Proposal for updated Sulphur Dioxide (SO_2) Air Standards
Presentation to Clean Air Sarnia and Area

Ministry of Environment and Climate Change

December 6, 2017

Purpose & Outline

Purpose

- To provide a summary of the Ministry's proposal for updated sulphur dioxide (SO_2) air standards

Outline

- Ontario Air Standard Setting Process
- Summary of proposal to update the SO_2 AAQCs and air standards

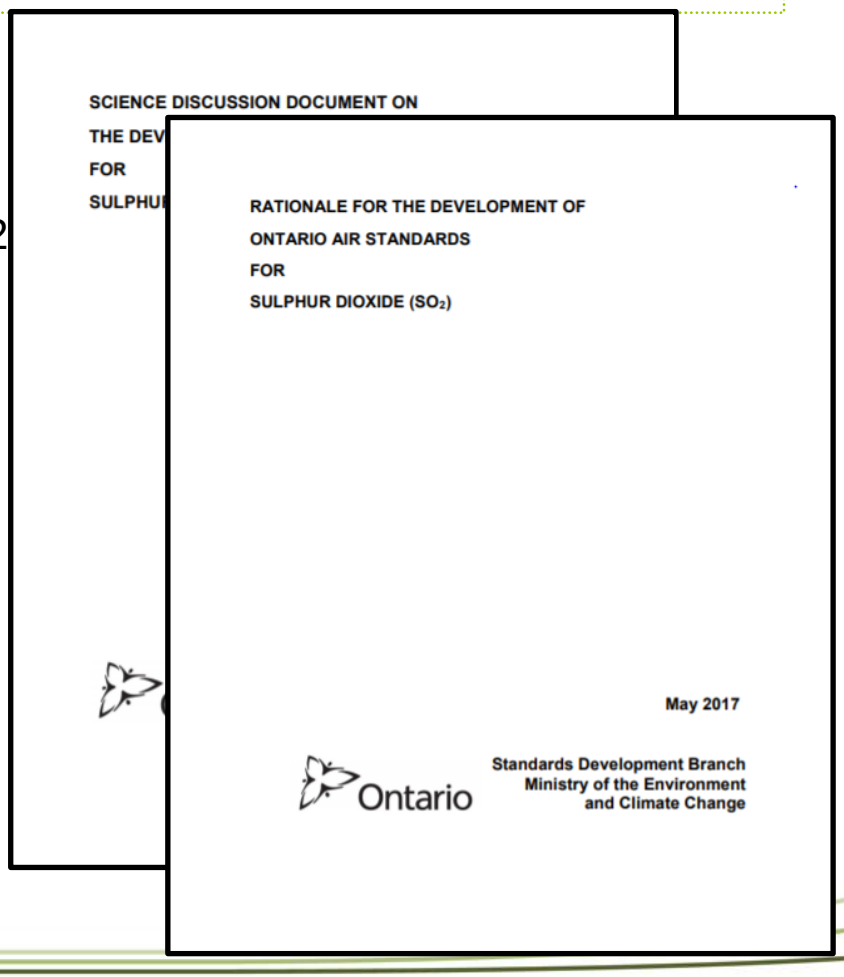
Ontario

Ontario Air Standards Development – a 3-step process

1) **Review the science** – prepare Science Discussion Document and post information notice on the Environmental Bill of Rights (EBR) Environmental Registry (EBR 012-7192 March 2016); meet with First Nations and stakeholders (May/July 2016).

2) **Propose standard and regulatory amendments** (45 day consultation period) - Rationale Document posted on the EBR Environmental Registry (EBR 013-0903; October 27, 2017); meet with stakeholders / comments until Dec 11, 2017

3) **Post final decision** – decision posted on the EBR Environmental Registry; regulation is amended.



Ontario

Air Standards Development

- The ministry sets standards based on health and environmental impacts without consideration of technology or economic issues.

- Toxicological information from peer-reviewed studies (animal, occupational, epidemiological) about a contaminant is reviewed to understand the contaminant's potential effects and to identify:
  - the critical effect (e.g., cancer, irritation, odour)
  - the most sensitive receptor (human, plant, animal)

- Air standards are set at concentrations well below the levels where adverse effects are observed.

- Most air standards are based on human health effects (i.e., most effects data is related to human health). For some contaminants, we have more than one standard, based on more than one effect of interest: *Two standards are proposed in the current update; an acute health-based standard, and a chronic ecological-based standard*

AAQCs and Air Standards

- The outcome of the science review is the development of ambient air quality criteria (AAQCs), which are non-regulatory targets for air quality. AAQCs are used to establish air standards under the regulation.

  - **AAQCs are used to assess ambient air quality** (i.e., resulting from *all sources of a contaminant to air*).

  - **Air standards are used to assess a regulated facility** and, if exceeded, drive abatement actions or requests to comply with the regulation through technology-based approaches.

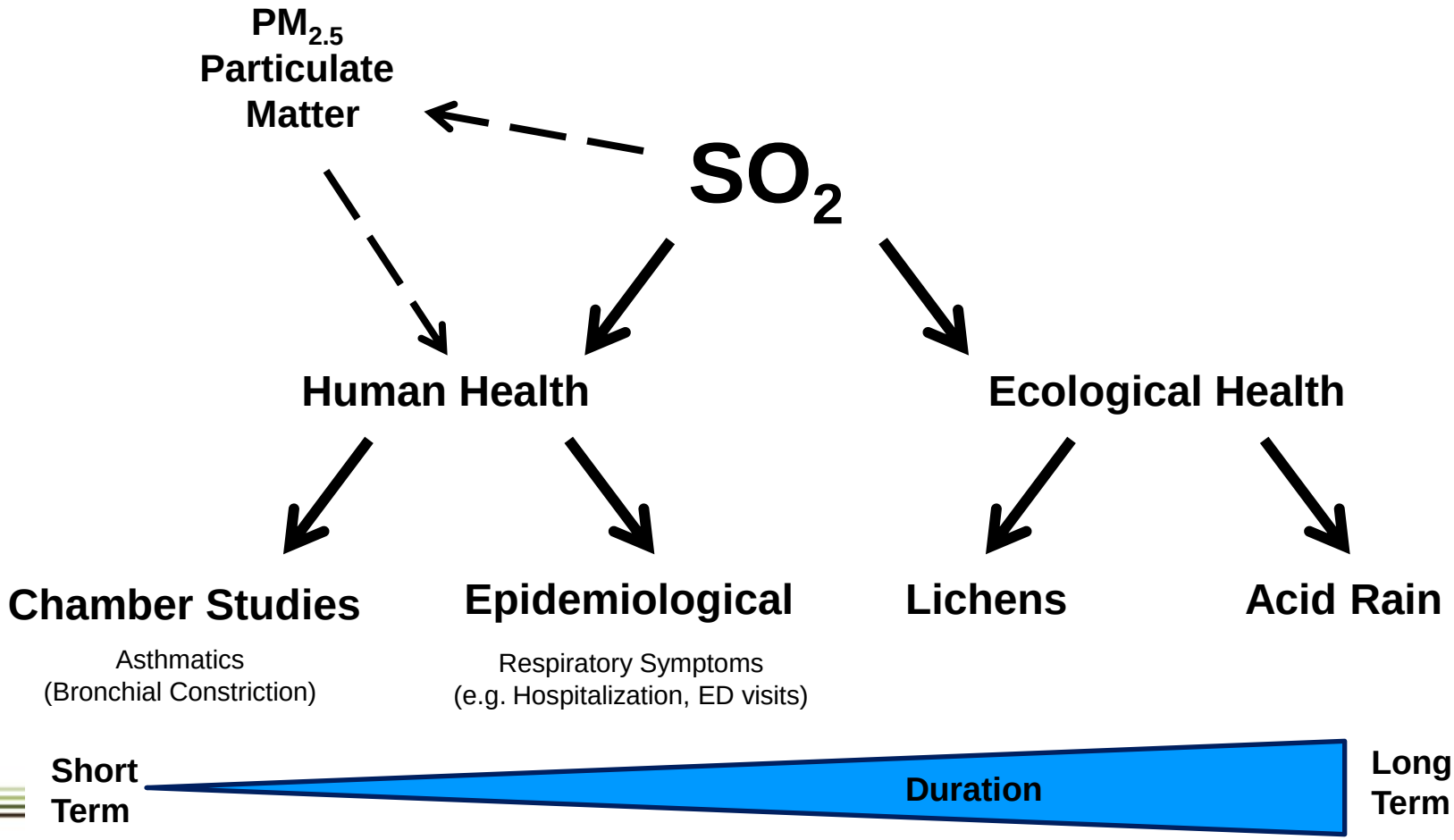
Why Are We Concerned About Sulphur Dioxide?

- Short-term exposure to sulphur dioxide causes **acute health effects** in the form of lung irritation (e.g., coughing, asthma attacks, cardiovascular impacts).

- Long-term exposure to sulphur dioxide causes **chronic health effects** by contributing to smog (e.g., breathing problems, hospital admissions, cardiovascular impacts).

- Long-term acidic deposition of sulphur dioxide causes **ecological effects**, such as vegetative damage and acidification of lakes.

SO_2 Effects



Ontario

Summary: Air Standards and AAQCs for SO_2

Existing (1974):

Standards:

- 830 μg/m³ (½ hour)
- 690 μg/m³ (1-hour)
- 275 μg/m³ (24-hour)

AAQCs:

- 690 μg/m³ (1-hour)
- 275 μg/m³ (24-hour)
- 55 μg/m³ (annual)

Proposed (2017):

Standards:

- **100 μg/m³ (1-hour)** (human health effects)
- **10 μg/m³ (annual)** (ecological effects)

AAQCs:

- **180 μg/m³ (10-min)** (human health effects)
- **100 μg/m³ (1-hour)** (human health effects)
- **10 μg/m³ (annual)** (ecological effects)

Proposed 1-hour Air Standard: 100 µg/m^3 (human health effects)

- The proposed 1 hour standard is designed to protect against critical human health impacts of SO_2.
- The science used to inform the proposed standard, includes the Health Canada reference concentration of **180 µg/m^3 (10-minute)**
- Based on the meteorological conversion factors used in O. Reg. 419/05, a reference concentration of 180 µg/m^3 (10-minute) converts to **100 µg/m^3 (1 hour)**
  - This conversion factor minimizes the number of 10-minute periods within the hour that the reference concentration (180 µg/m^3) is exceeded under real-world wind and weather conditions.
- Consistent with the standard-setting approach under the regulation, the selected value is considered to be **protective of both the general population and sensitive individuals** against the critical effects of acute exposure to sulphur dioxide.

Proposed Annual Air Standard: 10 µg/m³ (ecological effects)

In addition to a 1-hour standard set to address critical effects to human health, an SO_2 **annual standard of 10 µg/m³** is also proposed.

- Protects against sulphur dioxide contributions to acid deposition ("acid rain") and damaging effects on plants, including sensitive species such as lichens.
- Developed through consideration of World Health Organization (WHO) limits, studies from the Sudbury area, protection of crops, and the values assessed during the federal CAAQS process for sulphur dioxide.
  - The annual CAAQS for sulphur dioxide is 12 µg/m³ in 2020, and 10 µg/m³ in 2025.
  - The 10 µg/m³ target also aligns with the WHO value.

EBR Registry Number 013-0903

Title: Regulatory amendments to air emissions of sulphur dioxide and other items

a) Updated air standards for sulphur dioxide

Ministry specifically is seeking input on whether to apply the updated standards to Southern Ontario and have the current standards apply to Northern Ontario or part thereof.

b) Clarification of the requirements for assessing operating conditions

Questions or Comments

EBR Registry Number 013-0903

Date: December 11, 2017 (Public Record)

Contact:

All comments on this proposal must be directed to:

Lubna I. Hussain
Manager
Ministry of the Environment and Climate Change
Environmental Sciences and Standards Division
Standards Development Branch
40 St. Clair Avenue West
Floor 7
Toronto Ontario
M4V 1M2
Phone: (416) 212-0081
Fax: (416) 327-9187

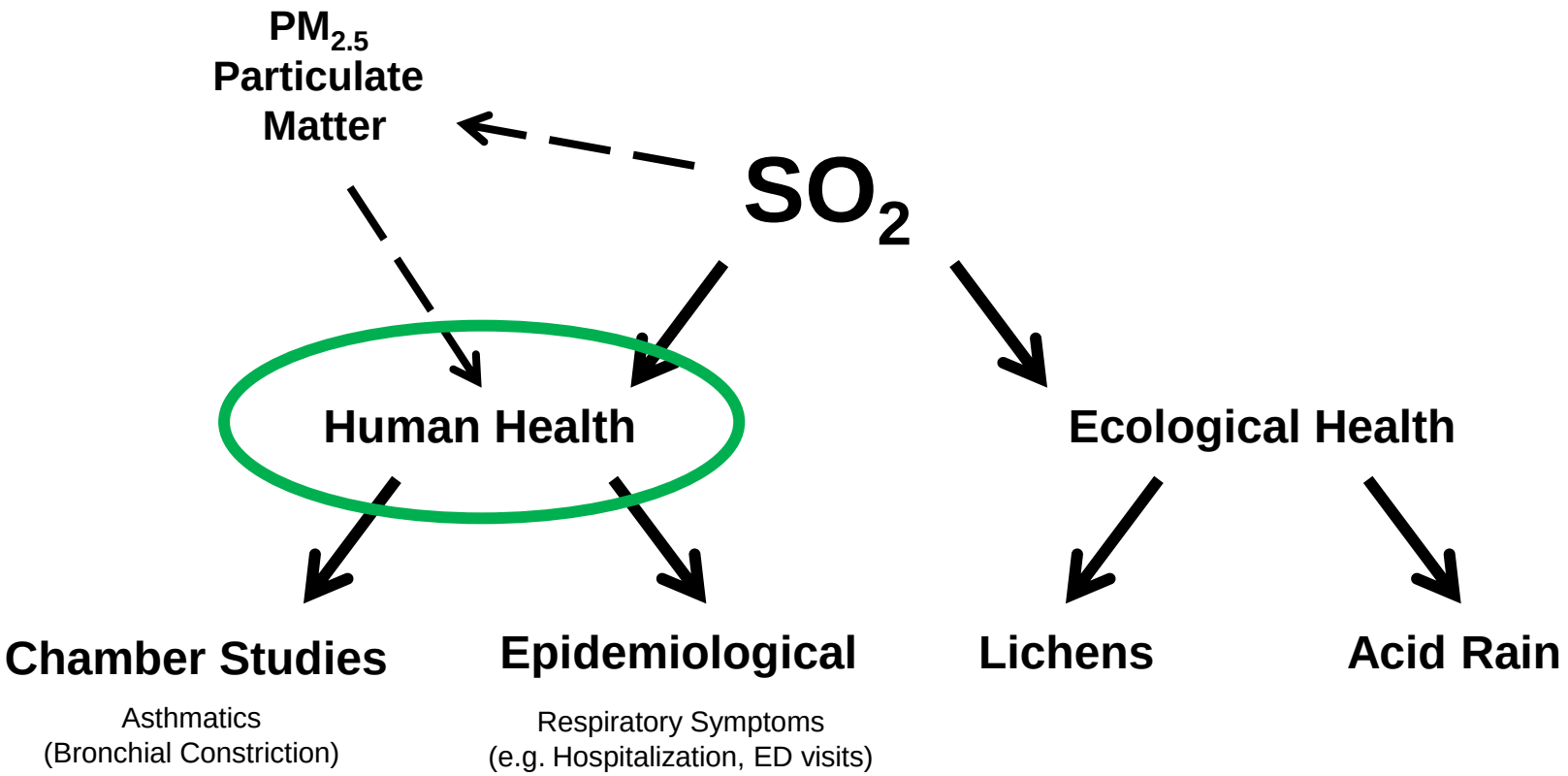
To submit a comment online, click the submit button below:

Submit Comment (opens in new window)

Ontario

Appendix

SO_2 Effects



Ontario

Rationale for a Short-Term AAQC & Air Standard

Human Health Endpoint

Mode Of Action

SO_2 inhalation

⇩

Bronchial chemosensitive receptors
in the tracheobronchial tree are stimulated

⇩

Vagal nerve stimulation
(afferents to CNS)

⇩

Smooth muscle contraction
(reflexive)

⇩

Bronchoconstriction

cough,
apnea followed by rapid shallow breathing,
mucus secretion,
mucosal vasodilation, and
cardiovascular system (bradycardia) hypotension or hypertension

MINISTRY RATIONALE: The Ministry will consider respiratory effects as the critical adverse health endpoint for short-term SO_2 exposure.

Susceptible Population

- Asthma is characterized by inflammation and airway hyper-responsiveness, which presents as excessive bronchoconstriction to irritants and other stimuli
- 3 million Canadians, representing about 9% of the population
- Epidemiologic (population) studies at relevant SO_2 concentrations show an increase in asthma-related hospital admissions in studies of all age groups (e.g., children, older adults)
- Clinical data show that respiratory effects experienced by asthmatics following SO_2 exposure appear to be more severe than among non-asthmatics

MINISTRY RATIONALE: Asthmatics are considered a susceptible population in studying the effects of SO_2 associated with bronchoconstriction.

Studies of Exercising Asthmatics

- Studies of exercising asthmatics allow for specific lung function measurements to be taken at specific concentrations of SO_2.
- The body's response to inhaled SO_2 is immediate.
- Despite a strong causal relationship between breathing difficulties and short-term exposure in population studies, studies of exercising asthmatics provide a more reliable method of quantitation than the semi-quantitative information gleaned from population studies

Rationale for Key Study

MINISTRY RATIONALE: The development of an acute AAQC for SO_2 is better served by the quantitative evaluation of lung function as observed in exercising asthmatics under controlled conditions (i.e., chamber studies), supported by semi-quantitative information from relevant epidemiological studies.

Thus, similar to Health Canada, the Ministry will utilize the U.S. EPA meta-analyses of multiple chamber studies of exercising asthmatics, in place of the selection of a single ‘key study’.

Approach #1 to develop an Acute AAQC: Health Canada (RfC) (2016)

Critical effect	Respiratory effects (bronchoconstriction)
Key study	Meta-analysis of clinical studies under controlled conditions (i.e., chamber studies) of exercising asthmatics (U.S. EPA, 2008, WHO 2005 and Johns and Linn, 2011)
Point of Departure	400 ppb (as a LOAEC) •400 - 600 ppb for 5-10 minutes •20-60% exercising asthmatics experience decrease in lung function •sRaw ≥ 200% increase and/or FEV1 ≥ 20% decrease •asthmatics may - symptoms (e.g., wheezing, chest tightness)
Uncertainty Factor(s)	6
Approach #1 Acute AAQC	**67 ppb (10 minutes)**

Ontario

Approach #2 to develop an Acute AAQC: Ontario-modified Health Canada RfC (2016)

Critical effect	Respiratory effects (bronchoconstriction)
Key study	Meta-analysis of clinical studies under controlled conditions (i.e., chamber studies) of exercising asthmatics (U.S. EPA, 2008, WHO 2005 and Johns and Linn, 2011)
Point of Departure	200 ppb (akin to BMD) •200 - 300 ppb (≈525 – 800 µg/m3) for 5-10 minutes •5-30% exercising asthmatics experience decreases in lung function •sRaw ≥ 100% increase and/or FEV1 ≥ 15% decrease •some asthmatic individuals - asymptomatic
Uncertainty Factor(s)	3 (for intra-species sensitivity)
Approach #2 Acute AAQC	**67 ppb (10 minutes)**

Ontario

Proposed AAQC Derivation

Regardless of the approach taken in deriving a health-based AAQC, both approaches to derivation (i.e., #1, Health Canada RfC; #2, Ontario-modified Health Canada RfC) are supportable, and both result in an AAQC of 67 ppb (180 µg/m^3) associated with a 10-minute exposure.

MINISTRY RATIONALE: Based on the U.S. EPA and Health Canada meta-analyses of chamber studies of exercising asthmatics, the Ministry considers 67 ppb (180 µg/m^3) an appropriate health-based value for an acute AAQC derivation, in order to protect the general population and sensitive individuals against the health effects associated with a 10-minute exposure to SO_2.

Ontario

Rationale for Averaging Time

- Science shows that 5-10 minute exposures are the most health-relevant.
- An AAQC could be considered over 10 minutes, but a 1-hour value IS more practical for the air standard.
- When setting the air standard, consideration must be made of meteorological variation within an hour period that can result in peaks of 10-minutes

MINISTRY RATIONALE: A 10-minute averaging time would be the most health-relevant for the proposed acute AAQC of 67 ppb (180 µg/m^3). Additionally, a 1-hour AAQC and 1-hour air standard of 40 ppb (100 µg/m^3) are proposed to support evaluation of ambient air monitoring and O. Reg. 419/05, respectively.

Recommended Acute AAQC and Air Standard for SO_2

- Based on a quantitative analysis of human clinical studies under controlled conditions of exercising asthmatics experiencing respiratory morbidity, the Ministry proposes the following health-based acute AAQC for SO_2:

  • 10-minute AAQC of 180 µg/m^3 for SO_2 (67 ppb), based on respiratory morbidity in exposed sensitive populations

- Using the preceding health-based 10-minute AAQC as a foundation, the following converted AAQC and air standard are proposed:

  • 1-hour AAQC of 100 µg/m^3 for SO_2 (40 ppb), based on respiratory morbidity in exposed sensitive populations

- For Ontario Regulation 419: Air Pollution – Local Air Quality compliance purposes, the Ministry proposes the following air standard for SO_2:

  • 1-hour air standard of 100 µg/m^3 for SO_2 (40 ppb), based on respiratory morbidity in exposed sensitive populations

Summary of proposed AAQCs and Air Standards for SO_2

Averaging Time	AAQC ($\mu g/m^3$)	Air Standard ($\mu g/m^3$)	Basis
10 min	180	–	Health (respiratory morbidity)
1-hr	100	100	Health (respiratory morbidity)
Annual	10	10	Vegetation (damage)

Ontario

Rationale for a Long-Term AAQC & Air Standard

Ecological Endpoint

Ecological Effects

- In humid air and under fog conditions, SO_2 dissolves in water molecules leading to the formation of a sulphuric acid mist, increasing potential of adverse effects on plants (i.e., acid deposition)

MINISTRY RATIONALE: The Ministry considers the direct effect of SO_2 on vegetation, including foliar injury, decreased photosynthesis, and decreased growth, as the critical adverse endpoint for long-term SO_2 exposure.

- Lichens are among the first species affected by acidifying deposition in land ecosystems, and are known early-warning indicators of air pollution.

MINISTRY RATIONALE: The Ministry considers lichens as the susceptible species in studying the chronic effects of SO_2 on the environment.

Rationale for a Long-Term AAQC

- The Ministry considered World Health Organization (WHO) limit for the protection of lichens, and considered studies on vegetation in the Sudbury area, the protection of crops, and the values considered during the Federal CAAQS process.

MINISTRY RATIONALE: The Ministry considers the lower bound of the CCME range 4 ppb (10 µg/m^3) as appropriate proposed value for a chronic AAQC for SO_2, in order to protect against ecological impacts.

- The Ministry considered toxicological and implementation issues in assigning an averaging time.

MINISTRY RATIONALE: An annual averaging time would be the most toxicologically-relevant for the chronic ecologically-based AAQC and air standard.

Recommended Chronic AAQC and Air Standard for SO_2

- Considering the observable effects on lichen abundance and biodiversity with environmental chronic exposures to SO_2, the Ministry proposes the following ecologically-based chronic AAQC for SO_2:

  • Annual AAQC of 10 µg/m^3 for SO_2 (4 ppb), based on vegetation damage in exposed sensitive species

- Additionally, for Ontario Regulation 419: Air Pollution – Local Air Quality compliance purposes, the Ministry proposes the following air standard for SO_2:

  • Annual air standard of 10 µg/m^3 for SO_2 (4 ppb), based on vegetation damage in exposed sensitive species

Phase-In Considerations

- Consistent with updates to most previous standards, a 5-year phase-in is proposed.
  - Note that O. Reg. 419/05 sets out timing related to making requests for site-specific standards (e.g. in certain circumstances, request are to be submitted to the Director 15 months prior to the effective date of the new standard). See s.32 of O. Reg. 419/05.

Upper Risk Threshold (URT)

- URT's: are set at a concentration of a contaminant in air above the general air standard as part of the framework for managing risk.

- The framework for establishing, implementing and assessing URTs was established through consultation with stakeholders including public health associations and industry and is described in the Guideline for Implementation of Air Standards in Ontario (GIASO).

- For substances

  non-carcinogenic effects = 10-fold higher than the standard.

  carcinogenic effects = 100-fold higher than the standard.

- URT may also include consideration of other effects that may be of concern at higher exposure levels and/or acknowledgment of current Ontario air standards for the compound, and this information may be used to adjust from the default levels.

Proposed URT for SO_2

- For SO_2 the current air standard represents a concentration which is protective against adverse health effects on the general population but not sensitive populations, the URT is proposed to be set at the level of the current SO_2 air standards, namely:

  1-hour URT of 690 µg/m^3 for Sulphur Dioxide (Section 20 facilities)

  ½ hour URT of 830 µg/m^3 for Sulphur Dioxide (Section 19 facilities)

- Generally, URTs under O. Reg. 419/05 are not phased-in. Hence, there is no phase-in period proposed for the proposed sulphur dioxide URTs.

Canadian Ambient Air Quality Criteria

- Canadian Ambient Air Quality Standards (CAAQS) are targets for regional air quality across Canada.
- The recent CAAQS process for sulphur dioxide considered a range of SO_2 concentrations (40 ppb to 70 ppb) to inform the CAAQS management levels
- Health Canada's interpretation of the range:
  - *At 40 ppb,* ***all members of the population, including sensitive subgroups such as individuals with asthma, would be expected to be protected if 40 ppb were not exceeded****.*
  - *At 70 ppb, the general population would be expected to be protected but there would be times when sensitive subgroups such as individuals with asthma may not be protected.*
- In October 2016, CAAQS targets of 70 ppb in 2020, and 65 ppb in 2025, were set.

Averaging time	Numerical Value in parts per billion (ppb)		Statistical form of the standards (metric)
	Effective 2020	Effective 2025	
1-hour	70	65	The 3-year average of the annual 99th percentile of the SO_2 daily maximum 1-hour average concentrations.
1-calendar year (annual)	5.0	4.0	The arithmetic average over a single calendar year of all 1-hour average SO_2 concentrations.

Ontario

CAAQS Management Levels

Management level and action	Management levels for the 1-hour CAAQS for SO_2 (ppb)		Management levels for the annual CAAQS for SO_2 (ppb)	
	Effective 2020	Effective 2025	Effective 2020	Effective 2025
Red To ensure that CAAQS are not exceeded through advanced air management actions	> 70 ppb (CAAQS)	> 65 ppb (CAAQS)	> 5.0 ppb (CAAQS)	> 4.0 ppb (CAAQS)
Orange To improve air quality through active air management and prevent exceedance of the CAAQS	>50 to ≤70 ppb	> 50 to ≤ 65 ppb	>3.0 to ≤ 5.0 ppb	> 3.0 to ≤ 4.0 ppb
Yellow To improve air quality using early and ongoing actions for continuous improvement	> 30 to ≤ 50 ppb		> 2.0 to ≤ 3.0 ppb	
Green To maintain good air quality through proactive air management measures to keep clean areas clean	≤ 30 ppb		≤ 2.0 ppb	

Ontario