.A. Background and Findings

Some of the LaSalle borough's buildings are also connected to a remote management software application that is separate from the software used by the DI. It enables the persons in charge to view the functioning of the HVAC system components in real time and control them from a distance. We were informed that 5 of the borough's 34 buildings are connected to this remote management software. According to the information obtained, the decision as to whether or not to connect a building to the central system is based among other factors on the importance of the building and its facilities as well as the cost/benefit ratio of the required investment.

Furthermore, as is the case with the DI and the Saint-Laurent borough, the persons in charge with whom we met mentioned that they do not necessarily monitor the systems connected to the central on an ongoing basis. However, based on the visual or audible signals emitted by the central system, the person in charge points out that it is possible to detect, diagnose and correct HVAC system malfunctions when they arise.

4.5.2. Gas Sensing Probes

4.5.2.A. Background and Findings

First of all, as was pointed out previously, several risk factors may have an impact on IAQ, including the number of occupants in the buildings (which can contribute to increasing carbon dioxide (CO₂) levels) or the temperature in the occupied rooms (which can impact occupants' comfort levels). Certain activities carried out in the buildings may also contribute to contaminating the ambient air (e.g., paint shops, mechanical workshops). Usually, these activities are carried out in rooms designed for that purpose and normally fitted with independent ventilation systems and contaminant source detection systems. Nevertheless, given these risk factors, good industry practices suggest the implementation of monitoring mechanisms to detect the presence of unwanted contaminants that could negatively affect IAQ or thermal comfort.

For IAQ monitoring to be possible, buildings must be equipped with probes, i.e., sensors that are installed at various locations within the building (e.g., in the garages, workshops and offices) or directly in the ventilation systems. Since thermal comfort parameters also determine IAQ, certain probes measure parameters such as temperature (thermostat) and—in certain cases—intervene directly to control the systems and ensure that the measured parameters meet the predetermined standard set points. Other probes are used to detect the airborne levels of toxic or dangerous gases (e.g., carbon dioxide [CO₂], nitrogen dioxide [NO₂], methylene [CH₂], ammonia⁴⁰ [NH₃] and methane [CH₄]).

In light of the information obtained from the persons contacted, we observe that the audited units have such IAQ monitoring mechanisms. Indeed, the different probes installed in the audited units' buildings are used to measure and control thermal comfort as well as to detect toxic gases in certain specific rooms and buildings that are part of their inventories. Furthermore, the persons in charge inform us that, in certain cases, the temperature and carbon dioxide (CO₂) sensing probes as well as all ammonia (NH₃) sensing probes are connected to the remote management central system.

The measures taken by the temperature and carbon dioxide (CO₂) sensing probes connected to the HVAC systems control the functioning of the system. The system makes the necessary adjustments until the temperature and carbon dioxide levels are in line with the applicable standards. For example, according to the indoor and outdoor temperature levels measured

⁴⁰ Ammonia is a chemical used in cooling processes, specifically in arenas. Under normal temperature and pressure conditions, it is a gas that is noxious if inhaled. At low doses, it will cause irritation and inflammation of the airways. Long-term inhalation exposure to low concentrations or short-term exposure to high concentrations of the gas may cause deleterious health effects.

by the probes, the louvers—HVAC system components that control the admission of fresh air into the system—are automatically adjusted to reach an acceptable temperature according to the applicable standards. In this regard, the city has adopted a norm on standardizing air, water, air conditioning and heating temperatures within the city's premises and buildings.⁴¹ The temperature levels set out in the norm are based on both the purpose that a building serves (e.g., sports centre, office building or premises, workshop) and the building's period of occupancy. The persons in charge of the DI point out that the norm was also adopted for the purpose of reducing energy costs.

With respect to the probes that detect the presence of ammonia (NH₃) in the arenas, although they are connected to the DI's central building automation system, they do not intervene in HVAC system operations. Indeed, according to the information obtained, the main goal of remotely monitoring these probes is to alert the persons in charge should an ammonia (NH₃) leak be detected in order to deploy the Plan particulier d'intervention en mesure d'urgence⁴² [TRANSLATION: Specific emergency intervention plan] developed for such incidents. Given the health consequences of an ammonia (NH₃) leak for occupants, the persons in charge who we contacted informed us that the probes are connected not only to the central building automation system but also to an operational centre⁴³ managed by the DI and the SIM. These aspects regarding emergency measures were not included in this audit however.

It must be pointed out that, except for the ammonia (NH₃) sensing probes and certain carbon dioxide (CO₂) sensing probes, the persons in charge of the units with whom we met informed us that the other toxic gas sensing probes are not connected to the central building automation system (surveillance by remote management). These probes are said to be "standalone probes" seeing as they trigger local alarms when they detect gas concentrations in the air that are higher than the predetermined allowable levels. In certain cases, the gas sensing probes trigger air exhaust fans directly in rooms where the presence of contaminants has been detected.

Whether or not they are connected to a central monitoring system, the probes must function adequately. For that reason, apart from the temperature probes—which are considered "inert"—, the probes used to detect the presence of toxic gases in the ambient air must be maintained and calibrated on a regular basis (e.g., twice a year) to ensure their proper functioning. Maintaining them is that much more important considering the severity of the

⁴¹ Standard titled "Gestion et contrôle de l'énergie dans les bâtiments municipaux," September 2011.

⁴² The goal of the Plan particulier d'intervention en mesure d'urgence [TRANSLATION: Specific emergency measures plan] is to protect the lives and health of the employees, users and abutting owners of sports facilities where ammonia is used as a coolant by ensuring swift and safe interventions when incidents occur.

⁴³ This operational centre operates 24/7. Among other functions, it provides remote monitoring, access control and alarm supervision services within several municipal buildings.

consequences for human health and life should they not function properly and not detect a toxic gas leak. Moreover, one of the persons in charge contacted within the DI went so far as to stress the importance of ensuring that probes are maintained and function properly to eliminate the risks of probes sending erroneous data to the central building automation system.

For each of the audited business units, we sought to obtain information allowing us to validate that the probes designed to detect toxic gases in the buildings had received the proper preventive maintenance and had been adequately calibrated.

4.5.2.1. Direction des immeubles

4.5.2.1.A. Background and Findings

The information obtained from the persons in charge within the DI indicate that, of the 511 buildings that the DI is responsible for maintaining, approximately 540 gas sensing probes were inventoried in the 98 buildings.⁴⁴ These probes serve specifically to detect concentrations of toxic or dangerous gases such as ammonia (NH₃), carbon monoxide (CO), nitrogen dioxide (NO₂) and carbon dioxide (CO₂).

Moreover, the same information obtained indicates that the maintenance and calibration of all of the gas sensing probes are under the responsibility of the Section des travaux d'entretien à contrat, which mandates external firms for this purpose on a biannual basis, as provided by the PMP⁴⁵ implemented for this component type. Given the importance and underlying risks of not maintaining this component type adequately, we sought to corroborate the information thus obtained and evaluate the extent to which these probes had actually been rigorously maintained on a preventive basis as scheduled. However, despite our repeated requests made to the persons in charge of the DI to obtain the necessary evidence to make this validation (e.g., contracts awarded, evidence of maintenances carried out), we were unable to consult any documentation. Under the circumstances, we can simply raise the question as to whether the maintenance of this component type was neglected or not carried out at all whereas these components are critical to IAQ monitoring and could have health and safety consequences for building occupants. If that is the case, we believe it is imperative to take corrective measures as soon as possible to ensure that the gas sensing probes are rigorously maintained and calibrated.

⁴⁴ The 98 buildings include among others city hall, the municipal courthouse, the SPVM's headquarters and neighbourhood police stations, the SIM's fire stations as well as certain arenas, sports centres, garages and municipal workshops.

⁴⁵ PMP 15990 – Inspection and calibration of gas detectors (probes).

4.5.2.1.B. Recommendation

We recommend that the Direction des immeubles take the necessary measures as soon as possible to ensure that the gas sensing probes in the buildings under its responsibility are maintained and calibrated both rigorously and periodically to prevent malfunctions that could negatively affect the health and safety of building occupants.

Business unit's response:

[TRANSLATION] A public call for tenders document is being prepared with the goal of awarding a contract in September 2014. (Planned completion: September 2014)

The completion of the maintenance work carried out by the service providers shall be rigorously tracked to ensure that work is completed as set out in the contract. In this regard, the maintenance contract also sets out penalties in the event the contractee defaults. Such penalties have already been imposed in the past. The DI shall take the necessary measures to have the clauses enforced should the service provider default. (Planned completion: September 2014)

4.5.2.2. Saint-Laurent Borough

4.5.2.2.A. Background and Findings

Concerning the Saint-Laurent borough, the persons in charge handed us an inventory listing 66 gas sensing probes installed in 9 of the borough's 45 buildings. These probes are used mainly to detect the airborne concentrations of toxic and dangerous gases such as ammonia (NH₃), carbon monoxide (CO), nitrogen oxides (NO and NO₂), methane (CH₄) and carbon dioxide (CO₂).

Except for the 17 carbon dioxide (CO₂) sensing probes, we were able to observe that, up to the middle of 2012, the borough contracted out the maintenance and calibration of the other probes to an external specialized firm. However, according to the information obtained from the persons with whom we met, during the remainder of 2012 and in 2013, it appears that the borough called upon a specialized firm to have the probes maintained and calibrated twice a year.

For the purpose of being able to validate the implementation of the maintenances ordered by the borough, we audited a sample of two buildings⁴⁶ equipped with a total of 31 gas sensing probes (excluding carbon dioxide [CO₂] sensing probes). This enabled us to obtain evidence indicating that the probes in the two buildings making up our sample had been maintained

⁴⁶ One arena and the building housing the borough's municipal workshops.

and calibrated twice in 2012 and 2013. As for the carbon dioxide (CO₂) sensing probes, we were informed that the external firm had neither maintained nor calibrated them even though they were connected to the borough's remote management system.

4.5.2.2.B. Recommendation

We recommend that the Saint-Laurent borough take the necessary measures to ensure that all of the gas sensing probes in the buildings under its responsibility are periodically maintained and calibrated.

Business unit's response:

[TRANSLATION] The carbon monoxide (CO), nitrogen oxide (NO and NO₂), ammonia (NH₃) and dangerous gas sensing probes are inspected twice a year.

*The carbon dioxide (CO₂) sensing probes are monitored on an ongoing basis using the Regulvar remote management system, which enables us to instantly track variations in a ventilation system's carbon dioxide (CO₂) levels. Our systems' carbon dioxide (CO₂) levels have always been below the ASHRAE's lower limit, as confirmed by the air quality reports prepared by the GESFOR group for three of our buildings (borough city hall, recreational centre, public works). **(Already in place)***

*The carbon dioxide (CO₂) sensing probes shall be calibrated yearly. **(Planned completion: December 2014)***

4.5.2.3. LaSalle Borough

4.5.2.3.A. Background and Findings

In the LaSalle borough, the persons in charge informed us that 23 gas sensing probes are inventoried among 5 of the borough's 34 buildings. According to the information obtained from these persons in charge, 14 of these probes are connected to the borough's central building automation system (i.e., 12 carbon dioxide [CO₂] sensing probes and 2 ammonia [NH₃] sensing probes). However, according to this same information, of the 23 probes making up the inventory, only those that are connected to the ventilation systems (i.e., 12 carbon dioxide [CO₂] sensing probes) are maintained and calibrated on a semi-annual basis in accordance with the requirements of one of the three HVAC system contracts awarded by the borough. Hence, the other 11 probes (of the 23 inventoried) are not particularly maintained on a preventive basis. These 11 probes are used among other purposes to detect the airborne concentrations of toxic and dangerous gases such as ammonia (NH₃), hydrogen sulfide (H₂S), carbon monoxide (CO) or nitrogen oxides (NO and NO₂). The persons in charge with whom we met however pointed out that they sporadically respond to service calls when certain interventions need to be carried out on these probes. To this effect, the only

interventions that we were able to trace concern a repair and a hook-up carried out on an ammonia probe (NH₃) in 2013.

With respect to the carbon dioxide (CO₂) sensing probes that are maintained and calibrated under contract, we sought to validate—for a sample of two buildings—that preventive maintenance had been implemented. Under the contractual agreement reached in 2013, this maintenance was to be carried out on a semi-annual basis. For 2013, we only obtained evidence of a single maintenance rather than the two that were scheduled. As for 2012, we were unable to obtain any evidence whatsoever of preventive maintenance for these carbon dioxide (CO₂) sensing probes. Indeed, as we previously pointed out (see Section 4.2.3), since the expiry in 2011 of the contract⁴⁷ for the maintenance of these probes, no other contract was awarded to this effect before September 2013.

However, in 2012, we managed to trace a certificate issued by a specialized firm to certify the proper functioning of six of the seven probes installed in the borough's municipal workshops.

4.5.2.3.B. Recommendation

We recommend that the LaSalle borough take the necessary measures as soon as possible to ensure that the gas sensing probes in the buildings under its responsibility are maintained and calibrated both rigorously and periodically to prevent malfunctions that could negatively affect the health and safety of building occupants.

Business unit's response:

[TRANSLATION] A meeting was held with the contracting firm last March 19. At that meeting, it was specified that the sensing probes incorporated in the ventilation systems must be calibrated semi-annually. A supporting document providing proof that the probes were calibrated must be provided. (Planned completion: June 2014)

A new external ventilation system sensing probe calibration contract shall be awarded to carry out the inspections. A calibration certificate shall be required. (Planned completion: June 2014)

4.5.3. Complaints Management

When complaints are filed, it is important to have administrative procedures in place to handle them quickly as well as to compile and analyze them over time. Indeed, compiled complaints

⁴⁷ Contract for the maintenance of HVAC system control components.

represent a source of relevant management information that is useful for analyzing the situation in search of the root cause of the signaled discomforts or problems and then implementing the necessary corrective measures.

Also, the diagnosis and analysis of reported complaints may prove highly useful for making decisions intended to improve maintenance activities, justifying the investments needed to improve facilities or recommending they be hooked up to the existing central building automation systems, if appropriate.

With that in mind, we examined how complaints were managed within each of the three business units audited.

4.5.3.1. Direction des immeubles

4.5.3.1.A. Background and Findings

The DI provides the users of the municipal buildings under its responsibility with a telephone number⁴⁸ that building occupants can dial to file any type of complaint concerning a problem they experience. All complaints received take on the form of “inquiries” and are entered into the SIGI by the receptionists assigned to this task.

Once the inquiries have been entered into the SIGI, work orders can be generated and assigned to blue collar workers by the forepersons within the DI. Inquiries of an urgent nature are reported directly by the receptionists to the persons in charge, and they are also entered into the SIGI. According to the information obtained, in the case of buildings for which maintenance is carried out under contract, the inquiries are entered into the SIGI and sent directly to the external firms responsible for the maintenance of the building in question.

Moreover, the persons with whom we met pointed out that occupants can also file their complaints directly (by email or phone) with the persons in charge of the buildings, thereby avoiding the central telephone system. The persons in charge assured us that such complaints are handled by blue collar workers, but the complaints are not filed or documented in the SIGI in such cases.

That being said, for 2011 and 2012, we observed that the DI had compiled approximately 22,000 inquiries per annum concerning either the Section d’entretien Est, Section d’entretien Ouest or Section des travaux d’entretien à contrat. Of this number, approximately 15% of all inquiries (i.e., 3,336 in 2011 and 3,299 in 2012) concerned HVAC systems. However, we

⁴⁸ Commonly referred to as “1.2.3.4 inquiries.”

must specify that these statistics do not include an unknown number of complaints received directly by the persons in charge of maintenance (complaints which were not entered into the SIGI).

The persons concerned agree that complaints regarding IAQ are not frequent and that major IAQ problems are isolated cases. Thus, most inquiries concerning HVAC systems have more to do with thermal comfort, i.e., indoor temperature. Furthermore, it was also pointed out to us that when it comes to IAQ, a good number of the situations that lead to complaints being filed can be corrected using the central building automation system of each of the audited business units. Indeed, when a building is connected to such a system, the information obtained from the central system very often enables the persons involved to make an initial diagnosis of the complaint received and, if necessary, intervene immediately and remotely in the concerned HVAC system. For example, these remote interventions may involve restarting a ventilation system, resetting fresh air intake louvers or regulating the temperature.

Tracking complaints involving HVAC systems is relevant when it comes to evaluating the proper functioning of systems and also serves as an indicator of the quality of the maintenance carried out on HVAC system components. In this sense, we attempted to verify if the issues raised in the complaints as well as the DI's interventions in response to these complaints had been properly documented.

We first note the existence of a management report titled "Suivi des requêtes" [TRANSLATION: Complaint follow-up]. This report is generated from the SIGI and indicates the number of inquiries as well as their status (i.e., "en cours," "différé," "annulé" or "terminé" [TRANSLATION: "in progress", "postponed", "cancelled", "completed"]). Next, we consulted a more detailed inquiry report generated by the SIGI (titled "Sommaire des bons de travail" [TRANSLATION: Work order summary]). This report provides among other information the name of the concerned building, the name of the person who requested the inquiry, a short description of the problem reported, the date it was reported and the date the intervention was carried out. Finally, each of the maintenance sections may also generate a report that enables the persons in charge to track the inquiries that are still active in the application and have therefore not yet been handled. This report is titled "Liste des demandes ouvertes" [TRANSLATION: List of open complaints].

In general, we observe that the DI uses a relevant management tool to index the number and nature of complaints and track them over time. However, in the case of complaints that have been settled or cancelled, we note that there exists no documented history in the application of the diagnosis made or of the measures taken to correct the problem having given rise to the complaint. Indeed, according to the information received from the persons with whom we

met, it may occur that the blue collar workers assigned to handle a complaint write down comments on the work order indicating the measures they took to correct the situation. However, it is the opinion of the persons met that no comments or other annotations are entered into the SIGI. Also, it appears that the work orders (hard copies) are not kept once the work has been completed.

We are aware that the inquiries concerning IAQ that are entered into the SIGI exhibit variable levels of risk and that some of these inquiries have very little effect on occupants' health and safety. Nevertheless, in the absence of a history of the corrective measures taken, it could be more difficult for the city to demonstrate that it acted diligently should a more critical situation arise.

4.5.3.1.B. Recommendation

We recommend that, in order to demonstrate that it acted diligently when an air quality problem arose, the Direction des immeubles take the necessary measures to keep a documented history of the diagnoses made and measures taken to correct the situations having given rise to complaints.

Business unit's response:

[TRANSLATION] The DI favours the use of a sole and single system, namely the SIGI and its SIGI-Mobile application, used to enter information and document the history of actions taken. In order to do so, a procedure shall be disseminated to the personnel, namely to forepersons, to ensure that the air quality inquiries are more rigorously documented in this system. (Planned completion: November 2014)

4.5.3.2. Saint-Laurent Borough

4.5.3.2.A. Background and Findings

To enable the users of the buildings for which the Saint-Laurent borough is responsible for maintaining to report all types of complaints, regardless of the problems encountered, the borough provides them with access to the same telephone line (1.2.3.4 inquiries) as the one used by the DI. As is the case with the DI, the complaints received are compiled in the form of inquiries that are then entered into the SIGI. This enables forepersons to generate the work orders and assign them to blue collar workers for the purpose of having the required work carried out. To track these inquiries, the borough can use the SIGI to generate the same reports as those used by the DI.

For 2011 and 2012, we found that approximately 1,900 inquiries per year had been compiled (1,887 in 2011 and 1,900 in 2012). Between 3% and 5% of these inquiries concerned the HVAC systems. The persons in charge point out that air quality complaints are rare and have more to do with thermal discomfort in certain rooms than with major problems.

As is the case with the DI, we therefore observe that the borough uses a relevant management tool for indexing the number and nature of complaints and tracking them over time. However, in the case of complaints that have been settled or cancelled, the persons met confirmed to us that there exists no documented history in the SIGI of the diagnoses made or of the measures taken to correct problems having given rise to complaints. Also, although the blue collar workers assigned to handle a complaint may write down comments on the work order indicating the measures they took to correct the situation, none of these comments or other annotations are entered into the SIGI. Furthermore, the work orders (hard copies) are not kept once the work has been completed.

We are aware that the inquiries concerning IAQ that are entered into the SIGI exhibit variable levels of risk and that some of these inquiries have very little effect on occupants' health and safety. Nevertheless, in the absence of a history of the corrective measures taken, it could be more difficult for the borough to demonstrate that it acted diligently should a more critical situation arise.

4.5.3.2.B. Recommendation

We recommend that, in order to demonstrate that it acted diligently when an air quality problem arose, the Saint-Laurent borough take the necessary measures to keep a documented history of the diagnoses made and measures taken to correct the situations having given rise to complaints.

Business unit's response:

[TRANSLATION] All inquiries concerning issues that compromise air quality are processed immediately. Henceforth, inquiries shall be rigorously tracked to ensure that the history of interventions and subsequent comments are entered in the SIGI.

The DI shall develop a report for the purpose of documenting the history of interventions. (Planned completion: December 2014)

4.5.3.3. LaSalle Borough

4.5.3.3.A. Background and Findings

With respect to the LaSalle borough, the persons met pointed out that complaints are usually received by telephone or email. However, they are neither compiled nor documented in any particular fashion with respect to their magnitude or nature. This makes it impossible to track them over time. Consequently, we have no idea of the number of complaints that the borough received on an annual basis. Nevertheless, it was mentioned to us that complaints involving air quality are rare and in most case involve thermal discomfort in certain rooms.

Under the circumstances, it is our opinion that the LaSalle borough would benefit from implementing a management system to compile all types of complaints regarding problems experienced by the occupants of buildings under its responsibility and trace the history thereof. The selected tool should enable the borough to among other things:

- compile the number and nature of complaints received;
- track how complaints are handled over time;
- have access to a documented history of the diagnoses made and measures taken to correct problematic situations.

As we previously mentioned, the compilation of complaints gives rise to a relevant source of management information for the purpose of analyzing situations to pinpoint the sources of discomforts or problems, taking the necessary corrective measures and ultimately rendering accounts thereon. Although the complaints received do not all exhibit a major level of risk, it is nevertheless important for the borough to have access to an efficient tool that enables it to easily demonstrate that it acted diligently should more serious situations require it.

4.5.3.3.B. Recommendation

We recommend that the LaSalle borough take the necessary measures to implement a structured mechanism for the purposes of compiling and documenting the complaints filed by the occupants of the buildings under its responsibility in order to be able to consult the history of complaints, track them over time and render accounts thereon for management purposes.

Business unit's response:

[TRANSLATION] All complaints concerning air quality and temperature must be sent to the secretary of the administrative unit of the Division des immeubles et matériel roulant. Accordingly, a notice shall be sent to all borough personnel.

The work order management system (GDT) shall be used to compile and track complaints. (Planned completion: June 2014)

4.6. Accountability Reporting

To enable the city's various business units to assess the efficiency of the measures taken to provide city building occupants with a healthy and safe environment in terms of IAQ, it is important to implement periodic accountability mechanisms. These mechanisms must provide sufficient information to allow the managers in charge to evaluate:

- the performance of the PMPs implemented for the HVAC systems with respect to the established objectives;
- the compliance of these PMPs with respect to the applicable standards and regulations;
- the occupants' satisfaction rates in light of the complaints recorded.

Of course, these mechanisms must provide reliable management information to support informed decision making.

4.6.1. Direction des immeubles

4.6.1.A. Background and Findings

Because of the shared roles and responsibilities, the DI assumes responsibility for the maintenance (routine and preventive) of certain buildings making up the central departments building inventory (e.g., the SIM's fire stations and the SPVM's neighbourhood police stations). It also ensures the maintenance of the buildings located on the territories of the nine boroughs of the former Ville de Montréal despite the fact that this responsibility falls upon the boroughs with respect to the inventory of buildings located on their respective territories, by virtue of the *Charter of Ville de Montréal*.

Although the responsibility for building maintenance has thus been delegated to the DI, by virtue of their jurisdiction, the boroughs of the former Ville de Montréal nevertheless render accounts to their citizens and employees. Hence, since IAQ represents an important issue, it is our opinion that these boroughs should be systematically informed of the performance of the PMPs concerning the HVAC system components in their buildings as well as of any other relevant management information in order to be able to respond proactively should the expected results not be produced.

In this regard, the persons met within the DI mentioned that in order to be able to better evaluate and prioritize the required investments in the three-year capital expenditures

program, the DI sporadically produced for these boroughs annual reviews indicating the physical obsolescence of certain building components. For example, such reviews were produced to expose the condition of building roofs. However, these same persons confirmed to us that no particular accountability reporting is provided with respect to the performance of the HVAC system PMPs which nevertheless involve the maintenance of components that are critical for air quality. Under the circumstances, it appears that the boroughs of the former Ville de Montréal do not dispose of any tangible information enabling them to evaluate the extent to which the preventive maintenance of the HVAC systems is actually carried out by the DI within the buildings under its responsibility.

Therefore, it is our opinion that—given its responsibilities—the DI has the duty to introduce the necessary accountability mechanisms. In order to achieve this, the parties would benefit from reaching a service agreement setting out the nature and periodicity of the information required for accountability reporting purposes (e.g., percentage of HVAC system PMPs implemented, measures implemented to ensure compliance with new regulatory provisions concerning IAQ, number of complaints received). This would encourage greater accountability on behalf of the boroughs concerned with respect to their obligations to obtain the required service.

In the same vein, we were informed of the existence of a service agreement between a borough created from a former suburban municipality and the DI. Since 2009, the borough has been calling upon the DI to carry out the preventive maintenance of ice rink refrigeration systems (PMP 1700), mechanical ventilation systems (PMP 2000) and filters (PMP 2200) for the arenas located on its territory. We obtained and reviewed the underlying documents for the 2012 service agreement. Following our review, we note that no obligation is set out for the DI to render accounts to the borough respecting the extent to which the planned PMPs were completed.

That being said, we also noted that the DI was able to generate from the SIGI a report titled “Bilan des PEP” [TRANSLATION: PMP summary]. As we set out in a previous section⁴⁹ of this audit report, this report presents the percentage of completion of HVAC system PMPs with respect to what was planned as well as a ratio of the actual time spent completing the work over the standard scheduled time. According to the information obtained from the person in charge within the DI, this report is generated monthly for the PMPs implemented by the Section d’entretien Est and Section d’entretien Ouest and is discussed during management committee meetings. The persons met confirmed our observations, i.e., the numerous shortcomings identified with respect to the unreliable data entered into the SIGI, namely with

⁴⁹ See Section 4.3.1.1. “Implementation and Tracking of the Completion of the Preventive Maintenance Programs – Internally.”

respect to the HVAC system components. These shortcomings raise questions as to the relevance of the report generated. Indeed, it should be noted that doubts were raised as to the reliability of this PMP summary report because of the lack of follow-up and documentation regarding work completion in the SIGI as well as the fact that the building and component inventories and HVAC system PMPs are incomplete and outdated, among other reasons.

Finally, as concerns the maintenance of the building under the responsibility of the Section des travaux d'entretien à contrat, the persons with whom we met pointed out that there is no formal accountability reporting mechanism in place for the implementation of the PMPs for these buildings.

In sum, it is clear that, in the absence of an accountability reporting mechanism that is well established and adequately supported by reliable management information, it is necessarily more difficult to demonstrate that the equipment within city buildings was maintained on a preventive basis as scheduled and in accordance with industry standards. Furthermore, the DI managers are thus deprived of information that would enable them to intervene proactively in problem sectors given the inherent risks and magnitude of both technical and financial needs.

4.6.1.B. Recommendation

We recommend that, for the purpose of enabling the boroughs to which it provides building maintenance services to be informed of the performance of the preventive maintenance programs carried out in their buildings, including with respect to heating, ventilation and air conditioning system components the Direction des immeubles:

- **take the necessary measures to reach service agreements with these boroughs stipulating the nature and periodicity of the accountability mechanisms agreed to by the parties;**
- **plan, upon the renewal of existing service agreements with certain boroughs created from former suburban municipalities, for the inclusion of these same measures with respect to the agreed-to accountability mechanisms.**

Obviously, implementing such mechanisms is conditional upon first implementing the required corrective measures to ensure the reliability of the information contained in the Système intégré de gestion des immeubles.

Business unit's response:

[TRANSLATION] The DI's objective is to use the SIGI to provide all of the city's business units with access to PMP completion data. (Planned completion: January 2015)

The DI favours exchanges with the more than 30 different business units for the purpose of sharing its results rather than making personalized service agreements which are not conducive to a consistent, comparable and relevant level of accountability.

Auditor general's comments:

I disagree with the DI's point of view according to which making service agreements stipulating the nature and frequency of accountability mechanisms agreed to between the parties is not relevant for the purpose of enabling the boroughs to evaluate PMP completion.

Indeed, although the responsibility for building maintenance has been delegated to the DI, the fact remains that, by virtue of their powers, the boroughs are accountable to their citizens and employees. Accordingly, it is my opinion that these delegated responsibilities should be exercised as part of a formal process. The concerned boroughs could thus agree on the required management information to enable them to appreciate the extent to which (preventive and corrective) maintenance activities have been completed in order to provide the occupants of the concerned municipal buildings with a safe and healthy environment in terms of IAQ.

4.6.1.C. Recommendation

We also recommend that, to be able to evaluate the performance of the preventive maintenance activities that are carried out by the external firms, the Direction des immeubles incorporate the appropriate accountability mechanisms in its service agreements with the boroughs.

Business unit's response:

[TRANSLATION] In the next call for tenders concerning the maintenance under contract of the electromechanical systems, the successful bidder shall be required to provide the director with a monthly signed document indicating the rate of completion (as a percentage) of the maintenance work carried out within each of the buildings covered by the contract.

*The director expects that all of the preventive maintenance work shall be completed (100%). The financial penalties set out in the contract shall be imposed on the successful bidder should he fail to comply with the maintenance schedules. **(Planned completion: September 2014)***

4.6.2. Saint-Laurent Borough

4.6.2.A. Background and Findings

With respect to accountability reporting, we observed that this borough produces an annual detailed report on building maintenance activities. In light of our review of the reports produced for 2011 and 2012, we note that various types of information has been compiled, including the year's main accomplishments (e.g., installation of new equipment in buildings or renovation of other buildings) as well as the number of interventions carried out in the buildings (e.g., the number of requests for plumbing, carpentry and painting work). We also note that the reports compile the number of preventive maintenance programs (PMPs) in place for HVAC system components among others. In this regard, in light of the observations made previously in this audit report,⁵⁰ we question the reliability of the information provided in the summary reports given our observation that the hard copies of the work orders that are generated by the SIGI and assigned to the borough's blue collar workers are not rigorously tracked and that their completion is not confirmed in the application. Moreover, the reports provide no information whatsoever on the extent to which the HVAC system component PMPs specific to the borough were implemented. The persons with whom we met gave us confirmation that no PMP completion tracking report or official accountability reporting mechanism was provided to this effect. Under the circumstances, it goes without saying that making optimal use of the SIGI's functionalities would certainly result in the generation of more accurate and complete information.

4.6.2.B. Recommendation

We recommend that the Saint-Laurent borough periodically render accounts on the extent to which the preventive maintenance program has been implemented to demonstrate the proper functioning of heating, ventilation and air conditioning systems and the maintenance of optimal air quality conditions within its buildings.

Business unit's response:

[TRANSLATION] From now on, the annual assessment of the Division de la mécanique des bâtiments et de l'éclairage des rues make reference to the air quality monitoring interventions in the buildings and specifically provide the following information:

- *the number of PMPs completed;*
- *the number of inquiries and PMP corrections;*
- *the details regarding sensing probe inspections;*
- *the details regarding water cooling tower maintenance. (Planned completion: December 2014)*

⁵⁰ See Section 4.3.2.1. "Implementation and Tracking of the Completion of the Preventive Maintenance Programs."

4.6.3. LaSalle Borough

4.6.3.A. Background and Findings

Under the contracts of the LaSalle borough, contractors are required to confirm the completion of work by sending a detailed report of their system inspection and maintenance activities (work orders). Thus, apart from the transmission of these work orders, we note that the borough uses no other mechanism to compile the information required to produce a management report indicating the rate of implementation of the planned PMPs by the contracting external firms. According to the information obtained, there is no official accountability reporting (e.g., annual summary report) to borough management as far as building maintenance activities are concerned.

4.6.3.B. Recommendation

We recommend that the LaSalle borough periodically render accounts on the extent to which the preventive maintenance program has been implemented to demonstrate the proper functioning of heating, ventilation and air conditioning systems and the maintenance of optimal air quality conditions within its buildings.

Business unit's response:

[TRANSLATION] Following the implementation of the preventive maintenance software application, it shall be possible to generate an annual report on the level of completion of the scheduled maintenance activities. (Planned completion: December 2016)

On a temporary basis, a report shall be generated from the maintenance programs, logs and work orders. (Planned completion: January 2015)

5. General Conclusion

Managers are unable to provide the assurance that all of the necessary measures have been implemented to keep the heating, ventilation and air conditioning (HVAC) system components operating efficiently within municipal buildings and thereby provide occupants with a healthy and safe environment.

Indeed, our audit highlighted a sufficient number of shortcomings to raise questions as to the compliance of the maintenance work with industry standards. This is all the more worrisome since the situation raises doubts as to the risk that the identified shortcomings could also affect other building component categories (e.g., plumbing systems, domestic water heaters, gas furnaces, elevators and sprinklers) that should also be maintained on a preventive basis.

These shortcomings lead us to conclude that the management of the preventive maintenance carried out on city buildings' HVAC system components is deficient. Our conclusion is based on the following observations among others:

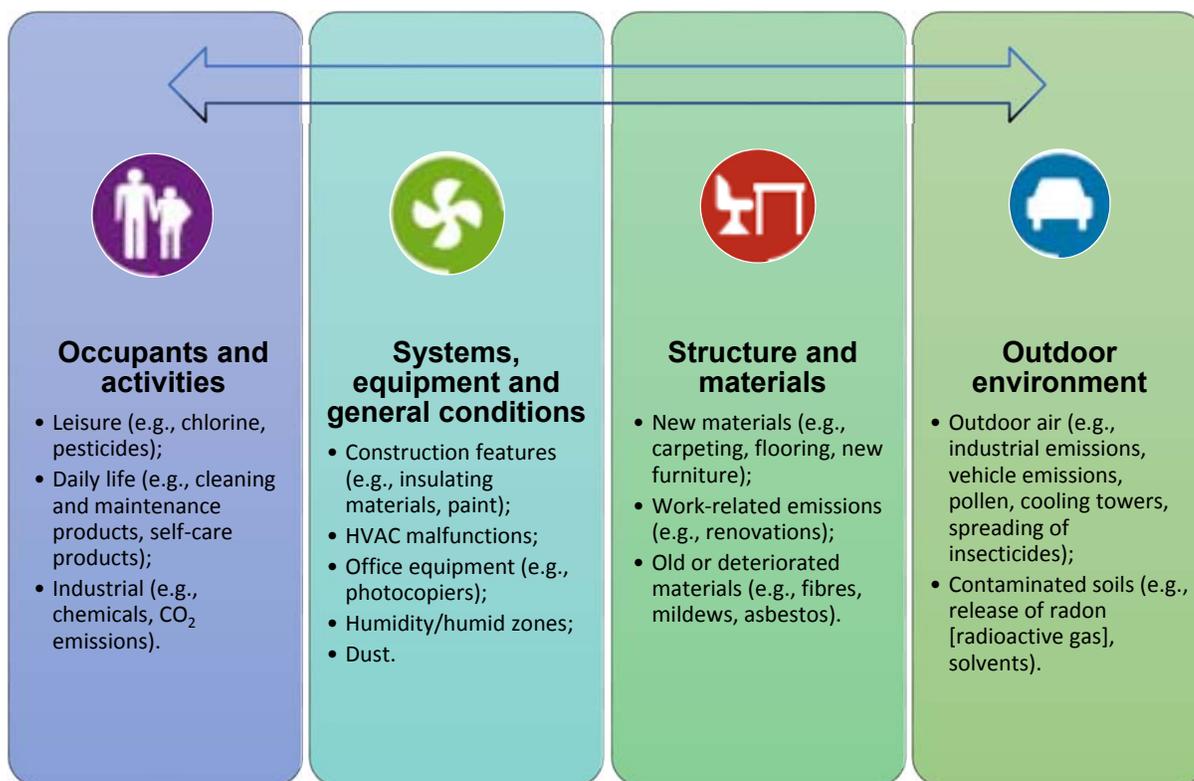
- It is possible that new buildings have not been inventoried. Consequently, they have not been incorporated into the preventive maintenance programs (PMPs);
- The inventory of buildings' air components is either incomplete or outdated;
- There is no structured and coherent communication mechanism to ensure that the component inventory is updated on an ongoing basis;
- The PMPs used for HVAC system components are not necessarily complete, up to date or compliant with good practices and industry standards, whether with respect to activities, tasks, standard maintenance completion times, frequencies or periods of the year during which these maintenances must be scheduled;
- Although the HVAC system PMPs were revised, these revised PMPs were not entered into the Système intégré de gestion des immeubles (SIGI) or included in the maintenance contracts awarded to external firms to be used during regular maintenance activities;
- In certain cases, the PMPs suggested by the external firms to which maintenance contracts were awarded are not systematically obtained for internal tracking purposes;
- It can prove difficult to establish the actual number of PMPs that were implemented given the lack of reliable compilation mechanisms or tools;
- Abnormalities were found with respect to the air quality monitoring mechanisms implemented;
- There are practically no accountability reporting requirements when it comes to the implementation of the PMPs.

Consequently, although some of the envisioned improvements are currently being implemented (e.g., implementation of SIGI-Mobile, entry of the revised PMPs in the SIGI), it is our opinion that major efforts must be made to ensure that the management process and tools recommended for maintaining the HVAC system components are fully operational and can be used to support informed decision making.

6. Appendices

6.1. Sources and Factors that Contribute to Indoor Air Quality

Figure A – Sources and Factors That Contribute to IAQ



6.2. Shared Roles and Responsibilities in the Maintenance of City Buildings

Table A – Roles and Responsibilities in Building Maintenance

Buildings		Applicant (responsible for the building)	Executor (responsible for maintenance)
Categories	Examples		
Central building inventory			
Central administrative service buildings and industrial or sports buildings that are the property of the city	<ul style="list-style-type: none"> Administrative: city hall Industrial: municipal garages, pumping stations Sports: Aréna Maurice-Richard 	DSTI	DI
SPVM buildings	<ul style="list-style-type: none"> Headquarters Neighbourhood police stations 	DSTI	DI
SIM buildings	<ul style="list-style-type: none"> Headquarters Fire stations 	DSTI	DI
Buildings in parks of the former MUC ^[a]	<ul style="list-style-type: none"> Parc-nature du Cap-Saint-Jacques Parc-nature de la Pointe-aux-Prairies 	DSTI and Direction des grands parcs et du verdissement ^[b]	Service de la qualité de vie
Public markets	<ul style="list-style-type: none"> Marché Atwater Marché Jean-Talon 	DSTI	Maintenance carried out by the Corporation de gestion des marchés publics de Montréal under contract with the DI
Wastewater treatment plant and drinking water filtration plants		DSTI and Service de l'eau	Service de l'eau
Buildings making up the Montréal Nature Museums: <ul style="list-style-type: none"> Biodome Botanical garden Insectarium Planetarium 		DSTI and Service de la qualité de vie	Service de la qualité de vie
Buildings in large parks of the former Ville de Montréal	<ul style="list-style-type: none"> Jarry Park Lafontaine Park 	DSTI	DI
Local building inventory (boroughs – including local parks)			
Buildings of the boroughs (9) of the former Ville de Montréal		Boroughs	DI
Buildings of the boroughs (10) created from the former suburban municipalities		Boroughs	<p>Boroughs</p> <p><i>Except when there exists an agreement with the DI for the maintenance of certain systems.</i></p> <p>For example:</p> <ul style="list-style-type: none"> Arena refrigeration system maintenance in the Montréal-Nord borough; Roof and mobile door maintenance in the Pierrefonds-Roxboro borough.

^[a] Montréal Urban Community.

^[b] The Service de la qualité de vie is responsible for this directorate.

6.3. Presence of Components in Heating, Ventilation and Air Conditioning Preventive Maintenance Programs

Table B – HVAC System Components Present in the PMPs

		The component and certain of its suggested actions are covered		
		In the PMPs		In the tendering documents
11 selected components	Suggested actions in accordance with good industry practices ^[a]	DI	Saint-Laurent borough	LaSalle borough
Outdoor air intake	Inspection, cleaning and repair of the outdoor air intake and its surroundings each season or more often if required.	YES	YES	NO ^[b]
Air filters	Replacement or cleaning of filters at regular intervals, twice a year or as recommended by the manufacturer.	YES	YES	YES
Coils	Cleaning of the coils at least once a year, regular inspection and daily verification of the water level in the drain.	YES	YES	YES
Fans	Periodic verification as recommended by the manufacturer, inspection at least twice per year, cleaning, adjustment and replacement of parts if required.	YES	YES	YES
Humidifier	Cleaning at least every three months during the heating period or as recommended by the manufacturer and annual cleaning of the purification systems' feed network.	YES	YES	YES
Diffusers and return-air grills	Verification twice a year of the unobstructed passage of air in the diffusers, maintenance and flow adjustment if required.	YES	YES	NO ^[b]
Thermostats	Calibration as recommended by the vendors and annual verification of their functioning or when a complaint is received.	YES	NO	YES
Stale air discharge	Periodic inspection and verification that the opening is free of any obstacle that could prevent the system from directing the stale air outside.	NO	YES	NO ^[b]
Ventilation timers	Verification and adjustments in accordance with the schedules established for starting up and shutting down the ventilation system.	NO	NO	YES
Cooling towers	Periodic bleeds, cleanings and analyses. Visual inspection once per week during the period of use. Microbial scale and corrosion control and bacterial analysis testing.	YES	YES	YES
Duct dampers	Regular inspection and replacement, if necessary, of the pistons to ensure an optimal functioning of the ventilation system.	NO	NO	YES

^[a] Reference sources:

- *L'entretien préventif des systèmes de ventilation*, Association paritaire pour la santé et la sécurité du travail secteur « affaires municipales », Technical sheet No. 31, Fall 2002.
- *Entretien de systèmes de ventilation en milieu scolaire – Responsabilités et bonnes pratiques*, Ministère de l'Éducation, du Loisir et du Sport, Document No. 6571, updated December 4, 2006.
- *Guide de qualité de l'air intérieur dans les établissements du réseau de la santé et des services sociaux*, Corporation d'hébergement du Québec for the Ministère de la Santé et des Services sociaux, 2005.

^[b] Component not mentioned in the LaSalle borough's HVAC system maintenance specifications, but may be included in the maintenance carried out by one of the contracting firms.