GREAT LAKES BINATIONAL TOXICS STRATEGY

MANAGEMENT ASSESSMENT

FOR

ALKYL-LEAD

U.S. Environmental Protection Agency
Great Lakes National Program Office
Chicago, IL

&

Environment Canada

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EXECUTIVE SUMMARY

INTRODUCTION

The Great Lakes Binational Toxics Strategy identifies specific challenge goals for each Level 1 substance for the U.S. and Canada, with a timeframe that expires in 2006. As 2006 approaches, an analysis of progress and determination of next steps is needed to respond to the mandate set forth in the Strategy. A *General Framework to Assess Management of GLBTS Level 1 Substances* was developed to provide a tool to assist the Parties, Environment Canada and the U.S. Environmental Protection Agency, and stakeholders in conducting a transparent process to determine the appropriate management outcomes for the Level 1 substances. This report presents an analysis of alkyl-lead conducted using the general framework.

CHALLENGE GOAL STATUS

Canada was challenged to reduce the use, generation, or release of alkyl-lead by 90 percent. The U.S. was challenged to confirm the discontinued use of alkyl-lead in automotive gasoline and to support and encourage stakeholder efforts to reduce alkyl-lead releases from other sources. According to the most recent alkyl-lead use data available (see Section 3 of this report), Canada and the U.S. have both met their challenge goals outlined in the Strategy.

ENVIRONMENTAL ANALYSIS AND SOURCES OF ALKYL-LEAD

In general, there is sufficient data for GLBTS purposes to assess the impact of alkyl-lead in the Basin. Trend data shows that there has been a significant decline in U.S. alkyl-lead levels nationwide since 1970. This large reduction is primarily due to the regulated phase-out of leaded gasoline in on-road vehicles. In the past decade, with the elimination of leaded gas for automobiles, however, it is more difficult to assess whether the trend in use continues downward. The two primary remaining sources of alkyl-lead in Ontario and the U.S. are aviation gasoline (avgas) in piston-engined aircraft and leaded motor gasoline for use in competition vehicles. There is also likely some remaining use of leaded gasoline in marine recreation or other off-road uses. Of the remaining permitted uses of alkyl-lead, the most significant is avgas.

There is not sufficient reason to warrant concern based on evidence of use, release, and exposure. The remaining significant sources of alkyl-lead are very small compared to historic on-road automotive sources. As a result of Canadian and U.S. regulations, the production of leaded gasoline and its use in on-road vehicles, as well as estimates of lead emissions resulting from on-road vehicles, have declined dramatically. With the phase-out of leaded gasoline used in on-road vehicles, there has been a substantial reduction in the risk of exposure for the general public. Environment Canada conducted monitoring programs in 1997 at two Canadian race tracks (an oval track and a drag-strip), where a worst-case scenario was produced at each location. These results were used by Health Canada to perform a lead exposure assessment for toddlers, adolescents and pregnant women, as they are considered the most susceptible receptors of the general population. A separate case for a toddler living 800 m from the oval track was also considered. The assessment concluded that weekly lead exposures for spectators and nearby residents were acceptable when compared to the World Health Organization (WHO) Provisional

Tolerable Weekly Intake (PTWI). In May 2000, Environment Canada conducted airborne particulate matter monitoring and soil sampling at one of the three busiest airports in Canada for piston-engined aircraft movements. Lead levels were below the standards and guidelines in Ontario and other jurisdictions in all air and soil samples.

MANAGEMENT OUTCOME

There is little opportunity for the GLBTS to effect further reductions in the remaining uses or releases of alkyl lead. Both the aviation and automobile racing sectors can more effectively be addressed at the national level. Therefore, the final management outcome is to suspend GLBTS workgroup activities, and to refer or defer reduction efforts for alkyl-lead to another program.

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ACRONYMS

AOPA	Aircraft Owners and Pilots Association
ASTM	American Society for Testing and Materials
ATSDR	Agency for Toxic Substances and Disease Registry
B(a)P	Benzo(a)pyrene
CAA	Clean Air Act
CAAA	Clean Air Act Amendments
CASCAR	Canadian Association of Stock Car Racing
CEPA	Canadian Environmental Protection Act
COA	Canada-Ontario Agreement
CRC	Coordinating Research Council
DOE	Department of Energy
EC	Environment Canada
FAA	Federal Aviation Administration
GLBTS	Great Lakes Binational Toxics Strategy
GLNPO	Great Lakes National Program Office
HCB	Hexachlorobenzene
LL	Low Lead
ML	Million Liters
NASCAR	National Association for Stock Car Automobile Racing
OCS	Octachlorostyrene
PCBs	Polychlorinated Biphenyls
PBT	Persistent, Bioaccumulative, and Toxic
PM	Particulate Matter
PTWI	Provisional Tolerable Weekly Intake
TEL	Tetraethyllead
TML	Tetramethyllead
USEPA	United States Environmental Protection Agency
WHO	World Health Organization

DRAFT MANAGEMENT ASSESSMENT FOR ALKYL-LEAD

1.0 INTRODUCTION

The Great Lakes Binational Toxics Strategy (GLBTS) identifies specific reduction challenges or goals for each Level 1 substance for the U.S. and Canada. The time frame for achieving the Strategy's challenge goals expires in 2006. As 2006 approaches, an analysis of progress and determination of next steps is needed to respond to the mandate set forth in the Strategy. The *General Framework to Assess Management of GLBTS Level 1 Substances* was developed to provide a tool to assist the Parties, Environment Canada (EC) and the U.S. Environmental Protection Agency (USEPA), and stakeholders in conducting a transparent process to determine the appropriate management outcomes for the Level 1 substances: mercury, polychlorinated biphenyls (PCBs), dioxins and furans, hexachlorobenzene (HCB), benzo(a)pyrene (B(a)P), octachlorostyrene (OCS), alkyl-lead, and five cancelled pesticides: chlordane, aldrin/dieldrin, DDT, mirex, and toxaphene. The framework presents a logical flow diagram for evaluating progress and the need for further action by the GLBTS on the Level 1 substances. Further details on the background and objectives of the framework are provided in Appendix A.

This report discusses the analysis of alkyl-lead using the *General Framework to Assess Management of GLBTS Level 1 Substances.* While the framework's flow diagram guides the discussion, the primary intent of the analysis is to present an overall evaluation of the status of the substance with respect to:

- Progress toward the GLBTS challenge goals;
- Levels in the Great Lakes environment; and
- Future management of the substance within the GLBTS.

Alkyl-lead compounds are man-made compounds used as a fuel additive to reduce "knock" in combustion engines and also to help lubricate internal engine components. Alkyl-lead is released to the environment primarily through evaporative emissions from unburned gasoline retained in an engine's carburetor or fuel tanks and through evaporative losses during the filling of gasoline tanks, accidental spillages, and releases during production. However, alkyl-lead compounds combine with other compounds during the combustion process to form inorganic lead halides that are subsequently emitted as microparticulates in exhaust. Research has clearly shown that exposure to alkyl-lead can cause serious toxic effects to the nervous system of humans, with the potential to cause neurological disorders, such as mood shifts and impairment of memory. While these exposures do not appear to pose a health risk for most of the human population, certain groups, such as children and certain occupational groups may be at risk. The human exposure pathways for alkyl-lead are through inhalation of leaded gasoline vapors, or by dermal exposure to leaded gasoline. Subsequent deposition of these lead halides contributes to exposure to lead through ingestion of lead contaminated soil or dust, and ingestion of lead-contaminated food or water (USEPA, 2000a).

In the body, alkyl-lead compounds are distributed through the blood to "soft tissues," particularly the liver, kidneys, muscles and brain. Children are at a higher risk of lead poisoning than adults due to their lower body weights and developing neurological systems. Blood-lead concentrations as low as 10 μg/dL have been associated with neurological damage in children, and increasing

blood-lead levels have been highly correlated with decreased performance on standardized intelligence tests (i.e., lower I.Q. test scores) (USEPA, 2000a).

Legislation banning the use of leaded gasoline in on-road vehicles introduced in Canada under the 1999 Canadian Environmental Protection Act (CEPA) and in the U.S. under the Clean Air Act (CAA) and the 1990 Clean Air Act Amendments (CAAA) has resulted in both countries meeting their challenge goals as outlined in the Strategy.

Section 2.0 of the report documents progress toward achieving the Strategy's challenge goals. Section 3.0 evaluates the impact of the substance on the Great Lakes Basin using environmental and human health data. In the case of alkyl-lead, use data will be used as surrogates for environmental and human health monitoring data. Section 4.0 evaluates the ability for the GLBTS to effect further reductions and determines the appropriate management outcome for the GLBTS.

2.0 CHALLENGE GOAL STATUS

Have the challenge goals for the substance been met?

The GLBTS challenge goals for the U.S. and Canada, as stated in the 1997 Great Lakes Binational Toxics Strategy agreement, are:

Canadian Challenge: Seek by 2000, a 90 percent reduction in use, generation, or release of alkyl-lead consistent with the 1994 COA.[1]

U.S. Challenge: Confirm by 1998, that there is no longer use of alkyl-lead in automotive gasoline. Support and encourage stakeholder efforts to reduce alkyl-lead releases from other sources.

According to the most recent alkyl-lead use data available (see Section 3 of this report), Canada and the U.S. have both met their challenge goals outlined in the Strategy.

Ontario

Canada has met and exceeded the challenge to reduce alkyl-lead use, generation, and release by 90 percent between 1988 and 2000. By 1997, leaded gasoline sales in Ontario had declined from about 3 billion liters in 1988 to roughly 33 million liters - a reduction of almost 99 percent. The two primary remaining sources of alkyl-lead in Ontario are aviation gasoline (avgas) for piston-engined aircraft and leaded motor gasoline for use in competition vehicles. Of the remaining

[1] COA (Canada - Ontario Agreement). Signed in 1994, this agreement between the Governments of Canada and Ontario provides for a framework for systematic and strategic coordination of shared federal and provincial responsibilities for ecosystem management in the Great Lakes Basin. Tier I and II substances, and their targets for reduction, have been incorporated into the GLBTS.

primary permitted uses of alkyl-lead, the most significant is avgas. The 33 million liters of leaded gasoline sold in 1997 consisted of 6.6 million liters (20 percent) of leaded motor gasoline and 26.7 million liters (80 percent) of avgas. However, avgas represented only 1.5 percent of total aviation fuel use in Ontario (almost 1.8 billion liters for both jet fuel and avgas). Jet fuel does not contain alkyl-lead. Relative to total motor gasoline sales (mogas), avgas and leaded mogas comprised only 0.2 percent and 0.05 percent, respectively, of Ontario's gasoline mix in 1997. In addition, it is believed that virtually no avgas is produced in Ontario at this time (EC, 1999).

United States

The U.S. has met the challenge goal of confirming no-use of alkyl-lead in automotive gasoline by 1998. "Automotive gasoline" is defined as gasoline used in on-road vehicles (light and heavy gasoline vehicles, motorcycles, and gasoline trucks). The most common alkyl-lead compound used as an anti-knock agent in gasoline is tetraethyl lead (commonly abbreviated as TEL). Tetramethyl lead (commonly abbreviated as TML) is also used as an anti-knock agent. TEL and TML are the most common alkyl-lead compounds that have been used in the past and are still in use today in the U.S.

Historically, on-road automotive sources in the U.S. have been the major contributors of lead emissions to the atmosphere; however the 1990 CAAA prohibited the use of leaded gasoline as fuel for on-road automotive use. As a result of this prohibition and earlier CAA regulations, the production of leaded gasoline and its use in on-road vehicles declined dramatically, as have estimates of lead emissions resulting from on-road vehicles.

It is clear that the vast majority of on-road vehicles use unleaded gasoline as their primary fuel. According to a final GLBTS challenge report, entitled *U.S. Challenge on Alkyl-Lead: Report on Use of Alkyl-Lead in Automotive Gasoline* (USEPA, 2000b), the production of leaded gasoline has decreased from 77.5 billion gallons in 1967 to 3.1 billion gallons in 1991, or to 3 percent of all gasoline produced. Conversely, the production of unleaded gasoline has risen sharply. In 1991, almost 95 billion gallons of unleaded gasoline were produced, representing approximately 97 percent of all gasoline produced. Figure 1 illustrates the trends in unleaded versus leaded gasoline production.

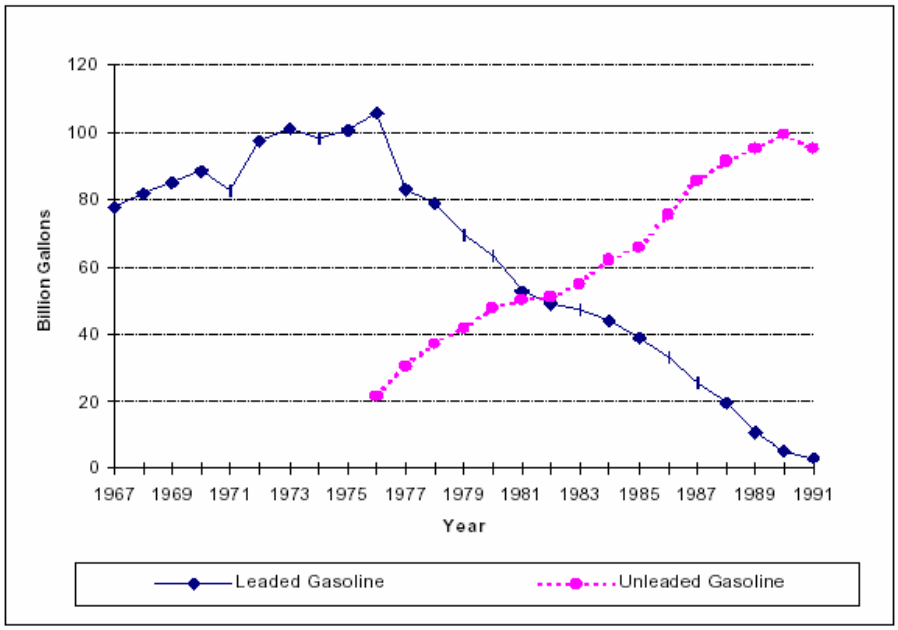


Figure 1. Summary of Unleaded vs. Leaded Gasoline Production in the U.S., 1967-1991. Source: USEPA, 2000b

To address the second portion of the U.S. challenge, to support and encourage stakeholder efforts to reduce alkyl-lead releases from other sources, USEPA is currently working with the supplier of National Association for Stock Car Automobile Racing (NASCAR) racing fuels to find substitutes to permanently remove alkyl-lead from racing fuels. USEPA also continues dialogue with the Federal Aviation Administration (FAA) on the use of leaded gasoline in the aviation industry and the possibilities for reducing the lead content and/or replacing leaded gasoline with unleaded gasoline in piston-engined aircraft. Similar discussions will continue with the Coordinating Research Council (CRC) task force, an industry group investigating alternative (no-lead) gasoline for aircraft.

3.0 ENVIRONMENTAL ANALYSIS

The Framework calls for analysis to consider Canadian and U.S. monitoring data and established human health or ecological criteria as the primary basis for an objective evaluation of whether the substance imposes a negative impact on the Great Lakes Basin. Direct environmental monitoring of alkyl-lead is not feasible because alkyl-lead quickly degrades in the environment eventually forming stable inorganic lead compounds. Assessing levels of inorganic lead in the environment is inconclusive relative to alkyl-lead because other sources of lead (such as house paint and industrial emissions) also contribute significantly to inorganic lead levels in the environment. Therefore, data on the ***use*** of alkyl-lead are used in place of environmental monitoring data.

Considering that the U.S. challenge goal applies to the use of alkyl-lead in automotive gasoline nationwide, a broader scope of measures was used for assessing the impacts of alkyl-lead on the Great Lakes Basin. The same could be said for Ontario data. While the geographic focus for the Canadian challenge for alkyl-lead is Ontario, the best data available in some cases is for Canada nationwide. For example, data on imports of TEL and on the competition vehicle sector could be compiled only at the national level.

3.1 ENVIRONMENTAL AND HUMAN HEALTH DATA

Relying on alkyl-lead use data as an environmental monitoring surrogate, a metric for monitoring data can be established. The question then becomes whether the current data on the known remaining uses is sufficient. The dominant historic uses of alkyl-lead have been

discontinued, and the remaining uses are limited to aviation fuel for piston-engined aircraft, fuel for racing cars, and fuel for off-road and marine vehicles.

An argument can be made that additional monitoring data is needed to adequately assess the impact of the remaining uses of alkyl-lead. The GLBTS *Final Report on Alkyl-Lead: Sources, Regulations and Options* states that "other than aviation gasoline, very little data exists on current levels of leaded gasoline use. Since 1991, the Department of Energy (DOE) stopped tracking information on the production of leaded gasoline for non-aviation uses. Consequently, there is no readily accessible information on how much leaded gasoline is being produced for the continued, legal use of alkyl-lead in racing cars, off-road, non-road vehicles, etc." (USEPA, 2000a).

Another argument could be made that there is sufficient data for GLBTS purposes relative to the remaining sources – that is to say, sufficient data to know that aviation fuel and automotive racing fuel represent significant uses. Other legally-permitted non-road equipment is not likely to be used in significant quantities for several reasons. First, separate supplies of leaded gasoline are not maintained for logging contractors, construction machinery, and agricultural equipment. Most equipment used in these daily operations is diesel-powered, and most of the units which burn gasoline are also operated on public roadways and are designed to run on unleaded gasoline. Equipment which is not driven on public roadways and that burns gasoline in lieu of diesel also uses unleaded gasoline – or what is available and significantly cheaper than leaded gasoline. Snowmobiles, jet skis, and other recreational watercraft also are fueled with unleaded gasoline at roadside service stations or at dockside, again because of availability and cost considerations (USEPA, 2000a).

In addition, assessments conducted by Environment Canada have concluded that the remaining uses of leaded gasoline do not result in significant adverse environmental or human health effects. In 1997, Environment Canada conducted monitoring studies at two Canadian race tracks (an oval track and a drag-strip), where a worst-case scenario was produced at each location (EC, 1997). The results of these studies were used by Health Canada to perform a lead exposure assessment for toddlers, adolescents, and pregnant women, as they are considered the most susceptible receptors of the general population. A separate case for a toddler living 800 m from the oval track was also considered. The assessment concluded that weekly lead exposures for spectators and nearby residents were acceptable when compared to the World Health Organization (WHO) Provisional Tolerable Weekly Intake (PTWI).

In May 2000, Environment Canada conducted airborne particulate matter (PM) monitoring and soil sampling at one of the three busiest airports in Canada for piston-engined aircraft movements. The average and maximum levels of lead in the PM_{10} and particle fraction were 0.030 and 0.302 ug/m^3 at the airport and 0.007 and 0.012 ug/m^3 at the background site, respectively. The average and maximum levels of lead in the $PM_{2.5}$ particle fraction were 0.028 and 0.308 ug/m^3 at the airport and 0.007 and 0.018 ug/m^3 at the background site, respectively. Some variability was evident in the average concentrations at the different airport sites, but in general, the airport samples were almost four times higher than at the background site. This is consistent with the existence of a nearby source since the greater variability found in lead levels indicates that emissions have not had an opportunity to mix well with the background air mass. Lead levels in the airborne particles at the airport were 0.15 percent and 0.24 percent, respectively, in PM_{10} and $PM_{2.5}$. It is therefore likely that avgas combustion leads

to the formation and emission of primary aerosol particles (typically less than 7 μm) containing lead. The absolute lead levels measured in the soil were similar at the airport and the background site. The presence of a local source was not as evident from the soil data. All air and soil samples were below the standards and guidelines in Ontario and other jurisdictions (EC, 2000).

The following discussion presents use data relative to the remaining sources (i.e., aviation and automotive racing) that have been identified for purposes of assessing the likely impact of alkyl-lead on the Great Lakes Basin. The table and ensuing discussion show that, in general, **there are sufficient data for GLBTS purposes** relative to the remaining sources to assess the impact of alkyl-lead in the Basin.

Ontario Use Data

Leaded gasoline use in Ontario, as measured by sales volume, has declined from about 3 billion liters in 1988 to roughly 33 million liters (ML) in 1997, a decline of 99 percent (see Table 1). In contrast, overall motor gasoline consumption increased from 12.7 to 13.3 billion liters during the same period.

Year	Total Leaded Gasoline (ML)
1988	3,064
1989	1,449
1990	199
1991	37
1992	23
1993	24
1994	25
1995	32
1996	30
1997	33

ML – Million Liters

Table 1. Ontario Gasoline Sales Volume
Source: EC, 1999

Competition Vehicles

In Canada, there are about 110 racetracks hosting approximately 1,200 events per year. Not all of these races use leaded fuel. For example, the Canadian Association of Stock Car Racing (CASCAR) stated that many of their races use unleaded gasoline (EC, 1999). Statistics Canada reported a total of 4.9 ML of leaded gasoline sales in Canada in 1996, a significantly small fraction of all gasoline sales. This amount includes gasoline used in competition vehicles as well as other applications such as tractors, combines, or any other machinery used in farming; boats; and large trucks, but not avgas.

Leaded gasoline production, importation and sale have been prohibited, for the most part, under the *Gasoline Regulations*, since December 1, 1990. Approximately 1 ML of leaded racing fuels were imported into Canada in 2001. This represents less than 0.01 percent of the 36 billion liters of gasoline (mostly unleaded) used annually in Canada (EC, 2003).

In early 2002, Environment Canada conducted a review of the racing sector. The importation of leaded fuel into Canada has risen about 37 percent since 1998. Most of this increase (21 percent) took place from 1998 to 1999. Racing industry experts have indicated that U.S. competitors may have changed one of their earlier practices. Prior to the 1998 amendment to the *Gasoline Regulations*, U.S. drivers brought leaded fuels with them to Canadian events. After the amendment, American competitors began purchasing leaded fuels in Canada.

As no additional air sampling has been conducted since 1997, Health Canada's 1997 lead exposure assessment was updated based on the worst-case scenario that the 37 percent increase in importation of leaded fuel since 1998 would be equivalent to a 37 percent increase in lead emissions at race tracks. Since the previous assessment identified toddlers as the most susceptible receptors, the current lead exposure assessment was performed using only toddlers as an indicator. The updated estimated weekly lead intake for a toddler as a spectator, both at the oval track and at the drag strip, is 47 percent of the WHO PTWI. An additional calculation was performed based on a four-hour exposure (above calculation based on a 12-hour exposure), which was considered a more realistic scenario, and it resulted in an estimated lead intake of 42 percent of the PTWI. In conclusion, estimated weekly lead exposures for spectators at race tracks remain within the tolerable intake developed by the WHO and accepted by Health Canada.

General Aviation

There are essentially two different types of fuel used in the aviation industry - jet fuel and avgas. Jet fuel, containing no lead, is used in the jet engines and turboprops that power larger aircraft. Avgas is used in the piston engines that power most light aircraft and some smaller commercial types of aircraft. Although different in terms of energy characteristics, a comparison of the number of liters of jet fuel and avgas consumed provides a useful indicator of the relative scale of fuel use. Table 2 lists Ontario's aviation fuel sales volumes. In 1997, total aviation fuel use in Ontario was almost 1.8 billion liters of both jet fuel and avgas. Avgas made up just 1.5 percent of the total aviation fuel, a diminutive portion of Ontario's aviation fuel sales volume. In comparison, of the 13.3 billion liters of motor gasoline consumed (that does not contain alkyl-lead), total aviation fuel comprised only 13.4 percent by volume. Relative to motor gasoline, avgas comprised 0.2 percent of Ontario's gasoline mix in 1997. With such a small portion of Ontario's gasoline mix dedicated to avgas, use data beyond 1997 was not collected.

The Ontario Ministry of Environment announced in the fall of 2004 that it will require gasoline sold in Ontario to contain an average of 5 percent ethanol by 2007. Since aircraft cannot use gasoline containing ethanol, this may result in an increase in the use of leaded aviation gasoline and in increased lead emissions.

Year	Avgas	Jet Fuel
1988	41.2	1,665.4
1989	38.9	1,603.7
1990	46.6	1,423.5
1991	28.6	1,312.3
1992	21.0	1,276.5
1993	21.7	1,282.6
1994	22.2	1,344.9
1995	25.6	1,462.4
1996	26.6	1,646.4
1997	26.7	1,767.4

Table 2. Ontario Aviation Fuel Sales Volumes from 1988 to 1997 (ML) Source: EC, 1999

United States Use Data

Today, leaded gasoline (containing alkyl-lead) in the U.S. is used as fuel predominantly for general aviation (piston-engine) aircraft, but also in non-road competition race vehicles (cars, boats, etc.). Current overall production and use rates of alkyl-lead in gasoline in the U.S., particularly for non-road motor vehicles, are difficult to determine due to the fact that the U.S. Department of Energy discontinued the tracking of leaded gasoline in 1990. Thus, most of the available information on alkyl-lead use in gasoline is limited to older data on sales, imports, exports, and throughput at bulk distribution plants (USEPA, 2002).

As discussed earlier in Figure 1, the production of leaded gasoline decreased from 77.5 billion gallons in 1967 to 3.1 billion gallons in 1991, or roughly 3 percent of all gasoline produced, while the production of unleaded gasoline has risen sharply. Lower production estimates suggest the amount of leaded gasoline produced is not sufficient to serve as fuel for the significant proportion of on-road vehicles and that illegal misfueling of on-road vehicles with leaded gasoline is likely to be rare, if it occurs at all (USEPA, 2000a).

Overall lead emissions to air (all forms of lead and lead compounds, including alkyl-lead) in the U.S. have decreased by two orders of magnitude between 1970 (220,869 short tons emitted) and 2000 (4,228 short tons emitted) (USEPA, 2000c and USEPA, 2003). The largest reduction is a direct result of the regulated phase-out of leaded gasoline (reductions in both the lead content per gallon and the total gallons produced) and the increased availability of unleaded gasoline.

Table 3 summarizes annual total lead emissions estimates for the transportation source category. The bottom of the table lists the total emissions estimates for all sources (i.e. industrial processes, fuel combustion, and transportation). It should be noted that on-road vehicles were estimated by USEPA to account for less than one half of one percent of the total amount of lead emitted in 2000 (0.47 percent). This estimate does not imply a widespread use of leaded gasoline as a fuel source for on-road vehicles. Rather, the estimate reflects the trace amount of lead remaining in unleaded gasoline and the vast majority of on-road vehicles using unleaded gasoline as their primary fuel.

Table 3. U.S. National Lead Emissions Estimates, 1980, 1985, 1989–2000 (short tons) Source: USEPA, 2003.

Transportation	1980	1985	1989	1990	1991	1993	1994	1995	1996	1997	1998	1999	2000
ON-ROAD VEHICLES	60,501	18,052	982	421	18	19	19	19	19	20	21	22	20
Light-Duty Gas Vehicles & Motorcycles	47,184	13,637	733	314	13	14	14	14	12	13	14	14	14
Light-Duty Gas Trucks	11,671	4,061	232	100	4	5	5	5	7	7	7	7	5
Heavy-Duty Gas Vehicles	1,646	354	16	7	0	0	0	0	0	0	1	1	1
NON-ROAD ENGINES AND VEHICLES	4,205	921	820	776	574	529	525	544	505	503	497	497	545
Non-Road Gasoline	3,320	229	166	158	0	0	0	0	0	0	0	0	0
Aircraft	885	692	655	619	574	528	525	544	505	503	497	497	545
Total Transportation	**64,706**	**1,802**	**1,802**	**1,197**	**592**	**547**	**544**	**564**	**525**	**523**	**518**	**536**	**565**
Total ALL Sources	**74,153**	**22,890**	**5,468**	**4,975**	**4,169**	**3,916**	**4,047**	**3,929**	**4,077**	**4,137**	**4,057**	**4,199**	**4,228**

As shown in Figure 2, industrial processes were the major source of lead emissions in 2001, accounting for 78 percent of the total. The transportation sector (which includes both on-road and non-road sources) now accounts for only 12 percent of the total 2001 lead emissions, with most of that coming from aircraft (USEPA, 2003).

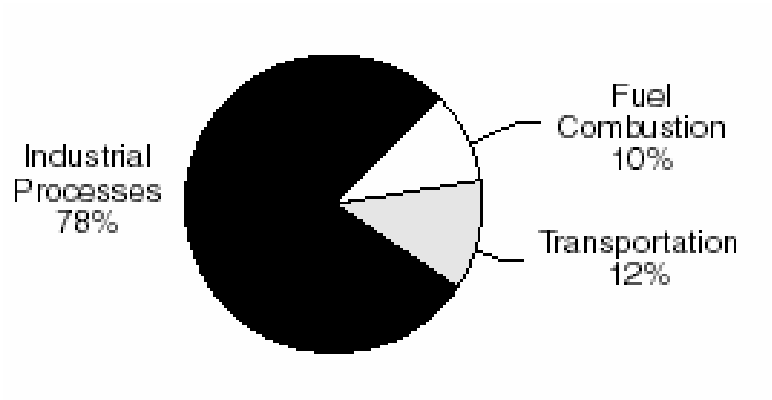


Figure 2. U.S. lead emissions by source category, 2001. Source: USEPA, 2003

In general, these data confirm that alkyl-lead has been virtually eliminated from use in automotive gasoline in on-road vehicles. However, leaded gasoline is still produced and legally

used as fuel for a variety of other vehicles in the U.S. Current production and use estimates for these remaining sources, as well as emissions data, are presented below.

Aviation Fuel

According to USEPA's final PBT National Action Plan for Alkyl-lead (USEPA, 2002), avgas is currently the fuel with the greatest TEL content. (Only TEL is used in aviation gasoline.) Leaded avgas is currently available in several grades with differing lead concentrations, and is used primarily in civil aviation for reciprocating piston engine aircraft. Avgas 80/87 has the lowest lead content at 0.5 grams of lead per gallon, and is only used in very low compression ratio engines. Avgas 100/130 is a higher octane grade avgas, containing about 4 grams of lead per gallon. Finally, a lower-lead blend, Avgas 100LL ("low lead") was designed to replace Avgas 100/130. Avgas 100LL contains about 2 grams of lead per gallon, and is typically the most commonly used avgas. TEL is the "silver bullet" ingredient in 100LL. To date, no other additives have been found that come close to the essential performance that TEL provides (AOPA, 2004).

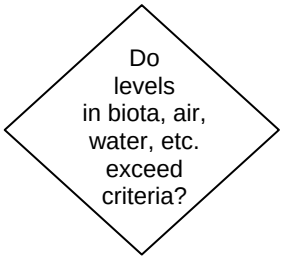
First sales of total avgas (all grades) in 1990 totaled 322.6 million gallons, while the total volume of avgas supplied in 1998 was 295.3 million gallons. It is important to note that the volumes represent only total gallons of avgas; the exact amount of alkyl-lead associated with this total is unknown without information which breaks down the production and use of aviation gasoline by grade. However, based on ATSM specifications for 100LL avgas (which typically constitutes the majority of avgas consumption), a rough conservative estimate of TEL used in aviation can be derived for 1998 by multiplying 295.3 million gallons of gasoline by 2.128 g (TEL)/gallon to derive 628 million grams of TEL, or 630 metric tons of TEL, which is in reasonable agreement with the Ethyl Corporation estimate of 508 metric tons.

Competition Vehicles

According to USEPA's final PBT National Action Plan for Alkyl-lead, "no readily available government source of information exists on the amount of leaded fuel used by racing cars and boats" (USEPA, 2002). In 1999, the National Motor Sports Council estimated that approximately 100,000 gallons of leaded gasoline were used by NASCAR in 1998. There are many different suppliers of leaded racing fuel in the U.S. Almost all of these suppliers offer racing fuel at various octanes and lead content; many suppliers offer unleaded fuel as well as leaded fuel. To some extent, unleaded gasoline is being used for races or at least in particular race vehicles.

As an alternative to the purchase of commercial racing gasoline, gasoline additives may be purchased that can be added to unleaded motor gasoline to raise the octane level. For example, Torco Racing Fuels offers an accelerator race fuel concentrate in both a leaded and unleaded form. There is also evidence that leaded aviation gasoline may be added to the fuel used for some racing vehicles. For example, some of the suppliers of gasoline additive products present information on how their concentrate can be blended with 100LL to create a higher octane racing fuel.

3.2 CRITERIA



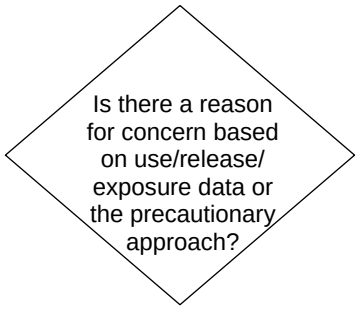
Criteria for alkyl-lead alone are not particularly useful because it degrades so rapidly in the environment. Criteria for lead were used to assess the impact of leaded gasoline used at airports and race tracks in Canada. As reported in Section 3.1, in 2000 airborne PM and soil samples were collected at a Canadian airport where piston-engined aircraft operate. All air and soil samples were below standards and guidelines for lead in Ontario and other jurisdictions. In 1997, air and soil monitoring conducted at two Canadian racetracks (an oval track and a drag-strip) determined that lead emissions from racing are essentially a non-issue. Lead concentrations in soil samples were between 5 and 20 μg/kg, concentrations well within background levels and the Canadian Soil Quality Guidelines of 140 μg/kg.[2] The 24-hour average of lead in the air was measured at between 0.1 and 2.1 $\mu g/m^3$, less than half of the 5 $\mu g/m^3$ Ontario guideline (EC, 1999). Estimated weekly lead intakes at the race tracks were sufficiently below the PTWI developed by the WHO (EC, 1997). This information suggests that **the remaining uses of alkyl-lead do not have an adverse impact on the Basin**.

3.3 TRENDS

Available data indicate that **there have been significant declines in the use of alkyl-lead** in both Canada and the U.S. In Ontario, leaded gasoline use declined by 99 percent from 1988 to 1997. In the U.S., the production of leaded gasoline decreased 96 percent from 1967 to 1991. Overall lead emissions (all forms of lead and lead compounds, including alkyl-lead) in the U.S. have decreased by two orders of magnitude between 1970 and 2000, totaling a reduction in lead emissions of approximately 98 percent. This large reduction is primarily due to the regulated phase-out of leaded gasoline in on-road vehicles. In the past decade, with the elimination of routine reporting of leaded automobile gas production, it is more difficult to assess whether the trend in use continues downward. However, the percentage of lead emissions resulting from the use of alkyl-lead in the transportation sector (both on-road and non-road sources) has declined dramatically since the phase-out of leaded gasoline for on-road use.

[2] Canadian Council of Ministers of the Environment. Soil Quality Guidelines for the Protection of Environmental and Human Health. Accessed on February 4, 2005 at: http://www.ccme.ca/initiatives/soil.html?category_id=44

3.4 EVIDENCE FOR CONCERN



There is not sufficient reason to warrant concern based on evidence of use, release, and exposure because the remaining significant sources of alkyl-lead are very small compared to historic on-road automotive sources and represent a small percentage of total historical lead emission in Canada and the U.S. As a result of the phase-out of leaded gasoline used in on-road vehicles, and earlier Canadian and U.S. regulations, the production of leaded gasoline and its use in on-road vehicles has declined dramatically, as have estimates of lead emissions resulting from on-road vehicles. As a result, there has been a corresponding substantial reduction in the risk of exposure for the general public. In addition, the remaining uses of alkyl-lead in piston-engined aircraft and auto racing were found to result in lead levels below available criteria.

3.5 ENVIRONMENTAL ASSESSMENT CONCLUSIONS

Canada and the U.S. have both met their challenge goals outlined in the Strategy. While virtual elimination has not been achieved, the dominant historic uses of alkyl-lead have been discontinued and the remaining uses are limited to aviation fuel in piston-engined aircraft, fuel for racing cars, and fuel for off-road and marine vehicles. The continued use of leaded gasoline at race tracks and airports has been shown to have little impact on lead exposures and environmental levels.

Trend data indicates a significant decline in alkyl-lead use and emission levels in both the U.S. and Ontario from on-road vehicles. Current overall production and use rates of alkyl-lead in gasoline in the U.S., particularly for non-road motor vehicles, are difficult to determine because the tracking of leaded gasoline ended in 1990. Consequently, there is no readily accessible information on how much leaded gasoline is being produced for the continued, legal use of alkyl-lead in racing cars. Most of the available information on alkyl-lead use in gasoline is limited to older data. It is also difficult to confirm the exact amount of alkyl-lead associated with total avgas, as U.S. aviation gasoline supplied is not broken down by lead content (Energy Information Administration, 2005).

4.0 GLBTS MANAGEMENT ASSESSMENT

The key question to consider in the GLBTS management assessment of a Level 1 substance is whether the GLBTS can effect further reductions. Considering the remaining uses of alkyl-lead, there is **little opportunity for the GLBTS to effect further improvements in the Basin**. Both the aviation and automobile racing sectors would more effectively be addressed at the

national level. In the U.S., aviation fuel requirements fall under the jurisdiction of the FAA and the automotive racing sector is organized at the national level. In addition, the USEPA PBT Program has taken responsibility for working with the automotive racing sector to address the use of leaded gas. In Canada, Transport Canada recognizes Supplement Type Certificates granted by the FAA.

4.1 MANAGEMENT OUTCOME

This section considers the environmental analysis presented in Section 3.0 to arrive at a final management outcome. Since there is little opportunity for the GLBTS to effect further reductions, the final management outcome is to suspend GLBTS workgroup activities. The GLBTS will refer or defer reduction efforts for alkyl-lead to another program. There will be no ongoing workgroup involvement with this substance, though it will undergo periodic reassessment, approximately every two years, using the *General Framework to Assess Management of GLBTS Level 1 Substances*, until the Parties determine that virtual elimination has been reached.

4.1.1 Referral or Participation in Another Forum

The overall outcome for alkyl-lead is to refer or defer reduction efforts to another program. The GLBTS will defer to national programs, such as USEPA's PBT Program, to work with racing associations such as NASCAR for voluntary agreements to reduce the use of leaded fuel in race cars, and with the FAA and industry to seek acceptable alternatives to leaded gasoline in aviation fuel.

Activities Related to Remaining Uses of Alkyl-Lead

International Outreach. USEPA will continue its current efforts to enhance and promote the phase-out of leaded gasoline use in motor vehicles worldwide. Since 1994, national governments have committed to the phase-out of lead in gasoline in key international and regional agreements (USEPA, 2002).

Aviation Fuel Research. The Canadian challenge report recommends that current work to develop an unleaded, high octane avgas be encouraged and monitored by Environment Canada and that no effort be made to mandate elimination of leaded avgas until a feasible alternative has been found (EC, 1999). Research continues in the U.S. to develop alternative fuels to replace alkyl-lead in avgas. USEPA will continue to support and encourage research activities for identifying an alternative to alkyl-lead for aviation fuel. Through the Unleaded Fuels Research Program, the FAA and an industry group, the CRC, continue work to develop an unleaded aviation gasoline for civil aircraft. Considering all of the testing that must be conducted, as well as the approvals from FAA and acceptance that must be obtained from the aviation industry, petroleum companies, and gasoline distributors, it is not possible to currently estimate a timeframe for the changeover to an unleaded high-octane aviation gasoline (USEPA, 2002). A member of CRC, the Aircraft Owners and Pilots Association (AOPA), supports this research effort and is working to ensure that a viable alternative is found before 100LL avgas is phased out. Dwindling global market demand for gasoline containing the additive TEL and increasing global environmental concerns have placed

considerable pressure on the continued use of 100LL or other aviation gasoline containing TEL (AOPA, 2004).

Racing Gasoline Research. USEPA is currently working with the supplier of NASCAR racing fuels to find substitutes to permanently remove alkyl-lead from racing fuels. There are many different suppliers of leaded racing fuel in the U.S., many of whom already offer unleaded fuel as well as leaded fuel. Competition vehicles are exempt from the Canadian gasoline regulations based on an economic assessment of the racing industry's competitive position in North America. The exemption has been extended until January 1, 2008. Environment Canada will continue to monitor the racing industry through the reporting of quantities of leaded racing gasoline produced, imported, and sold in Canada. EC also intends to monitor the development of environmental fuel requirements in the U.S. and to engage in bilateral discussions with the U.S. federal government as necessary (EC, 2003).

4.1.2 Final Result

As discussed in section 4.1, the final management outcome is to suspend GLBTS workgroup activities and refer or defer alkyl-lead reduction efforts to another program.

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APPENDIX A: GENERAL FRAMEWORK TO ASSESS MANAGEMENT OF GLBTS LEVEL 1 SUBSTANCES: BACKGROUND, OBJECTIVES, AND DOCUMENTATION

General Framework to Assess Management of GLBTS Level 1 Substances: Background, Objectives, and Documentation

BACKGROUND

Over the past thirty years, the governments of Canada and the United States have joined together with industries, citizen groups, and other stakeholders in a concerted effort to identify and eliminate threats to the health of the Great Lakes ecosystem resulting from the use and release of persistent toxic substances. A major step in this process was the enactment of the *Revised Great Lakes Water Quality Agreement (GLWQA) of 1978* which embraced, for the first time, a philosophy of "virtual elimination" of persistent toxic substances from the Great Lakes. In 1987, the GLWQA was amended, establishing Lakewide Management Plans (LaMPs) as a mechanism for identifying and eliminating any and all "critical pollutants" that pose risks to humans and aquatic life. In 1994, the International Joint Commission's *Seventh Biennial Report* under the GLWQA called for a coordinated binational strategy to "stop the input of persistent toxic substances into the Great Lakes environment." This led to the signing of the *Great Lakes Binational Toxics Strategy* (GLBTS, or Strategy) in 1997. The Strategy specifies Level 1 substances, each targeted for virtual elimination and each with its own specific challenge goals, along with Level 2 substances targeted for pollution prevention. The substances were selected on the basis of their previous nomination to lists relevant to the pollution of the Great Lakes Basin, and the final list was the result of agreement on the nomination from the two countries. The specific reduction challenges for each substance include individual challenge goals for each country, within a time frame that expires in 2006.

Significant progress has been made toward achieving the Strategy's challenge goals. As 2006 approaches, an analysis of progress and determination of next steps is needed to respond to the mandate set forth in the Strategy. The purpose in developing the *General Framework to Assess Management of GLBTS Level 1 Substances* is to provide a tool to assist the Parties (Environment Canada and USEPA) and stakeholders in conducting a transparent process to assess the Level 1 substances.

OBJECTIVE

The framework presents a logical flow diagram for evaluating progress and the need for further action by the GLBTS on the Level 1 substances in order to meet the following objective:

Evaluate the management of GLBTS Level 1 substances with the following potential outcomes:

1) **Active Level 1 Status & Periodic Reassessment by GLBTS**
2) **Consider Submission to BEC[3] for New Challenge Goals**
3) **Engage LaMP Process**

[3] The Binational Executive Committee (BEC) is charged with coordinating implementation of the binational aspects of the 1987 Great Lakes Water Quality Agreement, including the GLBTS. The BEC is co-chaired by EC and U.S. EPA and includes representatives from the Great Lakes states and the Province of Ontario, as well as other federal agencies in Canada and the U.S.

4) **Suspend GLBTS Workgroup Activities. Where warranted, refer to another program and/or participate in other fora. Periodic Reassessment by GLBTS, until Parties determine substance has been virtually eliminated.**

Additional outcomes that may result from the framework are:

- **Recommend benchmark or criteria development as a high priority; and**
- **Recommend additional environmental monitoring as a high priority.**

The framework is intended to serve as a guide in determining the appropriate management outcome(s) for the Level 1 substances: mercury, polychlorinated biphenyls (PCBs), dioxins and furans, hexachlorobenzene (HCB), benzo(a)pyrene (B(a)P), octachlorostyrene (OCS), alkyl-lead, and five cancelled pesticides: chlordane, aldrin/dieldrin, DDT, mirex, and toxaphene. The framework is not intended to specify details of how a Level 1 substance should be addressed once a management outcome is determined.

STRUCTURE OF THE FRAMEWORK

The framework is set up in a hierarchical fashion to allow efficiencies in the decision process. The hierarchy of the framework is to first consider progress toward the challenge goals committed to in the Strategy, then to conduct an environmental analysis and finally, a GLBTS management assessment which leads to various potential management outcomes for a substance.

The environmental analysis (depicted in green) and the GLBTS management assessment (depicted in blue) comprise the two main parts of the framework. The environmental analysis considers available Canadian and U.S. monitoring data and established human health or ecological criteria as the primary basis for an objective evaluation of a substance's impact on the Basin. For substances lacking sufficient risk-based criteria or environmental monitoring data, the framework recommends the development of benchmarks or criteria and additional monitoring as a high priority. While the environmental analysis places emphasis on good monitoring data, evidence of use, release, exposure, or precautionary concerns may also be considered.

If the environmental analysis concludes that there is no basis for concern, GLBTS workgroup activities may be suspended, with periodic reassessment of the substance until the Parties determine that the substance has been virtually eliminated. If, on the other hand, the environmental analysis concludes that there is a reason for concern, the GLBTS management assessment evaluates the ability for the GLBTS to effect further improvements in and out of the Basin. The GLBTS management assessment also considers whether the impact of a substance is basinwide or restricted to a single lake. In cases where the GLBTS can effect further reductions, consideration will be given as to whether new Strategy challenge goals can be established. Virtual elimination is an underlying tenet of the Strategy and should be kept in mind throughout the assessment process.

The GLBTS management assessment can result in a number of potential management outcomes; the outcomes provided in the framework allow a substance to remain in active Level 1 status or GLBTS workgroup activities to be suspended. The outcomes also recognize that it may be appropriate to more actively involve a LaMP process, to refer a substance to another program, to represent GLBTS interests in other fora (e.g., international programs), or to consider proposing new challenge goals. All outcomes include a periodic reassessment by the GLBTS (approximately every two years).

While it is recognized that the Parties have an ongoing responsibility to promote GLBTS interests in other arenas, a potential outcome of the framework is to recommend referral to another program and/or GLBTS representation in other fora. In the GLBTS framework, this option is presented when there is no evidence of Basin effects, or when the GLBTS cannot effect further significant reductions on its own, but can advocate substance reductions in other programs and in international fora.

It should be noted that, in using the framework to conduct assessments for the Level 1 substances, it may not be possible to definitively answer "YES" or "NO" to all questions. It is not necessary to have a definitive answer to proceed in the framework. For example, in assessing whether there is environmental or health data to assess the impact of the substance in the Basin, it may be determined that, while additional data would be helpful, there is some data on releases and environmental presence in certain media with which to assess the status of the substance. In this case, judgment is needed to decide whether these data are sufficient to proceed along the "YES" arrow or whether the available data are not adequate and the analysis should proceed along the "NO" arrow, placing the substance on a high priority list for monitoring. As a general guide, the framework allows flexibility and judgment in interpreting environmental data and in determining the most appropriate management outcome(s).

Each decision node, or shape, in the framework is illustrated below along with a brief explanation that describes, in further detail, the question to be assessed.

GLBTS Level 1 Substances

All 12 Level 1 substances will be assessed.

Have the challenge goals for the substance been met?

The first question to consider in assessing the GLBTS status and future management of a Level 1 substance is whether the challenge goals agreed to in the Strategy have been met. The answer to this question informs the subsequent assessment in many ways, not only indicating progress, but also revealing issues associated with the ability to pursue further reductions. Progress toward the U.S. and Canadian goals will be considered jointly. Challenge goals will be evaluated with the best data presently available. Note that some challenge goals target "releases" of a substance while others target its "use". As a result, different types of data may be required to evaluate challenge goal status (e.g., "use" data vs. environmental "release" data). The framework continues with both the environmental analysis and GLBTS management assessment, notwithstanding the status of the challenge goals.

ENVIRONMENTAL ANALYSIS

Characteristics of acceptable monitoring data to assess the temporal, spatial, and population representativeness of a substance in the Great Lakes Basin ecosystem include (but are not limited to) basin-specific measures in water, air, sediment, soil, indoor environments (e.g., dust), fish, biota, or human biological samples. If necessary, use or release data may be used as surrogates (e.g., in the case of alkyl-lead).

"What gets measured gets managed." Substances entering this box will be recommended as a high priority for monitoring to the Parties. The intent is that these GLBTS substances will be considered by a wide range of government or private agencies when they make decisions regarding which analytes to monitor in the environment. As sufficient monitoring data is developed, substances will be re-evaluated.

Have sufficient risk-based criteria been established (e.g., GLI or other)?

Relevant criteria include, but are not limited to:

- Water quality criteria
- Fish tissue concentrations
- Ambient or indoor air standards
- Sediment or soil standards
- Limits based on reference doses
- Health-based standards for human biota measurements

High Priority for Benchmark or Criteria Development

If there are no criteria against which to evaluate current levels, the GLBTS will consider whether there is a need for the Parties to recommend the development of human health or ecological criteria. This box effectively creates a GLBTS list of substances that are in need of human health or ecological criteria with which to identify exceedances in the environment.

Do levels in biota, air, water, etc. exceed criteria?

As the framework is intended to be flexible in its implementation, the choice of criteria to use in answering this question may vary. For example, the most strict criteria in one or more media may be used to evaluate environmental levels.

Is the trend decreasing?

If there are no criteria, or if current levels do not exceed criteria, this box considers whether there is a decreasing trend. A decreasing trend could be defined as a statistically significant negative slope. If the trend is decreasing, the substance is evaluated for evidence of concern based on use, release, exposure, or the precautionary approach. If a decreasing trend cannot be established, then the substance moves directly to the GLBTS management assessment to determine the ability of the GLBTS to effect further reductions.

* Note that, in the event that there are established criteria and the GLBTS substance is below those criteria but not decreasing in trend, further analyses may be required to estimate when criteria might be exceeded.

Is there a reason for concern based on use/release/ exposure data or the precautionary approach?

In cases where sufficient monitoring data is not available, or where environmental trends are decreasing and criteria have either not been established or are not being exceeded, the relevant question is whether there is evidence of Basin effects based on documented use, release, or exposure data, or from a precautionary point of view. An example of a precautionary point of view would be documented evidence of significant impact in another geographic location with the same sources and use patterns as in the Basin, or because the effects of a pollutant would be significant by the time it was able to be measured through monitoring.

GLBTS MANAGEMENT ASSESSMENT

Ability for GLBTS to effect further reductions?

Answering this question involves an accelerated version of the first three steps of the GLBTS 4-step process,[4] looking at sources and current programs and regulations to see where the reduction opportunities lie. Part of the assessment will involve consideration of whether the reduction opportunities will be significant enough to merit the effort.

Principally lake specific?

Based on a joint GLBTS-LaMP determination that the impact of a substance is restricted to a single lake, the appropriate LaMP will be engaged for coordination of leadership for reduction actions to be undertaken by the responsible organizations.

Can new challenge goals be established?

The GLBTS will assess the practicality of setting forth new challenge goals.

[4] The GLBTS four-step process to work toward virtual elimination is: 1) Information gathering; 2) Analyze current regulations, initiatives, and programs which manage or control substances; 3) Identify cost-effective options to achieve further reductions; and 4) Implement actions to work toward the goal of virtual elimination.

GLBTS MANAGEMENT OUTCOMES

Active Level 1 Status & Periodic Reassessment by GLBTS

The substance will continue as a Level 1 with reduction actions addressed by the appropriate process and with periodic reassessment, approximately every two years, using the *General Framework to Assess Management of GLBTS Level 1 Substances*.

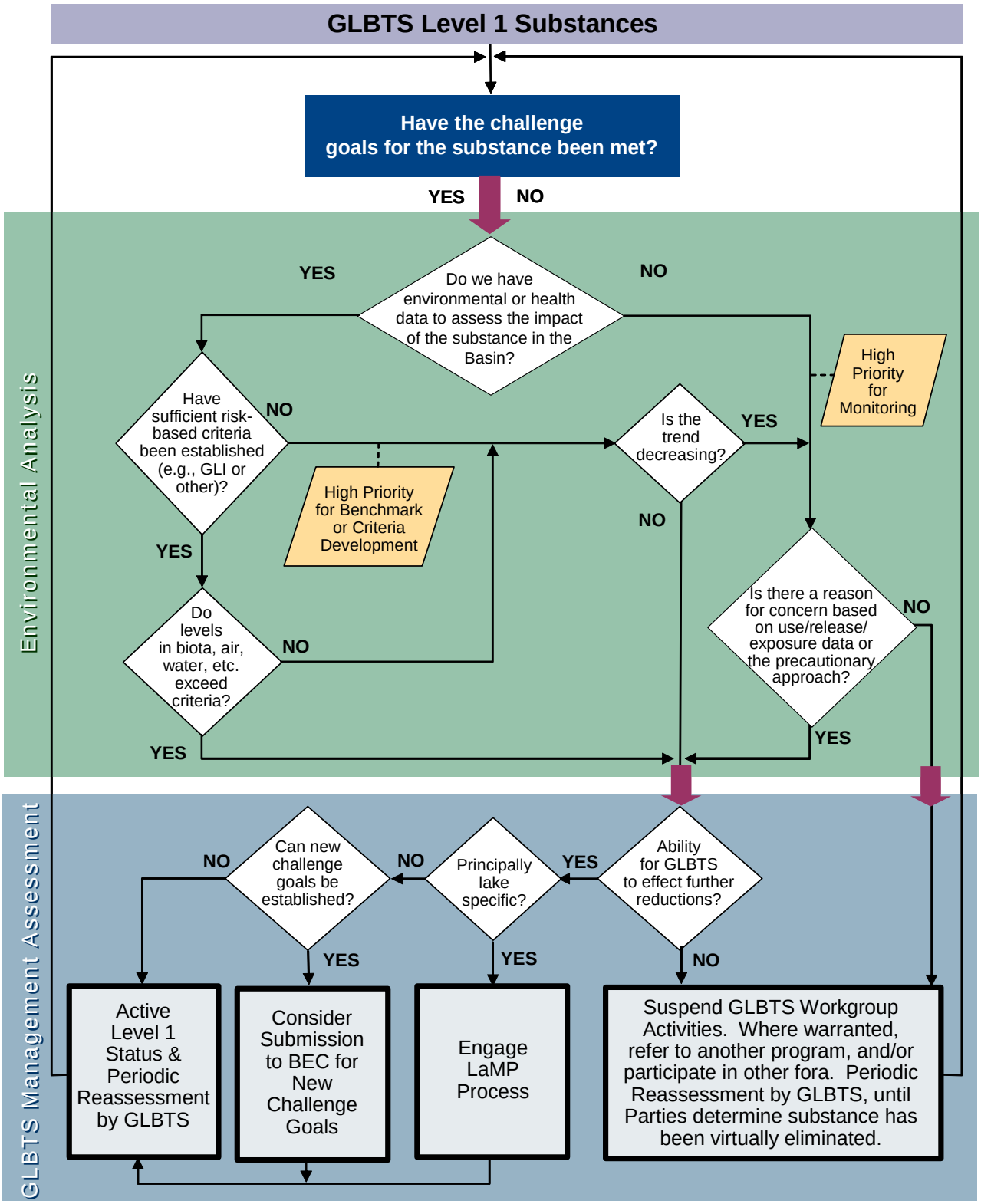
Consider Submission to BEC for New Challenge Goals

The GLBTS will consider recommending new challenge goals to BEC. The justification for new challenge goals will incorporate the findings of the framework analysis and will include assessment of the desired environmental improvement and feasibility. If the GLBTS decides to propose new challenge goals, the recommendation to BEC will include a reduction percentage, reduction timeline, and baseline for the proposed new challenge goals.

Engage LaMP Process

For substances whose impact is lake-specific, the appropriate LaMP will be engaged to coordinate substance reduction activities with continued support from the GLBTS, recognizing the limited direct implementation capacity of the LaMPs. It is understood that much of the actual implementation would be carried out by the agencies with responsibility to address these substances. A joint review of progress would be undertaken periodically.

Suspend GLBTS Workgroup Activities. Where warranted, refer to another program, and/or participate in other fora. Periodic Reassessment by GLBTS, until Parties determine substance has been virtually eliminated.

In the event that the GLBTS is not able to effect further reductions, or there is no evidence of Basin effects, GLBTS workgroup activities will be suspended. Where warranted, a recommendation will be made to a) refer reduction efforts for the substance to another program, and/or b) represent GLBTS interests in other fora (e.g., Commission for Environmental Cooperation, United Nations Environment Programme). There will be no ongoing workgroup involvement with these substances, though each one will undergo periodic reassessment, approximately every two years, using the *General Framework to Assess Management of GLBTS Level 1 Substances*, until the Parties determine that virtual elimination has been reached.

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