1992 Environmental Status Report on Canadian Petroleum Refinery Effluents

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Abstract

This status report provides an overview of refinery effluents from the Canadian petroleum refining industry. It also provides an assessment of the state of the oil industry's compliance with the federal Petroleum Refinery Effluent Regulations and Guidelines for 1992. During that year, on average, Canadian refineries were in compliance with the monthly amounts 97.3% of the time, with the daily amounts 99.9% of the time, and with the maximum daily amounts 99.6% of the time.

Résumé

Le présent rapport donne une vue d'ensemble de l'industrie canadienne du raffinage du pétrole en ce qui a trait aux effluents des raffineries. On y évalue dans quelle mesure l'industrie s'est conformée au Règlement sur les effluents des raffineries de pétrole *et aux directives connexes du gouvernement fédéral pendant l'année 1992. Cette année-là, en moyenne, les raffineries canadiennes ont respecté les quantités mensuelles 97,3 % du temps, les quantités quotidiennes 99,9 % du temps et les quantités maximales quotidiennes 99,6 % du temps.*

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Summary

This report provides an overview of the Canadian petroleum refining industry and a comprehensive review of its liquid effluents and related pollution control methods. In addition, it provides an assessment of the state of the industry's compliance with the federal Petroleum Refinery Effluent Regulations and Guidelines for the year 1992.

In 1992, 28 refineries were operating in Canada with a total crude throughput of approximately 239 000 m^3/day. Fourteen of the refineries are located in the Eastern provinces - two in Nova Scotia, one each in Newfoundland and New Brunswick, three in Quebec, and seven in Ontario. Of the remaining refineries, two are located in Saskatchewan, six in Alberta, five in British Columbia, and one in the Northwest Territories.

Petroleum refineries were assessed for compliance with the federal Petroleum Refinery Effluent Regulations and Guidelines. Refineries built after November 1, 1973 are subject to formal Regulations, whereas those built prior to November 1, 1973 are subject to Guidelines. Of the 28 refineries operating during all or part of 1992, seven were subject to the Regulations, while 21 were subject to the Guidelines. Four refineries of the 28 were not assessed: one refinery had no deposits, one discharged its effluent into a municipal sewer which spreads its effluent over land, and two (subject to the Regulations) used deep-well injection for disposal of all their process effluents. Storm water was not assessed for this report as most of the refineries combine process and storm water for treatment. Of the remaining 24 refineries, 13 were in compliance with all the limits 100% of the time and 7 were in compliance with all the limits more than 99% of the time for the data they submitted. All of the remaining 4 refineries had further treatment provided off-site.

On a national basis, the refineries were in compliance, on average, with the monthly amounts 97.3% of the time, with the one-day amounts 99.9% of the time, and with the maximum daily amounts 99.6% of the time. The seven regulated refineries complied with the monthly amounts 100% of the time, with the one-day amounts 100% of the time, and with the maximum daily amounts 99.9% of the time.

In general, the limits in the Regulations and Guidelines were exceeded when there were problems or mechanical deficiencies in the wastewater treatment systems. When problems were identified, corrective measures were taken to improve the quality of the effluent. The performance of refineries generally improved in 1992 from 1987.

From 1975 to 1992, there was a general downward trend for the net deposits (expressed in kg/d) of all the regulated parameters. Since 1987, oil and grease was reduced by 11%, phenols by 62%, sulfide by 19%, ammonia nitrogen by 51%, and total suspended matter by 30%. These general reductions were partially a result of the 4% drop in production, but are primarily due to the industry's continuous effort to meet and exceed federal and provincial requirements. Such achievement is in line with the Total Quality Management approach to operating a wastewater

treatment plant. Refineries have taken the initiative to continuously lower their pollutant discharges and have not stopped at the allowable limits. The refining industry is to be commended for its attitude and performance in this regard.

On average, only 79.7% of the tests called for by the Regulations and Guidelines were submitted in 1992. This was primarily because some refineries addressed only the provincial or municipal monitoring and reporting requirements which are sometimes different from the federal requirements.

Seventy-five percent of the refineries use either a secondary treatment system for treating their wastewater or a deep-well injection for disposal. Under good operating conditions, the existing treatment systems can easily meet the limits prescribed by the federal Regulations and Guidelines. Levels are often reached that are well below the limits. Environment Canada and the Canadian Petroleum Products Institute (CPPI) have commissioned a number of studies in the past to characterize refinery wastewater and assess the effectiveness of existing treatment systems in reducing the concentrations of trace contaminants. The major conclusion of these studies is that a well operated wastewater treatment system, which uses "best practicable treatment technology" (used by most refineries), is very efficient in removing organic priority pollutants from refinery wastewater, while heavy metals are concentrated in the sludges and do not enter surface water bodies.

Definitions and Acronyms

Activated carbon	Carbon that is specially treated to produce a very large surface area and is used to adsorb undesirable substances.
Actual deposits	The amount of contaminants discharged in refinery effluents.
Adsorption	Attraction exerted by the surface of a solid for a liquid, or a gas, when they are in contact.
Aerobic bacteria	Bacteria that require free oxygen to metabolize nutrients.
Air blowing	The process used to produce asphalt by reacting residual oil with air at moderately elevated temperatures.
Altered refinery	An existing refinery at which the primary crude oil atmospheric distillation tower was replaced after October 31, 1973.
Anti-icing additive	A fuel additive used to minimize ice formation.
Anti-knock compound	Chemical compounds added to motor and aviation gasolines to improve their performance and to reduce knock in spark-ignition engines.
Anti-oxidants	Chemicals added to products such as gasoline and lubricating oil to inhibit oxidation.
APHA	American Public Health Association.
API	American Petroleum Institute.
Authorized deposits	The amount of contaminant to be discharged with the effluent of a refinery as authorized by the federal Regulations and Guidelines.
Blowdown	Removal of liquid from a refinery vessel (storage or process) through the use of pressure. The term "blowdown" is also used to refer to the actual liquid removed.
BOD	Biochemical Oxygen Demand. The amount of oxygen required by aerobic microorganisms to biodegrade organic matters contained in wastewater. The BOD test is used to measure the organic content of wastewater and surface water.

BPT	Best Practicable Treatment.
Catalyst	A substance that promotes a chemical reaction without itself being altered.
COD	Chemical Oxygen Demand. The amount of oxygen equivalent of the organic matter required to complete chemical oxidation in an acidic medium. The COD test is used to measure the organic content of wastewater and natural water.
Cooling tower	A large structure, usually wooden, in which atmospheric air is circulated to cool water by evaporation.
CPPI	Canadian Petroleum Products Institute.
Existing refinery	A refinery that began operation prior to November 1, 1973.
Expanded refinery	An existing refinery that has declared a revised Reference Crude Rate of more than 115% of the initial Reference Crude Rate.
Fractionator	A cylindrical refining vessel where liquid feedstocks are separated into various components or fractions.
GVRD	Greater Vancouver Regional District.
Landfill	A location where solid waste is buried in layers of earth in the ground for disposal.
Leachate	A solution resulting from the dissolving of soluble material from soil or solid waste by the action of percolating water or rainfall.
Liquid-liquid extraction	The process whereby two immiscible liquids come in contact to allow for the soluble material in the carrier liquid to be extracted in the solvent.
LPG	Liquified Petroleum Gas.
Maximum daily amount	A limit set in the federal Regulations and Guidelines for a number of parameters pertaining to refinery effluents. The refinery effluent should not exceed this limit on any day of the month.

Mercaptans	A group of organosulfur compounds having the general formula R-SH where "R" is a hydrocarbon radical such as CH_3 and C_2H_5. Mercaptans have strong, repulsive, garlic-like odours and are found in crude oil.
Monthly amount	A limit set in the federal Regulations and Guidelines for a number of parameters pertaining to refinery effluents. This limit represents the amount that should not be exceeded in the refinery effluent on a daily average basis over each month.
New refinery	A refinery that has not commenced the processing of crude oil prior to November 1, 1973.
96-hour flow-through bioassay	A test procedure required by the federal Guidelines to evaluate the acute lethal toxicity of refinery effluent to fish. The procedure consists of exposing fish to a continually renewed effluent under controlled conditions over a 96-hour period. The percent mortality of fish is observed after the four-day period.
96-hour static bioassay	A test procedure similar to the 96-hour flow-through method but in which the effluent is not renewed during the period of test.
Octane	A number indicating the relative anti-knock value of a gasoline. The higher the octane number, the greater the anti-knock quality.
Once-through cooling water	Water that has been circulated once through heat exchangers in order to remove heat from process streams without coming into contact with the stream.
One-day amount	A limit set in the federal Regulations and Guidelines for a number of parameters pertaining to refinery effluents. Each refinery is allowed to exceed this limit only once during a month.
Ozonation	Water treatment method that uses ozone as an oxidant to remove pollutants, i.e., chemical pollutants present in small concentrations that are difficult to remove, or to disinfect water.
Photosynthetic action	A process by which organic compounds (mainly carbohydrates) are synthesized by chlorophyll-containing plant cells. The reaction takes place in the presence of light, carbon dioxide, and water.

Priority pollutants	A list of 129 toxic pollutants having known or suspected adverse effects upon human health or the environment. The United States Environmental Protection Agency (U.S. EPA) established this list and has the mandate, under the *Clean Water Act*, to control these pollutants in wastewater discharged to the environment.
Reference Crude Rate (RCR)	The quantity of crude oil, expressed in 1000 m^3/d, declared by a refinery and used to calculate the authorized deposits.
Residual pitch	A black, heavy residue produced in the processing of crude oil.
Sour water	Water containing impurities, mainly sulfide and/or ammonia, that make it extremely harmful.
Stripping	A process for removing the more volatile components from a mixture. Generally, the hot liquid from a flash drum or tower is passed into a stripping vessel, through which open steam or inert gas is passed to remove the liquid's more volatile components.
24-hour static bioassay	A test procedure similar to the 96-hour static method but in which the percent mortality of fish is observed after a 24-hour period.
Zeolite catalyst	A catalyst that contains any of the various silicates, e.g., hydrated aluminum and calcium (or sodium) silicates, used in catalytic cracking units.

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Introduction

In November 1973, Environment Canada issued the Petroleum Refinery Effluent Regulations and Guidelines under the *Federal Fisheries Act* (Environment Canada, 1974; Fisheries and Oceans Canada, 1985). The Regulations and Guidelines do not apply to facilities associated with the production of synthetic petroleum from coal or bituminous sands. The purpose of this report is to provide the Canadian public and the refining industry with a comprehensive assessment of performance against these Regulations and Guidelines. Environment Canada has published these status reports on the industry's compliance with the Regulations and Guidelines for 1975, 1977, 1980, 1983, 1984, and 1987. Refineries are identified by name and location, consistent with the department's policy on "information availability" which was announced in 1982 to comply with the *Access to Information Act* (Federal Government, 1985).

The compliance assessment is based on unpublished "Petroleum Refinery Compliance Reports" prepared by Environment Canada's regional offices in cooperation with industry and the respective provincial environmental agencies. Environment Canada and the provincial agencies periodically audit refinery effluents through field surveys.

The information in this report is presented according to the five Regions of Environment Canada: Atlantic Region (Newfoundland, New Brunswick, Nova Scotia, and Prince Edward Island); Ontario Region (the province of Ontario); Quebec Region (the province of Quebec); Western and Northern Region (Manitoba, Saskatchewan, Alberta, and the Northwest Territories); and Pacific and Yukon Region (British Columbia and the Yukon Territory). The industry's compliance with the Regulations and Guidelines was assessed on an individual (refinery-by-refinery), regional, and national basis.

Description of the Petroleum Refinery Industry

In 1992, 28 petroleum refineries were operating in Canada, which is one less than in 1987 when the last status report was published. The primary function of a petroleum refinery is to separate crude oil and convert it into products such as gasoline, diesel fuel oil, light and heavy fuel oils, petrochemical feedstock, aviation fuels, bitumen, liquified petroleum gas (LPG), lubricants, kerosene, and stove oil.

Crude oil is the principal raw material for a petroleum refinery. It may be of natural origin (from underground geological formations) or synthetic (recovered from tar sands). Crude oil is a mixture of many hydrocarbons and, depending on its source, varies considerably in composition and physical properties. Its elementary composition (by mass) usually falls within the following ranges: 84 to 87% carbon, 11 to 14% hydrogen, 0 to 3% sulfur, 0 to 2% oxygen, 0 to 1% nitrogen, 0 to 1% water, and 0 to 0.1% mineral salts. Crude oil may also contain trace amounts of heavy metals such as iron, arsenic, chromium, vanadium, and nickel.

Crude oils are broadly classified by hydrocarbon composition as paraffinic (not prevalent in Canada), naphthenic, asphaltic, mixed (contains paraffinic and asphaltic material), and aromatic base (prevalent in the Middle East).

2.1 General

The major steps in converting crude oil to various products are **separation**, **conversion**, **treatment**, and **blending**. In the first step, crude oil is separated into selected fractions mainly by distillation and to a lesser extent by solvent extraction and crystallization. Conversion processes are then used to change the size and shape of the hydrocarbon molecules to increase their monetary value. These processes include breaking molecules into smaller ones (catalytic cracking), rearranging molecules (catalytic reforming and isomerization), and joining molecules together (alkylation and polymerization). Impurities such as sulfur, nitrogen, and oxygen compounds that end up in intermediate products are removed or modified by treatment processes such as desulfurization, denitrification, or treatment with chemicals (caustic soda or acid). In the final step, the refined products are usually blended and some additives are added to improve the quality to meet finished product specifications.

These processes are discussed in more detail in the following subsections. A simplified flow diagram of the various refinery processes and products is provided in Figure 1.

2.2 Industry Processes

2.2.1 Separation

Atmospheric Distillation - In this process, the crude oil is preheated and mixed with water in a desalter. The water is then separated from the crude, taking with it the salts entrained in the oil from the geological formation. The desalted crude oil is heated and fed to the distillation column at slightly above atmospheric pressure. Next, the crude oil is separated, by distillation and steam

PETROLEUM REFINERY

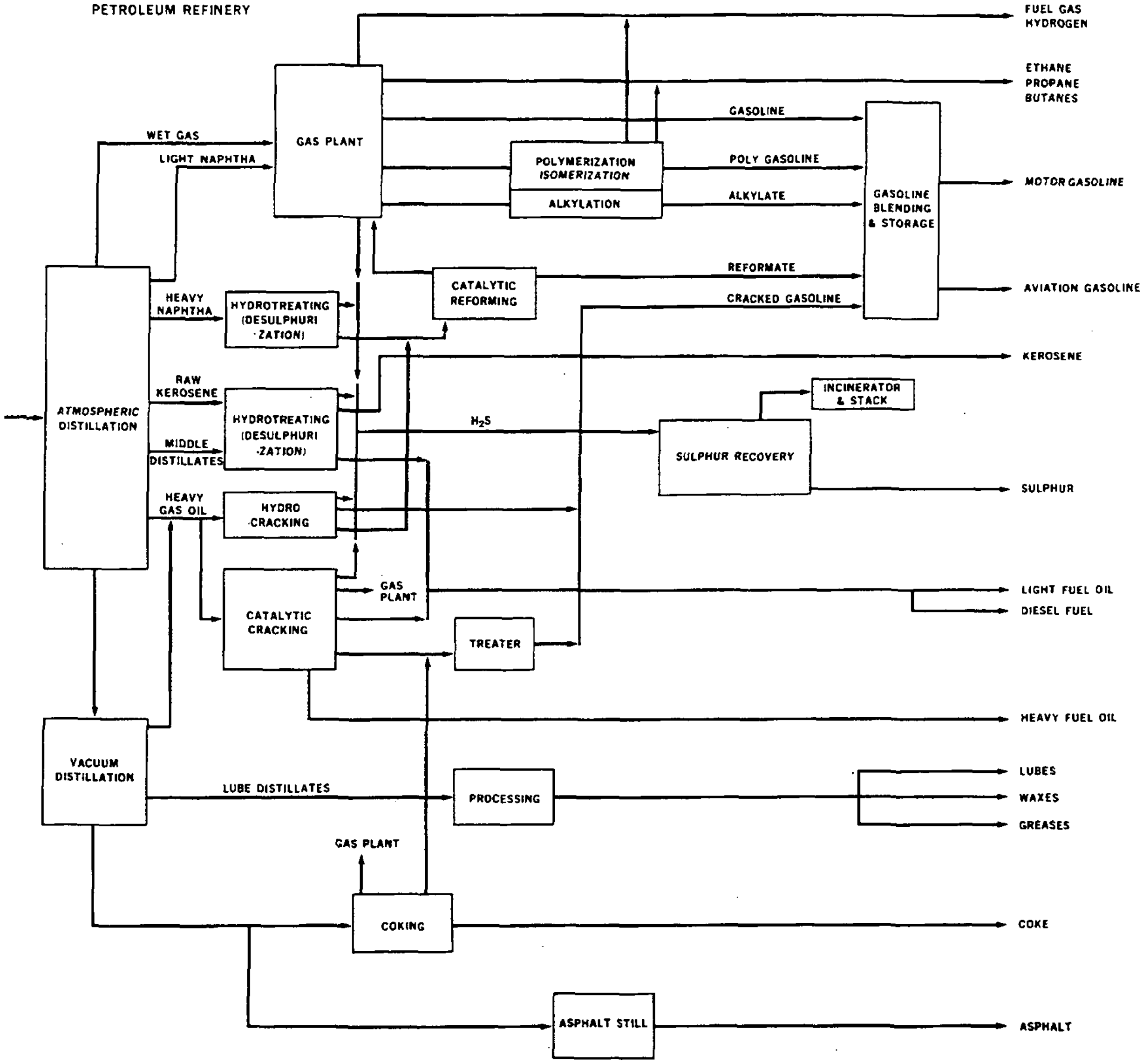


Figure 1 Simplified Petroleum Refinery Process Flow Diagram

stripping, into fractions in a range of specific boiling temperatures. The various fractions are continuously drawn off and diverted for further processing or used as finished products. The lighter products are withdrawn from the top of the column whereas lower points on the tower draw off progressively heavier fractions. The tower bottoms, which contain the heaviest petroleum fraction, are transferred to a vacuum distillation tower for further separation.

Vacuum Distillation - In this process, the residue from the atmospheric distillation tower is separated under vacuum into one or more heavy gas oil streams and heavy residual pitch.

2.2.2 *Conversion*

Cracking Processes - Typical cracking processes include catalytic cracking, hydrocracking, and visbreaking or coking, both of which are thermal cracking processes.

a) **Catalytic cracking** is a key process used to increase the quality and quantity of gasoline fractions. The most commonly used process is the fluid bed type, which uses a finely powdered zeolite catalyst that is kept in suspension in the reactor by the incoming oil feed from the bottom of the reactor. Upon contact with the hot catalyst, the oil vaporizes and is cracked into smaller molecules. Vapours from the reactor are separated from the entrained catalyst and fed into a fractionator, where the desired products are removed and heavier fractions are returned to the reactor. The catalyst is deactivated by thermal degradation and through contact with heavy metals in the feed, necessitating regeneration or replacement.

b) **Hydrocracking** is basically a catalytic cracking and a hydrogeneration process. In this process, polycyclic compounds are broken to produce single ring and paraffin-type hydrocarbons. In addition, sulfur and nitrogen are removed to produce hydrogen sulfide and ammonia. These reactions occur at high temperatures and pressures, in the presence of hydrogen and a catalyst.

c) **Visbreaking** is an old process that was replaced by catalytic cracking and hydrocracking. It involves a mild thermal cracking operation designed to reduce the viscosity of the charge stock. The feed is heated and thermally cracked in the furnace. Cracked products are routed to a fractionator where the low boiling materials are separated into light distillate products, while the heavy portion may be used for coker feed or as plant fuel.

d) **Coking processes** (fluid or delayed) are used by only a few refineries in Canada. Coking is a severe thermal cracking process in which the feed is held at high cracking temperature and low pressure so that coke will form and settle out. The cracked products are sent to a fractionator where gas, gasoline, and gas oil are separated and drawn off, and the heavier material is returned to the coker.

Rearranging Processes - Catalytic reforming, which is the most widely used rearranging process, improves the octane quality of gasoline obtained from crude oil. This is achieved by molecular rearrangement of naphthenes through dehydrogenation and of paraffins through isomerization and dehydrocyclization. The reformer catalyst, commonly platinum chloride on an alumina base, may also contain an activity-increasing noble metal such as rhenium. In many units, the catalyst is regenerated or replaced every 6 to 12 months. In other units, the catalyst is withdrawn continuously and regenerated on-site for further use. Refineries are more often choosing continuous reformers that do not require periodic shutdown for catalyst regeneration as conventional reformers do. The dehydrogenation and dehydrocyclization reactions produce large amounts of hydrogen as a by-product that can be used for various hydrogen-treating processes.

Combining Processes - Two processes, alkylation and polymerization, are used to produce gasoline-blending stocks from the gaseous hydrocarbons formed during cracking processes.

a) **Alkylation** is the reaction of an olefin with an iso-paraffin (usually isobutane) in the presence of a catalyst (either 98% sulfuric acid or 75 to 90% hydrofluoric acid) under controlled temperatures and pressures to produce high octane compounds known as alkylate. These products are separated in a settler where the acid is returned to the reactor and the alkylate is further processed. This hydrocarbon stream is scrubbed with caustic soda to remove acid and organically combined sulfur before passing to the fractionation section. Isobutane is recirculated to the reactor feed, the alkylate is drawn off from the bottom of the debutanizer, and the normal butane and propane are removed from the process.

b) **Polymerization** is a reaction that joins two or more olefin molecules. The use of this process has been declining as both the yield and quality of the gasoline product are inferior to those derived from the alkylation process. The feed must first be treated with caustic soda to remove sulfur compounds and then with water to remove nitrogen compounds and excess caustic soda. These treatments are required to protect the catalyst in the reactor. After treatment, the hydrocarbon feed is contacted with an acid catalyst in the reactor under high temperature and pressure. The catalyst is usually phosphoric acid or, in some older units, sulfuric acid. The polymerized product from the reactor is then treated to remove traces of acid.

2.2.3 Treating

Hydrotreating - Hydrotreating is a relatively mild hydrogenation process which saturates olefins and/or reduces sulfur, nitrogen, and oxygen compounds along with halides and trace metals present in the feed, without changing the boiling range of the feed. This process stabilizes the product by converting olefins and gum-forming unstable diolefins to paraffins and also improves the odour and colour of the products. Although there are various types of hydrotreating units, each has essentially the same process flow. The feed is combined with recycled hydrogen, heated to the reaction temperature, and charged to the reactor. In the presence of a catalyst (metal-sulfide), the hydrogen reacts with the hydrocarbons to form hydrogen sulfide, ammonia, saturated hydrocarbons, and free metals. The metals remain on the catalyst and other products leave the reactor with the oil-hydrogen stream. The reactor products are cooled and hydrogen sulfide is removed, while hydrogen is returned to the system. The hydrocarbons are sent to a fractionator where the various products are separated. This process is ideally suited for the production of low sulphur diesel and furnace fuel oil.

Chemical Treating - A number of chemical methods are used throughout the refinery to treat hydrocarbon streams. These can be classified into three groups:

acid treatment, sweetening processes, and solvent extraction.

a) **Acid treatment** consists of contacting the hydrocarbons with concentrated sulfuric acid to remove sulfur and nitrogen compounds, to precipitate asphaltic or gum-like materials, and to improve colour and odour.

b) **Sweetening processes** oxidize mercaptans to less odoriferous disulfides without actually removing sulfur. The most common sweetening processes are the Merox processes; others include the lead sulfide, the hydrochloride, and the copper chloride processes. In the Merox process, a catalyst composed of iron group metal chelates is used in an alkaline environment to promote the oxidation of mercaptans to disulfides using air as a source of oxygen.

c) **Solvent extraction** involves the use of a solvent that has an affinity for the undesirable compounds and is easily separated from the product. Mercaptans are extracted using a strong caustic solution. The solvent is usually regenerated by heat, steam stripping, or air blowing.

Gas Treating - This process is used to remove the sulfur compounds from the various gaseous streams. Hydrogen sulfide (H_2S) can be extracted by an amine solution to produce a concentrated stream of H_2S that can be sent to a sulfur recovery plant.

Treatment by Physical Means - Physical methods are intermediate steps in crude oil processing operations and are often used to treat hydrocarbon streams or remove undesirable components. These methods include electrical coalescence, filtration, adsorption, and air blowing. Physical methods are applied in desalting crude oil, removing wax, decolorizing lube oils, brightening diesel oil (to remove turbidity caused by moisture), and in other processes.

2.2.4 Blending and Additives

A number of intermediate streams, called "base stocks", are blended to produce a product that will meet various specifications, e.g., specific volatility, viscosity, and octane. The blending operation involves the accurate proportioning of the base stocks along with proper mixing to produce a homogenous product.

A number of additives are used to improve the properties of the products. For example, MMT is usually added to gasoline to increase the octane number since recent regulations forbid the use of lead in gasoline. Other additives, such as anti-oxidants, anti-icing agents, and metal deactivators, are also used.

Effluent Discharge

3.1 Regulatory Requirements

To protect fish and marine organisms, the Federal *Fisheries Act* prohibits deposit of deleterious substances in waters where fish are present. To this end, the Petroleum Refinery Effluent Regulations and Guidelines were issued on November 1, 1973. The provinces of Quebec, Ontario, Alberta, and British Columbia have objectives, Guidelines, or Regulations in addition to the federal requirements. In the other provinces, effluent control is based solely on federal Regulations and Guidelines and permit systems.

3.1.1 Federal Limits

The Canadian Petroleum Refinery Effluent Regulations apply to "new" refineries, which are those that started up on or after November 1, 1973. The Guidelines apply to "existing" refineries which are those in operation before this date. Regulations have the force of law, whereas Guidelines are statements of practice that is considered to be in compliance with the "spirit of the law". Failure to comply with the Guidelines is not in itself an offence but it may mean that the *Fisheries Act* is being transgressed.

The Regulations and Guidelines set limits for the deposits of oil and grease, phenols, sulfide, ammonia nitrogen, total suspended matter (solids), and pH levels in refinery effluents. They also specify monitoring methods and reporting frequency. Limits set in the Regulations are more stringent than those set in the Guidelines except for pH levels which are the same in both. In addition, the Guidelines set an acute fish toxicity limit which applies to both "existing" and "new" refineries. The intent of the Regulations and Guidelines is to apply a national baseline standard uniformly across Canada; however, more stringent standards may be imposed by provincial or local governments depending on local circumstances. The purpose of the federal Regulations and Guidelines is to ensure that all refineries in Canada apply "best practicable treatment" (BPT) technology to their liquid effluents.

Effluent limits - The limits shown in Table 1 represent the maximum allowable deposits for all parameters. The limits for oil and grease, phenols, sulfide, ammonia nitrogen, and total suspended matter represent the maximum net values, i.e., the amount contributed by the refinery, excluding background concentrations in the refinery intake water. In addition, the allowable deposits, expressed in $lb/10^3\ bbl \cdot d^{-1}$ ($kg/10^3 m^3 \cdot d^{-1}$) of crude oil, are based on the refinery "Reference Crude Rate" (RCR).

To assess compliance, the actual deposits of the contaminants measured in the liquid effluent are compared with the allowable deposits shown in Table 1.

Table 1 Amounts to be Used for Calculating Maximum Allowable Deposits of Deleterious Substances

	Monthly Amount lb/10^3bbl·d^{-1} (kg/10^3m^3·d^{-1}) of crude oil		One-day Amount lb/10^3bbl·d^{-1} (kg/10^3m^3·d^{-1}) of crude oil		Maximum Daily Amount lb/10^3bbl·d^{-1} (kg/10^3m^3·d^{-1}) of crude oil	
Substance	**Guidelines**	**Regulations**	**Guidelines**	**Regulations**	**Guidelines**	**Regulations**
Oil and Grease	6.0 (17.1)	3.0 (8.6)	11.0 (31.4)	5.5 (15.7)	15.0 (42.8)	7.5 (21.4)
Phenols	0.6 (1.7)	0.3 (0.9)	1.1 (3.1)	0.55 (1.6)	1.5 (4.3)	0.75 (2.1)
Sulfide	0.2 (0.6)	0.1 (0.3)	0.6 (1.7)	0.3 (0.9)	1.0 (2.9)	0.5 (1.4)
Ammonia Nitrogen	5.0 (14.3)	3.6 (10.3)	8.0 (22.8)	5.7 (16.3)	10.0 (28.5)	7.2 (20.5)
Total Suspended Matter	14.4 (41.1)	7.2 (20.5)	24.0 (68.5)	12.0 (34.2)	30.0 (85.6)	15.0 (42.8)
pH					6.0 to 9.5	
Toxicity					No more than 50% fish mortality	

Note: The Regulation and Guideline limits are in imperial units

There are three levels of allowable limits for each substance deposited per day. The first and lowest limit is the "**Monthly amount**" which represents the maximum daily average for each month. The second level is the "**One-day amount**". During a month, the refinery may deposit a substance in excess of this limit only once during a single day. An unallowable discharge is recorded for each additional day in which the deposit exceeds this limit. The third and highest level is the "**Maximum daily amount**" which is a limit that should not be exceeded on any day of the month. Deposits in excess of the monthly limit are considered to be the most serious as they may indicate an ongoing problem, particularly if they are repeated.

The liquid effluent and the once-through cooling water should not at any time have a pH value outside the allowable range or a fish mortality rate exceeding 50%.

Monitoring requirements - Each refinery is requested/required to test for each of the five substances three times per week (Monday, Wednesday, and Friday) and to record the amount being discharged on those days. In addition, the pH level is to be measured daily. Refineries that are subject to the Regulations must report the results of these tests. All refineries are requested to perform one toxicity test each month. The results of all analyses are to be reported monthly.

Storm water - Storm water is run-off resulting from precipitation, i.e., rain and snow, that falls on the refinery site or that originates outside the refinery but passes over or through the refinery site and is contaminated by any of the five parameters listed in Table 1. If clean (not contaminated) run-off is segregated, it is exempted from the Regulations and Guidelines. In addition to the authorized deposits listed in Table 1, further deposits of oil and grease, phenols, and total suspended matter are allowed on days that a refinery is discharging storm water. These additional limits are listed in Table 2. Storm water analysis was not conducted for this report as most refineries in Canada do not segregate storm water, but treat it along with their process water.

Reference Crude Rate - The Reference Crude Rate (RCR) is needed to calculate the allowable deposits and should therefore be reported by the refinery for each month. For an existing refinery, the initial RCR is the highest average crude rate sustained for seven consecutive days within the two-year period ending October 31, 1973. For a new refinery, the RCR is the maximum design stream day crude rate for that refinery. A revised RCR must be declared by the refinery if the crude rate falls below 85% of the RCR and then the revised RCR is used to calculate the authorized deposits. A revised RCR may be declared if the crude rate exceeds 115% of the RCR.

Refinery status - Each refinery operates under a declared status (new or existing) that indicates whether the refinery falls under the Regulations or the Guidelines. New refineries must meet the more stringent limits and are subject to the Regulations. An existing refinery is

Table 2 **Amounts to be Used for Calculating Additional Deposits of Deleterious Substances When Storm Water is being Discharged and Limits of Deposits Authorized**

Deleterious Substance	Allowance $lb/10^4 gal \cdot d^{-1}$ ($kg/10^4 L \cdot d^{-1}$) of storm water	Maximum Allowance per month $lb/10^3 bbl \cdot d^{-1}$ ($kg/10^3 m^3 \cdot d^{-1}$) of crude oil	
		Guidelines	Regulations
Oil and Grease	1.0 (0.10)	50.0 (142.7)	25.0 (71.3)
Phenols	0.1 (0.010)	5.0 (14.3)	2.5 (7.1)
Total Suspended Matter	3.0 (0.30)	150.0 (428.0)	75.0 (214.0)

Note: The Regulation and Guideline limits are in imperial units always subject to the Guidelines. An existing refinery may also have an expanded or altered status. A refinery is considered "expanded" when the declared RCR is greater than 115% of the i nitial RCR. The portion of the revised RCR that exceeds the initial RCR is subject to the more stringent allowable deposits equivalent to new refinery limits. The replacement of a crude tower is the indicator selected to determine whether a refinery has an "altered" status. The portion of the RCR represented by the new tower is subject to the new refinery limits.

Off-site treatment - A refinery may be given an exemption from the requirements for liquid effluent and once-through cooling water if treatment is provided in facilities outside the refinery (such as municipal sewage systems). This exemption can only be granted by the Minister if the off-site facility provides treatment equivalent to that required by the Regulations and Guidelines.

Toxicity - The Guidelines Respecting Acute Toxicity of Liquid Effluents from Petroleum Refineries were established to serve as an indicator of the presence of other contaminants that are not specifically controlled, such as biochemical oxygen demand (BOD), chemical oxygen demand (COD), and heavy metals. These guidelines apply to all refineries. The 24-hour static bioassay test should be performed every month by the refinery on both liquid effluent and the once-through cooling water. The 96-hour flow-through bioassay should be conducted periodically by the Environmental Protection Service.* The methods for these tests are described in the Guidelines.

The Regulations and Guidelines are intended to limit the quantities of contaminants discharged. This could also result in the reduction of volume of effluent discharged. To encourage the reduction of contaminants discharged but not to penalize refineries with low water consumption, a dilution of the refinery effluent is granted for those with a lower water usage rate.

3.2 Wastewater Contaminants

Contaminants in refinery wastewater originate from various sources: crude oil, refinery intake water, refinery storm water, ballast water, sanitary wastes, process chemicals and catalysts, reaction products from conversion units, and chemical additives.

Crude oil is a complex mixture of hydrocarbons with some impurities in the form of organic compounds of sulfur, nitrogen, oxygen, a number of heavy metals, and inorganic salts. To minimize the formation of hydrochloric acid in the distillation tower, crude oil should be desalted and the condensates neutralized with ammonia. To reduce salt, crude oil is contacted with water (forming an emulsion) and is passed through a chemical or electrostatic desalter where the brine is separated from the oil phase. The water phase will contain oil, desalting chemicals, dissolved salts, and suspended matter. After stripping, sour water is generally used as wash water in the desalter to reduce freshwater consumption and for phenol absorption by the crude oil.

Intake water contains a variety of impurities depending on the location of the

* Most (or all) regions have replaced the 96-hour flow-through bioassay with the 96-hour static bioassay, which is a similar but less cumbersome test procedure.

refinery, e.g., on the river, on the ocean, or downstream from other industries. The water usually requires treatment before being used in boilers and cooling towers. The hardness and silica content of the water determine the degree of treatment and the amount of blowdown from these systems.

Storm water that falls on the refinery site collects silt and any spilled oil from the refining processing and tank farm areas. Storm water may also contain traces of phenols and other contaminants.

Ballast water is carried in navigational vessels to provide stability. This also includes water used for cleaning cargo or ballast tanks. Refineries that ship products by marine tanker receive the ballast water before loading the vessel. The water generally contains oil, phenols, chlorides, and trace amounts of suspended and dissolved matter.

Sanitary wastes from employees in refinery office buildings, control rooms, and laboratories are collected and either treated on-site or sent to the municipal sewer system. This source makes up only a small part of the total refinery BOD and suspended matter.

Process chemicals and catalysts can lead to water contamination. Examples of process chemicals include caustic soda, sulfuric and phosphoric acids, amines, sulfolanes, furfural, glycol, ammonia, detergents for chemical cleaning, process additives such as antifoam agents, corrosion-inhibitors (chromium and zinc), lime and water-softening chemicals for boiler feed water preparation, and nutrients for biotreater operation. In processes such as the wet treating of products, some of these chemicals enter the refinery wastewater system.

Catalysts are used to facilitate the conversion of hydrocarbons into more valuable forms. The major catalysts that can lead to water contamination are sulfuric acid that is used in alkylation (a source of sulfonates, sulfates, organic esters, and sulfuric acid itself); hydrofluoric acid used in alkylation (can produce fluorides); phosphoric acid used in polymerization (can produce phosphates); and wet-treatment catalysts, e.g., Merox, Mercapfining.

Reaction products from conversion units generate contaminants that end up in the refinery wastewater. These processes include hydrotreating, thermal cracking/visbreaking, coking, catalytic cracking, hydrocracking, and reforming. The various water contaminants that can be generated by these processes are summarized in Table 3.

Chemical additives are used in the products to enhance their quality and meet specifications. These additives can include corrosion-inhibitors, anti-knock compounds, anti-icing compounds, and anti-oxidants. The additives may enter the wastewater as a result of leakage from chemical storage.

In summary, the major sources of water contamination are: crude desalting/crude distillation, sour condensates from hydrotreating and cracking units, boiler feed and cooling water blowdown, and process wash waters. The significant contaminants are oil and grease, phenols, sulfide, ammonia, suspended and dissolved matter, and substances

Table 3 Conversion Processing Units that Generate Water Contaminants

Processing Unit	Water Contaminants
Hydrotreating	- hydrogen sulfide, ammonia
Thermal Cracking/Visbreaking	- ammonia, nitrogen compounds, hydrogen sulfide, mercaptans, naphthenic acids, organic acids
Catalytic Cracking	- phenols, hydrogen sulfide, carbon disulfide, disulfides, triophenes and carbonyl sulfides, ammonia, cyanides and cyanates
Reforming	- benzene, toluene, and xylene
Alkylation	- sulfates, alkyl sulfonates, and fluorides

contributing to COD and BOD. Minor contaminants include cyanides, fluorides, alkylsulfonates, chromates, and heavy metals (iron, zinc, copper, lead, and nickel).

3.3 Wastewater Treatment

As intended by the federal Regulations and Guidelines, most refineries in Canada apply best practicable treatment technology to their wastewater (or in some cases, a variation thereof). The best practicable treatment is described in the Regulations and Guidelines as:

a) sour water stripping for ammonia and sulfide removal;
b) primary separation (such as API separator); followed by,
c) intermediate treatment (such as air flotation); followed by,
d) secondary treatment (such as biological treatment);
e) final effluent clarification if required; and
f) segregation and treatment of storm water if applicable.

In addition, good housekeeping and maintenance, safe disposal of spent chemicals, and adequate facilities for ensuring smooth, continuous operation of the treatment system are recommended for achieving acceptable effluent.

Currently, 75% of the refineries in Canada send their wastewater to secondary treatment systems. This includes refineries with primary or intermediate treatment systems on-site which also send their effluents for further treatment to municipal treatment plants.

3.3.1 Primary Treatment

Primary treatment systems include sulfide and ammonia stripping, gravity separation, liquid-liquid extraction, filtration, and pH control.

Stripping of sour water reduces sulfide, ammonia, and to a lesser degree, phenols found in wastewater. The stripping process consists of a trayed or packed tower supplied with steam, running counter-currently to incoming sour water. The stripped gases may be incinerated or fed to the sulfur-recovery plant. In the latter case, a two-stage stripping process may be required to separate ammonia from the hydrogen sulfide stream. Removing ammonia reduces problems associated with the presence of ammonia in the feed gas of the Claus sulfur recovery unit.

Gravity separation systems remove free oil and suspended matter from wastewater. The system may consist of a tank (such as ballast water tank), a pond (such as storm water retention pond), or a lagoon equipped with oil skimmers. While most refineries use an American Petroleum Institute (API) separator, use of the tilted-plate separator is increasing. The API separator is a large basin which allows free oil to rise to the surface to be reclaimed and solids to fall to the bottom for removal and disposal. Many important parameters govern the effectiveness of the API separator, including water temperature, the density and size of oil droplets, and the types of solids in the water. The tilted-plate separator is made of several corrugated plates tilted at a 45° angle. As the wastewater flows between the plates, oil droplets collect on the underside and rise to the top, while solids flow to the bottom of the unit.

The main application of **liquid-liquid extraction** in refineries is to extract phenolic compounds from various condensate waters. The extraction takes place in a crude oil desalter where water (usually stripped sour water) is mixed with crude oil. The emulsion formed is broken by electrical or chemical (adding caustic soda) means. Since phenols have an affinity to the oil phase, they are extracted from the water phase whereas crude oil is cleared of the silt and chlorides.

High-rate sand **filtration** which operates under pressure serves mainly as a polishing device and is capable of removing all suspended matter down to a few micrometres in size, limited amounts of colour agents, and traces of oil.

It may be necessary to **control pH** of refinery wastewater because a high pH could be detrimental to subsequent biological processes or receiving waters. Phosphoric acid or ammonia are sometimes added to control pH and at the same time to supply nutrients for subsequent biological treatment.

3.3.2 Intermediate Treatment

Intermediate treatment systems include flotation and equalization.

Flotation is used to further remove undissolved oil and suspended matter from API separator wastewater before discharge or biological treatment. Other contaminants, such as phenols, BOD, and sulfides, are reduced to a certain extent. The process may be either dissolved air or induced air flotation. In dissolved air flotation, wastewater is kept under pressure (275 to 350 kPa) and compressed air is added so that air dissolves. The wastewater then passes through a pressure-reducing valve, forming minute bubbles in the water. The bubbles then attach themselves to the oil and suspended particles in the wastewater and rise to the surface forming a froth which is continuously skimmed for treatment or disposal. To improve the unit's effectiveness in removing oil emulsions, chemical flocculating agents are sometimes added. In the induced air process, the air is entrained by specially designed agitators or diffusors and is dispersed throughout the wastewater.

Equalization basins are generally used ahead of biological oxidation units to reduce fluctuations in flow rates and loadings, since biological processes are sensitive to shock loading.

3.3.3 Secondary Treatment

Secondary treatment systems are biological oxidation processes which include activated sludge, trickling filters, deep shaft, wastewater stabilization ponds, and aerated lagoons. The purpose of these treatment systems is to remove phenols and reduce BOD (including biodegradable priority pollutants) in the wastewater by using the oxygen present in the supplied air. This is achieved by aerobic bacteria which consume the organic material in the wastewater and convert it to carbon dioxide and water. Oxygen and nutrients are required to promote this conversion. The biological mass of bacteria is then separated from the treated wastewater by settling and recirculated to the incoming wastewater.

Activated sludge is an aerobic biological treatment process in which high concentrations of microorganisms are suspended in wastewater within a holding tank. Oxygen is introduced to the basin by mechanical aerators or diffused air systems. The treated effluent then passes through a sedimentation tank before being discharged to the receiving water or in some cases to further treatment. The activated sludge is returned to the reaction tank and the excess sludge is sent to either a sludge thickener or a digester, and then to a vacuum or filter press. Once the volume of sludge is reduced, it can be land farmed or sent to a landfill site.

Trickling filters consist of beds of coarse aggregates subjected to bacterial growth. The bacteria remove organic material from the wastewater by adsorption, bioflocculation, and sedimentation. Oxygen is supplied for rapid metabolism of the removed organic matter. The wastewater is then clarified in a sedimentation tank.

Deep shaft is a biological treatment process in which wastewater is circulated in a shaft while exposed to very high concentrations of bacteria. The wastewater and bacteria are fed into the downflow section, carried to the bottom of the shaft, and returned through the upflow section, thereby providing a long contact time between wastewater and bacteria. Air is injected in the downflow and upflow section. The overflow from the upflow section is passed through a separator; the suspended solids (bacteria) are recycled to the downflow section, and the treated effluent is discharged.

Wastewater stabilization ponds and **aerated lagoons** are large shallow ponds in which dilute concentrations of microorganisms are mixed with wastewater. Oxygen produced by surface diffusion, mechanical aeration units, or photosynthetic action of the algae present in the pond is consumed by bacteria in the aerobic degradation of organic matter. Unlike the activated sludge process, the wastewater from the stabilization pond or aerated lagoon is not settled before discharge due to the low concentration of biological solids maintained in the system, and the biological solids are not recirculated.

3.3.4 Tertiary Treatment

Tertiary systems are used only by a few refineries in Canada. The primary purpose of tertiary treatment is to remove organic matter, taste- and odour-producing substances, and dissolved inorganic substances. Activated carbon, filtration, and chemical oxidation (such as ozonation) can be used effectively to remove these materials.

Effluent Discharges and Compliance with the Federal Regulations and Guidelines

This section presents the status of compliance of petroleum refineries in Canada with respect to the federal Petroleum Refinery Effluent Regulations and Guidelines. A detailed analysis has been made for the 1992 discharge data. The information provided by the refineries was assessed and compiled into annual compliance reports by Environment Canada regional offices.

The following points should be taken into consideration before interpreting the results that are presented in this section or those shown in Appendix A.

1. There is a great disparity in the number of tests submitted by each refinery because all the refineries did not submit all of the required tests. The performance of each refinery is best assessed by comparing its percentage of compliance with other refineries. The number of tests submitted is an important factor that must be considered and reflected in the results.

2. The analytical test methods prescribed in the Regulations and Guidelines for analyzing an effluent sample are those described either in the 13th Edition of the APHA *Standard Methods* (APHA, 1971) or any proven equivalent method. Many refineries are now using the 18th Edition of the APHA method as per provincial requirements (APHA, 1992).

4.1 *Refinery Assessment*

Petroleum refineries were last assessed for compliance with the federal Regulations and Guidelines for effluent discharge in 1987. In 1992, 28 refineries were operating in Canada: seven refineries came under the Regulations and 21 refineries came under the Guidelines. The following four refineries could not be assessed: Parkland--Bowden, as it had no effluent discharge; Moose Jaw Asphalt--Moose Jaw, as its effluent ended up spread over land; and Husky--Lloydminster and Turbo--Balzac as all their wastewater was deep-well injected. Three of these refineries are located in Alberta and one is located in Saskatchewan.

Federal Regulations and Guidelines stipulate that the concentrations of the five prescribed parameters be determined in composite samples from each effluent outfall every Monday, Wednesday, and Friday (or as requested by the Minister). The owner of a refinery is also requested/required to monitor and report the pH of each effluent outfall on a daily basis, while the acute toxicity of each effluent must be reported on a monthly basis. According to the federal Regulations and Guidelines, for 1992, the 12 monthly reports should include 366 pH results, 157 analyses for each of the five parameters, and 12 toxicity bioassays, for a total of 1163 results. Requirements from other government bodies, either provincial or municipal, might apply to the same contaminants with different limits or sampling frequencies, or to other contaminants. Refineries must submit all required information, however, and abide by the most stringent limits. Some refineries do not have a continuous effluent discharge and therefore effluents cannot be assessed three times a week as specified in the Regulations and Guidelines. Such refineries must notify Environment Canada and special arrangements can be made for the sampling frequency. Shell--Scotford was the only refinery with intermittent discharges. For the purpose of this report, results submitted by this refinery were assessed only on the days it was discharging.

Some refineries have access to off-site treatment, such as municipal sewage systems. In such cases and in order to benefit from this additional means of reducing contaminant levels in the environment, an exemption must be obtained from the federal Minister. This exemption is granted when the Minister has been shown that the off-site facility provides equivalent treatment to that required by the Regulations and Guidelines. If exemption is not granted, the effluents leaving the refinery remain subject to the requirements of the Regulations and Guidelines. Two refineries in Saskatchewan and all five refineries in British Columbia send their effluent to off-site treatment facilities. One refinery (Husky--Prince George) sends its effluent to a nearby pulp mill for biological treatment and two refineries (Co-op--Regina and Moose Jaw Asphalt--Moose Jaw) send their wastewaters, after a primary treatment on site, to a municipal sewer for further treatment. In Vancouver, four refineries (Esso--Ioco, Petro-Canada--Port Moody, Shell--Burnaby, and Chevron--North Burnaby) discharge their effluent to the GVRD sewer. Of these seven refineries, Moose Jaw Asphalt--Moose Jaw was not assessed as the City of Moose Jaw Sewage Treatment Plant disposes of the treated effluent through land application. The other six refineries were assessed at the refinery fence as it was the only information available.

4.2 Atlantic Region

In 1992, four refineries were operating in the Region: Esso--Dartmouth, Ultramar--Dartmouth, Irving--St. John, and Newfoundland Processing Ltd.--Come by Chance. Two refineries in the Atlantic Region have an existing status and are subject to the Guidelines (Esso, Ultramar), one is an expanded refinery (Irving Oil), and one is a new refinery (Newfoundland Processing Ltd.). The Newfoundland Processing Ltd. refinery was shut down for 11 years in March 1976 and restarted operations in June 1987. The Irving Oil refinery comes under the Guidelines, however, it must comply partially with the more stringent limits of the Regulations as it has an expanded status. The performance of individual refineries in this Region for 1992 is presented in Appendix A, Table A-1.

4.2.1 Esso--Dartmouth

This Imperial Oil refinery has a secondary treatment system (activated sludge) and discharges its treated effluent into the Halifax harbour. In 1992, the refinery was in compliance with the federal Guidelines for phenols, sulfide, and ammonia nitrogen. Several deposits of oil and grease and total suspended matter exceeded Guideline levels. The maximum daily amount for oil and grease was exceeded once in January causing the monthly amount of oil and grease to be exceeded. This was due to high amounts of oil in the once-through cooling water stream. The source of the oil was not apparent as there was no sheen or hydrocarbon popping in the separator. In June, the maximum daily amount for total suspended matter was exceeded once. An operational problem in one process unit led to a microorganism kill at the biox plant causing the sludge to be carried over with the effluent. In September, the one-day and the maximum daily amounts were exceeded once each for total suspended matter (TSM). High amounts of TSM were contributed by all three streams that make up the final effluent. TSM was high in the API stream due to dewatering of emulsion breaking. This was remedied by reducing silt entrainment with tank area stabilization. TSM was high in the once-through cooling water because of the release of built-up material at the inlet. The biox stream TSM was high due to variability of oil in the feed. This problem was resolved by installing a chemical injection system on the biox clarifiers. In October, the maximum daily amount for oil and grease was exceeded once due to high levels of oil in the once-through cooling water.

The refinery was in compliance with the monthly, one-day, and maximum daily amounts 98.3%, 99.9%, and 99.7% of the time, respectively. The one deposit that exceeded the monthly amount was less than 25% above the allowable limit. The average annual monthly deposits for 1992 were all below the Guideline limits and 100% of the tests requested were submitted.

The refinery's overall performance improved from 1987. The number of exceedences for phenols and total suspended matter decreased, deposits of all parameters decreased (with the exception of ammonia nitrogen), and the toxicity requirement was met at all times. However, the number of exceedences for oil and grease increased.

4.2.2 Ultramar–Dartmouth

This Ultramar refinery treats its effluent with an activated sludge biological system and then discharges into the Halifax harbour. This refinery operates under the Guidelines. It had an excellent performance in 1992 for the five prescribed parameters, each having 100% compliance for monthly, one-day, and maximum daily amounts. The toxicity and pH requirements were met at all times in 1992 (although 82 pH results were not reported), whereas in 1987, there were two exceedences for total suspended matter and one violation for pH.

All monitoring frequencies were met with the exception of pH which was only reported 78% of the time. All average annual monthly deposits were well below the Guideline limits. The refinery submitted 92.9% of the total requested tests.

4.2.3 Irving–St. John

This refinery has the largest crude capacity in Canada. It has a secondary treatment system consisting of activated sludge for the process wastewater and aeration lagoons for storm water. The treated effluent is discharged into the Little River, which flows into the St. John Harbour.

The refinery operated under an expanded Guideline status in 1992. There was one toxicity test failure. The one-day and the maximum daily amounts were each exceeded once in May for the oil and grease parameter. A lower-than-normal liquid level in the equalization pond resulted in heavy hydrocarbons being carried through the API separator. In June, the one-day and the maximum daily amounts were exceeded once each for ammonia nitrogen. Contamination of the sour water stripper with ballast water contributed to higher than normal ammonia in the effluent; steps were taken to prevent this from happening again. In October, the monthly, the one-day, and the maximum daily amounts were exceeded once each for phenols due to a phenolic stream being drained too quickly. There were unreported tests for all five parameters: two each for sulfide and ammonia nitrogen and one each for phenols, total suspended matter, and pH.

The Irving refinery complied 98.3% of the time for monthly amounts, 99.6% of the time for one-day amounts, and 99.7% of the time for maximum daily amounts. The 1992 average annual monthly deposits were below the expanded Guideline limits. The refinery submitted 99.4% of the required tests. There was an increase in the number of exceedences for all parameters, and the oil and grease deposits. There was a reduction in ammonia nitrogen and total suspended matter deposits, and in toxicity exceedences.

4.2.4 Newfoundland Processing Ltd. --Come by Chance

This refinery has a secondary treatment system (activated sludge) and discharges the treated effluent into Placentia Bay.

Newfoundland Processing Ltd. was in compliance 100% of the time with the monthly amounts, 100% of the time for one-day amounts, and 99.8% of the time for maximum daily amounts. Violations occurred for total suspended matter and pH. One violation of the maximum daily limit occurred in June for total suspended matter. There was one violation of pH in November, caused by draining spent caustic without proper neutralization; 43% of the required tests for pH were submitted. Oil and grease and ammonia nitrogen deposits increased slightly since 1987, while deposits of phenols, sulfide, and total suspended matter decreased. The average monthly deposits for the year were well below the federal Regulations. The performance of the Come by Chance refinery improved from 1987. While in operation, the refinery reported 82% of the required tests.

4.2.5 Assessment Summary

A comparison of the average deposits from each refinery in Atlantic Region in 1992 is provided for all parameters in Figures 2 to 6. Also, the range of pH measurements for each refinery is presented in Figure 7. The compliance assessment for the four refineries is presented in Table 4. The average annual monthly deposits of all refineries were below the Guideline/Regulation deposits. The Esso refinery in Dartmouth had the highest deposits for total suspended matter, the lowest deposits for sulfide, and the best overall performance in 1992. The Ultramar refinery had the highest deposits for phenols, but the lowest deposits for oil and grease, ammonia nitrogen, and total suspended matter. The Irving refinery had the largest deposits for oil and grease, and sulfide. Newfoundland Processing Ltd. had the highest deposits for ammonia nitrogen, but the lowest for phenols.

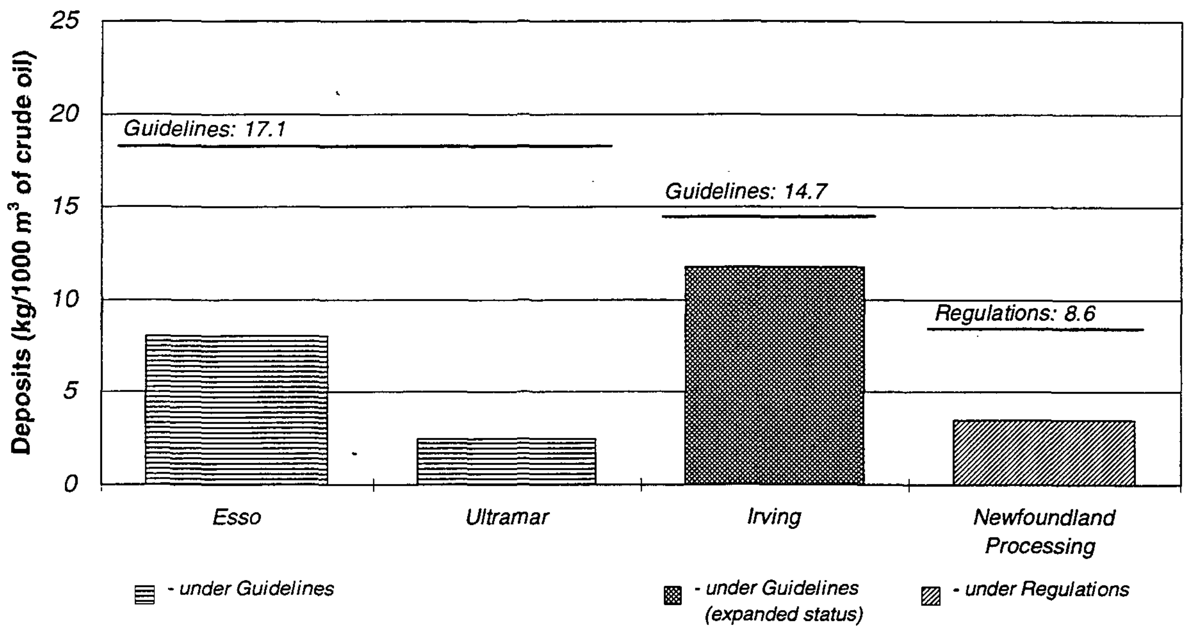


Figure 2 **Oil and Grease - Atlantic Region 1992**

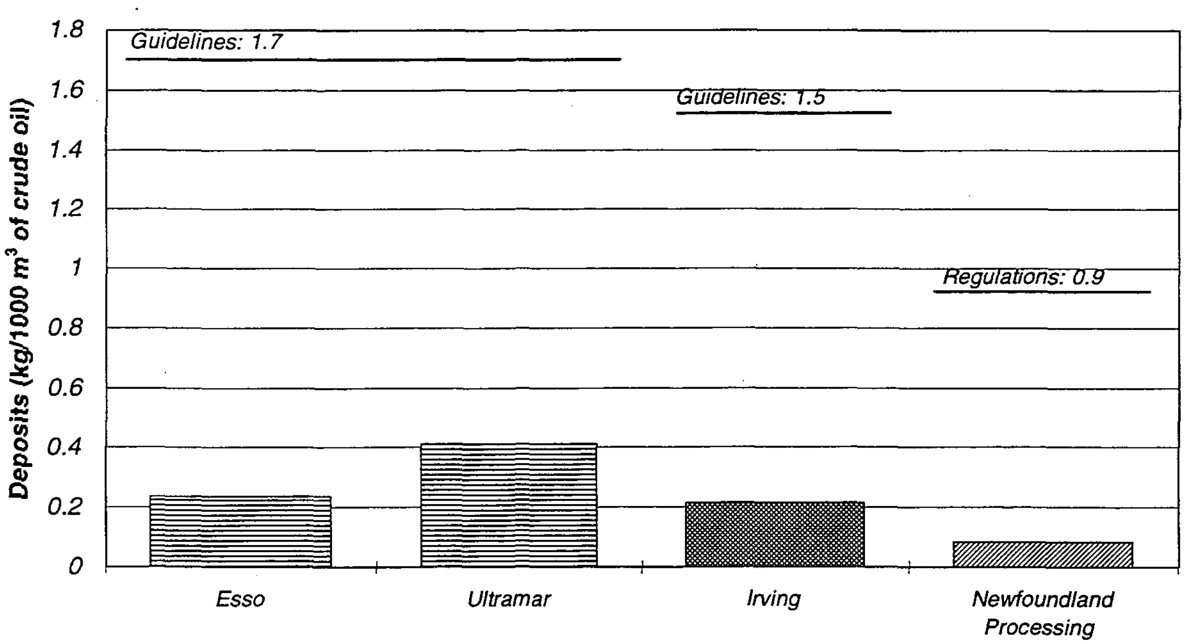


Figure 3 **Phenols - Atlantic Region 1992**

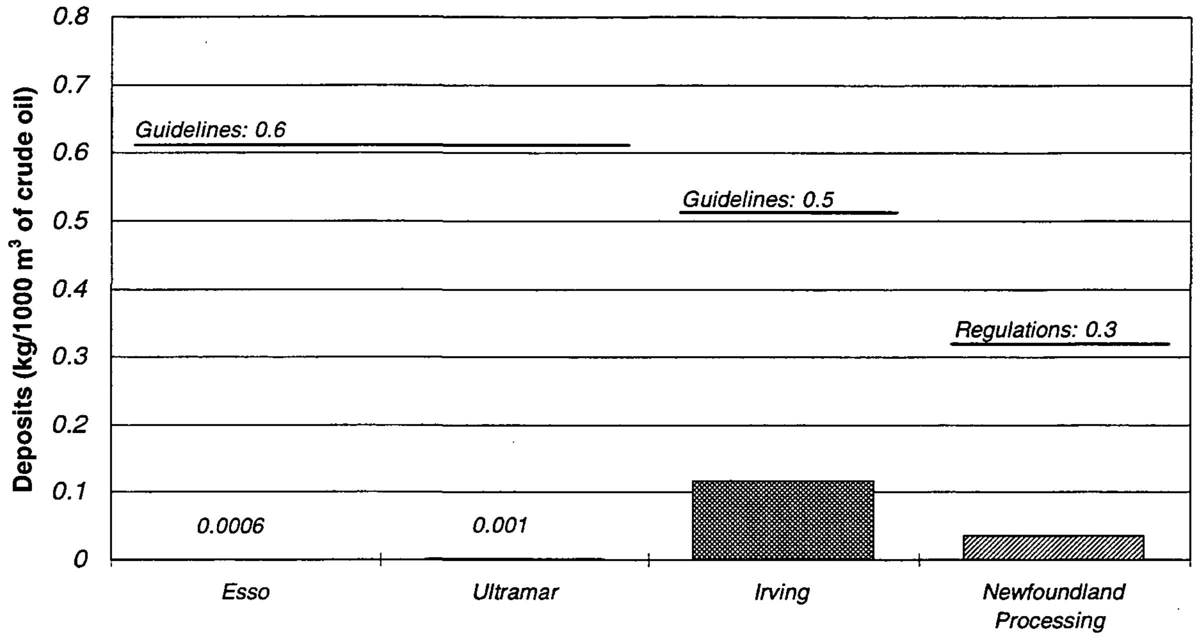


Figure 4 **Sulfide - Atlantic Region 1992**

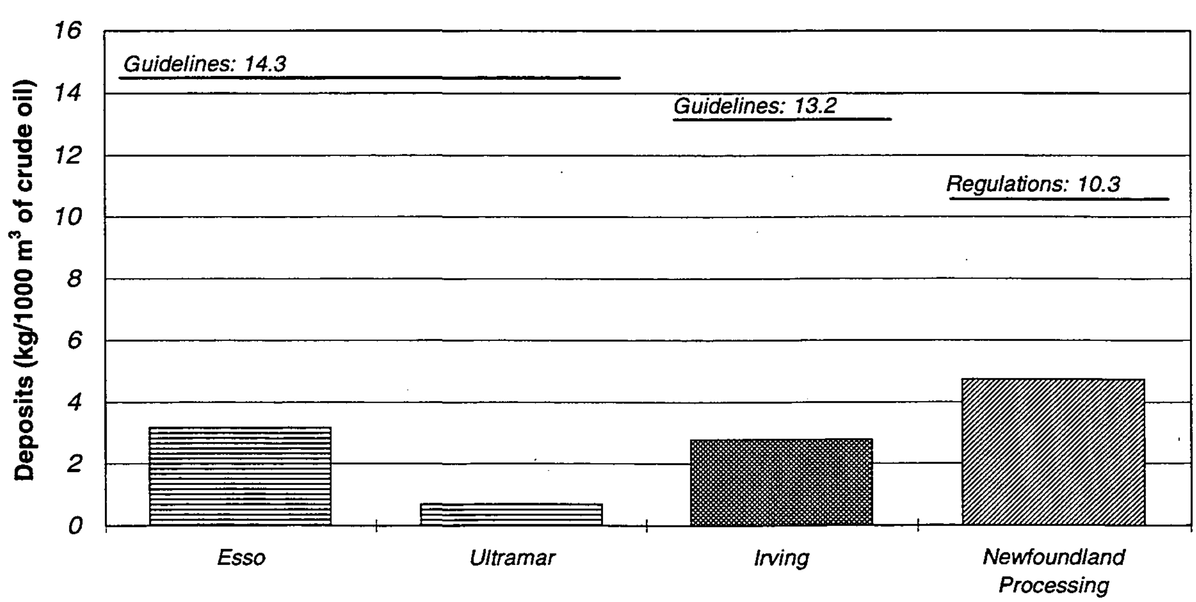


Figure 5 **Ammonia Nitrogen - Atlantic Region 1992**

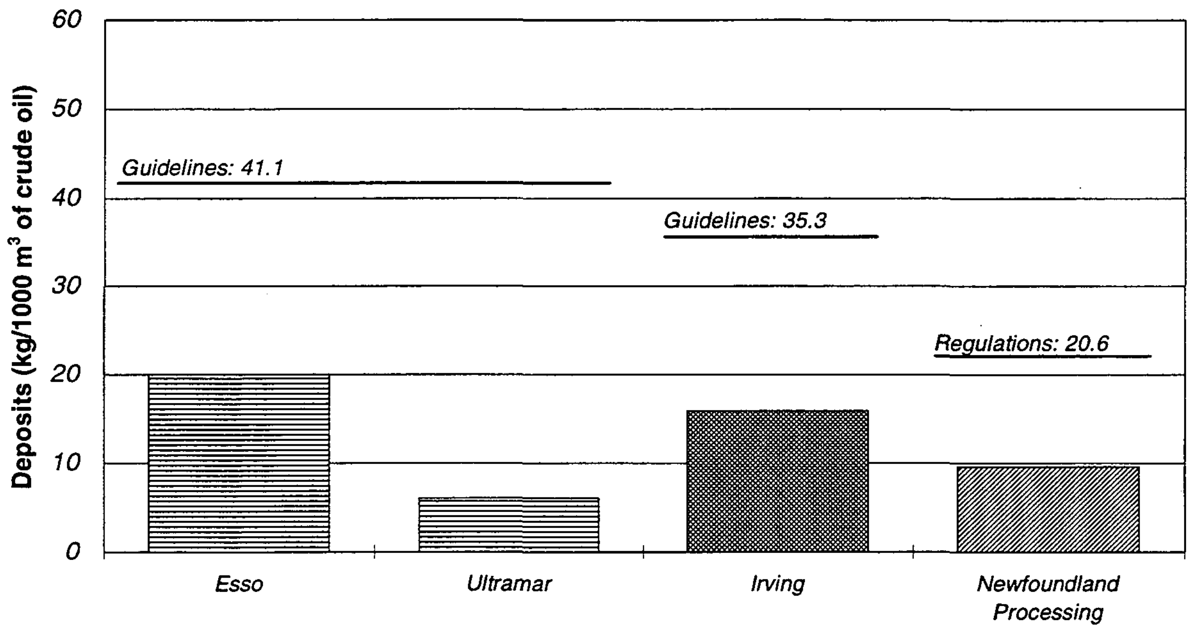


Figure 6 **Total Suspended Matter - Atlantic Region 1992**

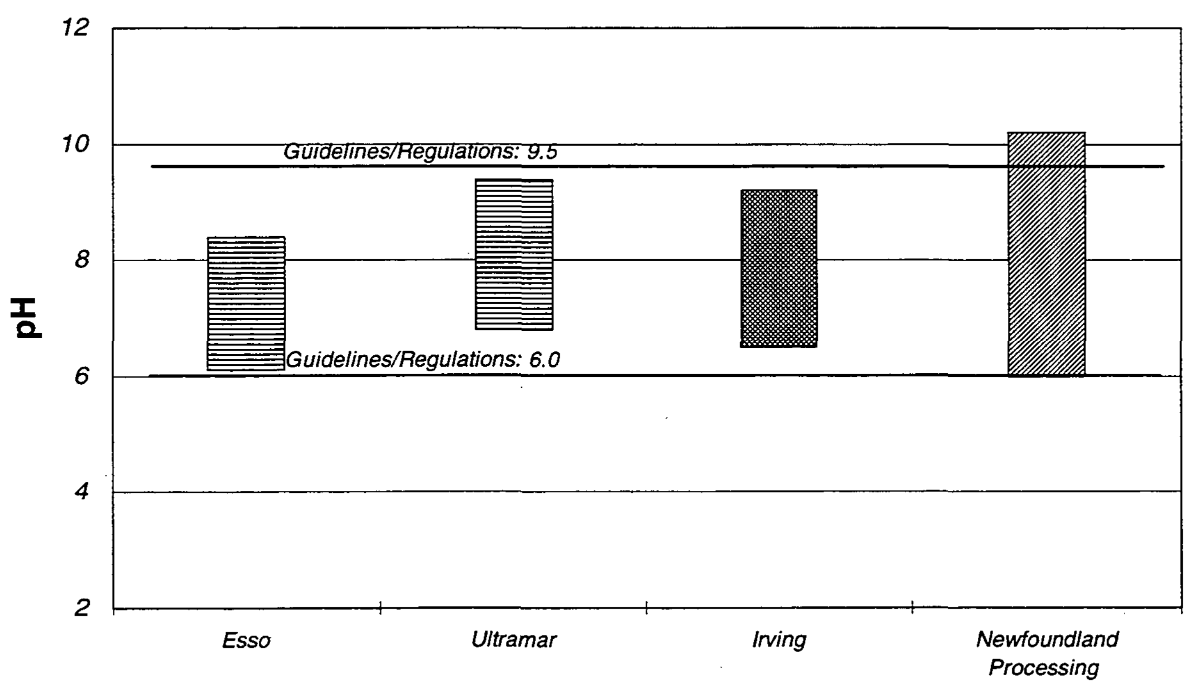


Figure 7 **pH Levels - Atlantic Region 1992**

Table 4 Percent Compliance of Refineries with Parameters - Atlantic Region

	Percent Compliance																	
	Oil and Grease %			Phenols %			Sulfide %			Ammonia Nitrogen %			Total Suspended Matter %			pH %	Toxicity %	Tests Reported %
Refinery	M	O	D	M	O	D	M	O	D	M	O	D	M	O	D			
Esso Dartmouth	91.7	100	98.7	100	100	100	100	100	100	100	100	100	100	99.4	98.7	100	100	100
Ultramar Dartmouth	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	*100*	92.9
Irving Oil St. John	100	99.4	99.4	91.7	99.4	99.4	100	100	100	100	99.4	99.4	100	100	100	100	91.7	99.4
Newfoundland Processing Ltd. Come by Chance	100	100	100	100	100	100	100	100	100	100	100	100	100	100	99.3	99.7	100	82.2

M - Monthly amount
O - One-day amount
D - Maximum daily amount

4.3 Quebec Region

In 1992, three refineries were operating in Quebec: Petro-Canada--Montreal, Shell--Montréal-Est, and Ultramar--St-Romuald. All of these have an existing status and are subject to the Guidelines. The three refineries discharge treated effluent into the St. Lawrence River. Petro-Canada treated a combined effluent generated by the refinery and its chemical plant. The performance of the individual refineries in this Region is presented in Appendix A, Table A-2.

4.3.1 Petro-Canada--Montreal

This Petro-Canada refinery has a secondary treatment system consisting of bio-filters and a polishing pond. The combined treated effluent from the refinery's petrochemical plant is discharged into the St. Lawrence River. This refinery is subject to the Guidelines. The performance of the refinery has improved from 1987, as deposit levels for the five parameters have been reduced from 20 to 71% of 1987 levels. In 1991, the refinery cleaned up its polishing lagoon and installed a concrete slab at the bottom of the lagoon. Petro-Canada has also begun to clean up the quarry where contaminated storm water is collected. The refinery has consequently reduced the flow rate and the loading of its final effluent. All this combined with regular maintenance of equipment has improved the effluent quality.

The Petro-Canada refinery fully complied for all monthly and one-day amounts and complied 99.9% of the time for maximum daily amounts, with the only exceedence being for oil and grease. Three tests for oil and grease, two for phenols, four for sulfide, two for ammonia nitrogen, and four for total suspended matter were not reported. The refinery submitted 98.7% of the requested tests. The pH and toxicity requirements were met at all times.

4.3.2 Shell--Montréal-Est

The wastewater from the refinery receives biological treatment (activated sludge) and is discharged into the St. Lawrence River. This refinery operates under the Guidelines. It had an excellent performance in 1992. The refinery improved greatly from 1987 in oil and grease and total suspended matter, with no exceedences in 1992. The deposit levels for each parameter were reduced more than 75% from 1987 to 1992. The refinery replaced the "dissolved air flotation unit" which significantly improved oil and grease removal. It has reduced its wastewater flow rate by reducing water usages at source and diverting uncontaminated storm water. The implementation of best operating practices has improved the effluent quality.

The refinery was in full compliance for all parameters at the three levels set in the Guidelines. Toxicity and pH requirements were met at all times. All annual monthly averages of deposits were well below the levels set in the Guidelines and could meet the Regulation requirements. The refinery reported 100% of the requested tests.

4.3.3 Ultramar--St-Romuald

This refinery upgraded its wastewater treatment system in 1983 by installing aerated lagoons, after commissioning a catalytic cracking unit. The treated effluent is discharged into the St. Lawrence River. This refinery is subject to the Guidelines. The refinery's performance was further improved from that of 1987. Its deposit levels were reduced from 50% (on average) due to the improvement of wastewater treatment operating practices and regular maintenance of pollution control equipment. The refinery was in full compliance for monthly, one-day, and maximum daily amounts in 1992. There were no exceedences for pH. All the average annual monthly deposits were well below the levels set in the Guidelines and could easily meet the Regulation levels.

One test each was not reported for oil and grease, total suspended matter, pH, and toxicity, while two tests each were not reported for phenols, sulfide, and ammonia nitrogen. The refinery submitted more than 99% of the requested tests. The 11 toxicity tests reported met all the requirements.

4.3.4 Assessment Summary

The 1992 deposit levels for each refinery in the Region are presented in Figures 8 to 12, while the range of pH measurements is presented in Figure 13. The compliance assessment of each refinery is given in Table 5. Petro-Canada had the highest deposits for all parameters, Ultramar had the lowest deposits for total suspended matter, and Shell had the lowest deposits for all other parameters.

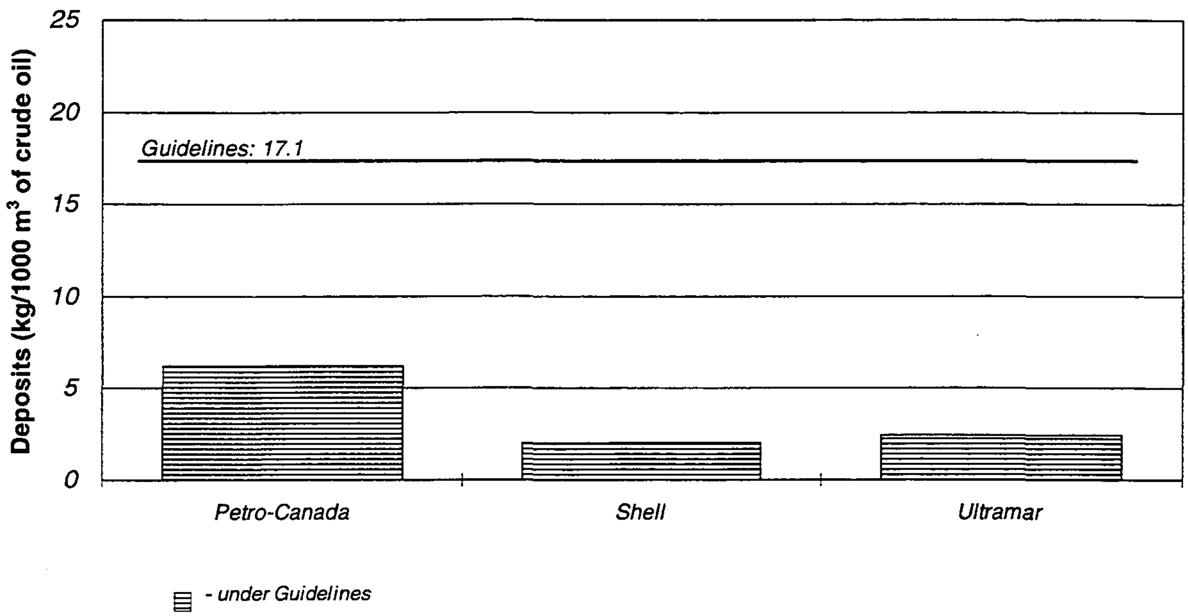


Figure 8 **Oil and Grease - Quebec Region 1992**

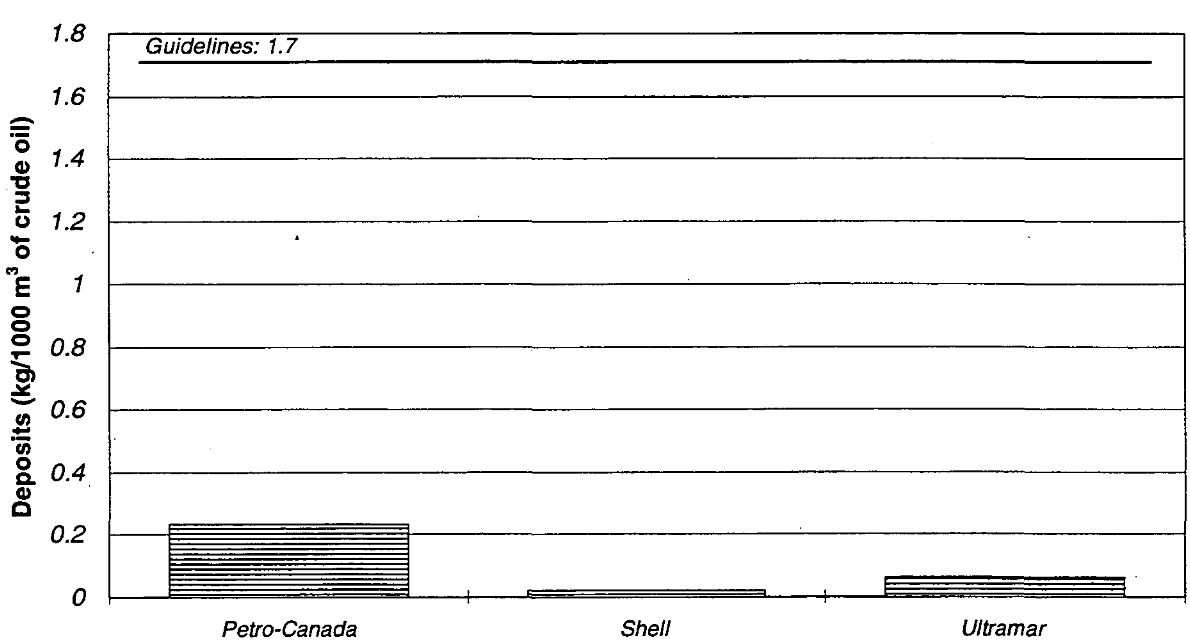


Figure 9 **Phenols - Quebec Region 1992**

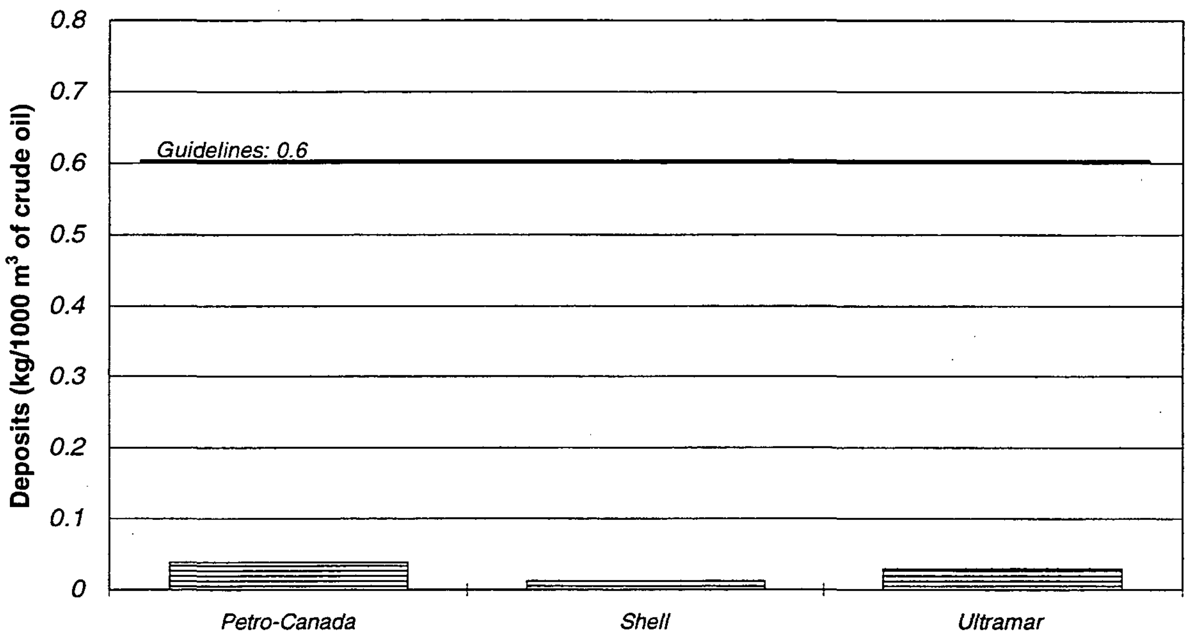


Figure 10 **Sulfide - Quebec Region 1992**

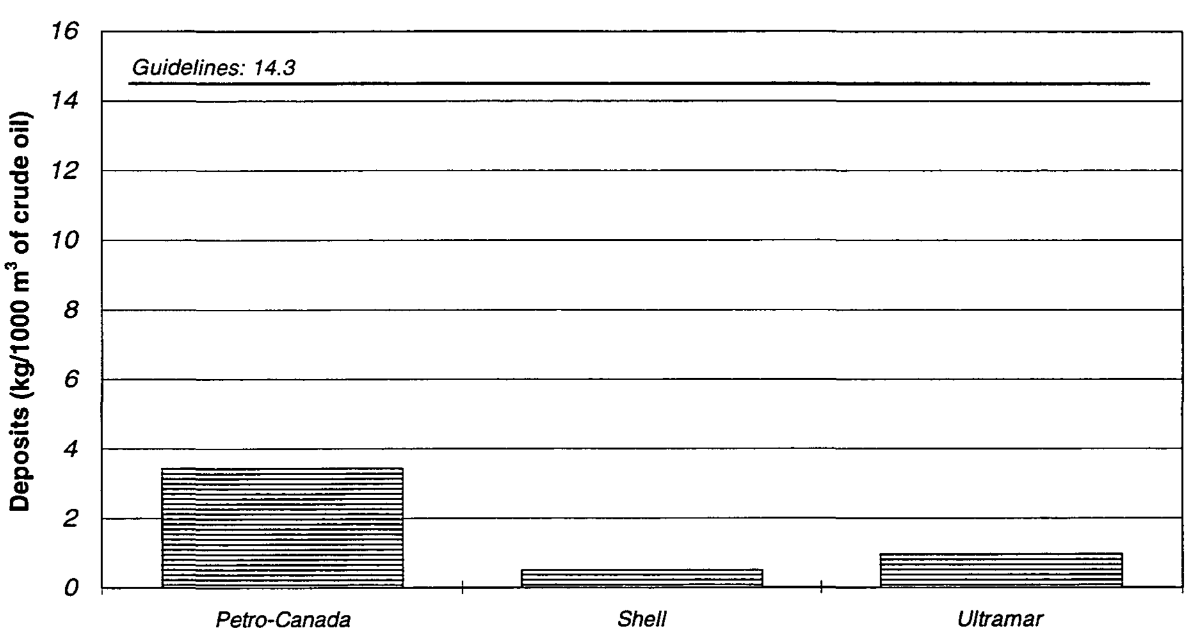


Figure 11 **Ammonia Nitrogen - Quebec Region 1992**

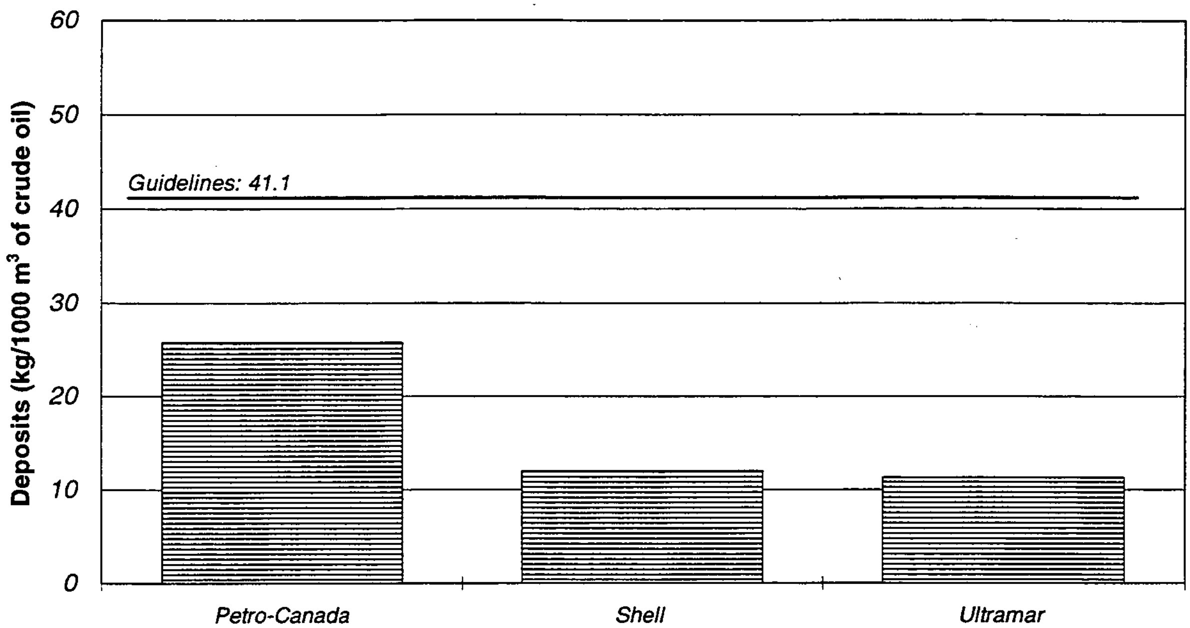


Figure 12 **Total Suspended Matter - Quebec Region 1992**

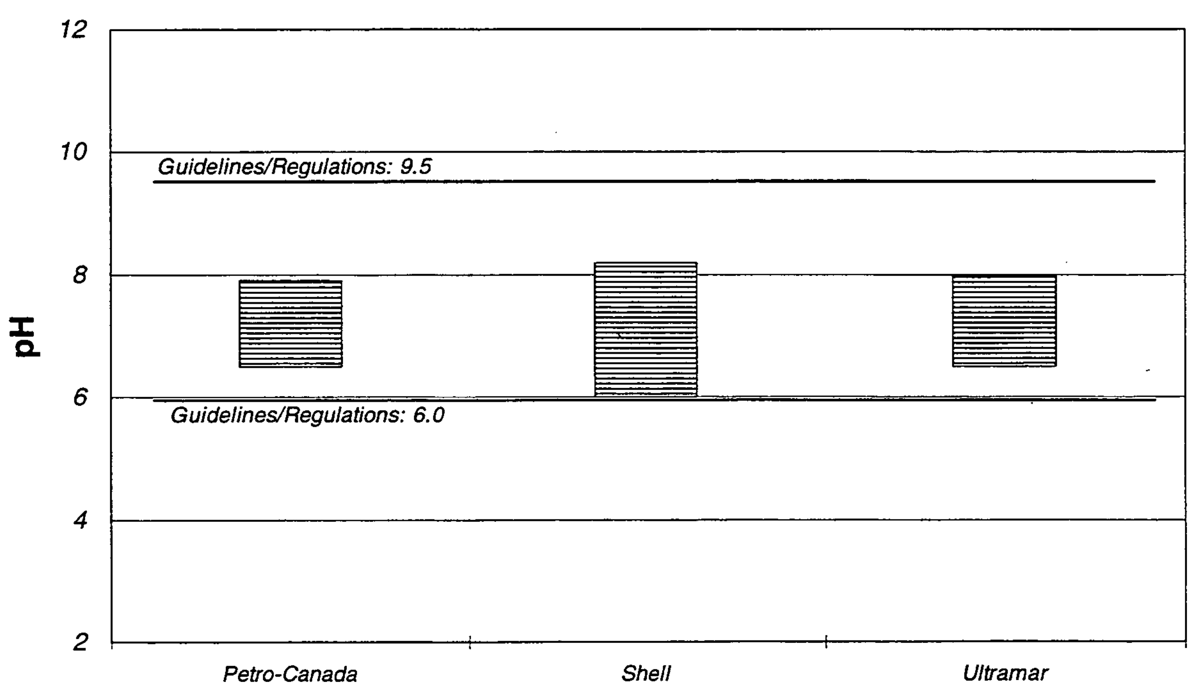


Figure 13 **pH Levels - Quebec Region 1992**

Table 5 Percent Compliance of Refineries with Parameters - Quebec Region

	Percent Compliance																
	Oil and Grease %			Phenols %			Sulfide %			Ammonia Nitrogen %			Total Suspended Matter %			pH %	Toxicity %	Tests Reported %
Refinery	M	O	D	M	O	D	M	O	D	M	O	D	M	O	D			
Petro-Canada Montreal	100	100	99.4	100	100	100	100	100	100	100	100	100	100	100	100	100	100	98.7
Shell Canada Montréal-Est	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Ultramar St-Romuald	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	91.7	99.1

M - Monthly amount
O - One-day amount
D - Maximum daily amount

4.4 Ontario Region

In 1992, seven refineries were operating in Ontario: Esso--Sarnia, Petro-Canada--Mississauga, Shell--Corunna, Petro-Canada--Oakville, Suncor--Sarnia, Esso--Nanticoke, and Novacor--Corunna. Five were subject to the Guidelines with two in the expanded category and three in the existing category. The other two refineries are subject to the Regulations. The Esso refinery in Sarnia, and the Shell and Novacor refineries in Corunna have adjacent petrochemical plants and treat combined effluent (refinery and petrochemical) in the refinery treatment system. At the Esso refinery, the petrochemical plant has its own wastewater treatment system, but part of its effluent is treated by the refinery system. All the refineries in the Region discharge treated effluent into the Great Lakes system, either the St. Clair River, Lake Ontario, or Lake Erie. The performance of the individual refineries in this Region for 1992 is summarized in Appendix A, Table A-3.

4.4.1 Esso--Sarnia

This Imperial Oil refinery is adjacent to its chemical plant. Although each facility has its own wastewater treatment system, some effluent from the chemical plant is treated in the refinery system. In addition, the chemical plant produces crude-based BTX (benzene, toluene, and xylene) which is considered as a "refinery" product, and the generated wastewater is treated at the chemical plant system. As in the past, only the effluent treated at the refinery was considered for the 1992 compliance assessment. The refinery has a biological treatment system (activated sludge process) and discharges its effluent into the St. Clair

River. The refinery is subject to the Guidelines and was in compliance 100% of the time for all parameters. The pH and toxicity requirements were met at all times. All average annual monthly deposits were well below the limits. The refinery submitted 100% of the requested tests.

4.4.2 Petro-Canada--Mississauga

The Mississauga refinery treats its process and ballast water in an activated sludge system. The treated effluent is discharged into Lake Ontario. A sewer line was installed in 1986 to divert storm water through the treatment plant, allowing all storm water to be treated. The modifying and upgrading of equipment in the refinery tank farm increased the ability to contain storm water and control its release to the treatment plant. A wet slop injection system was installed at the desalter preventing the release of emulsified oil to the wastewater treatment plant.

In 1992, the refinery had an existing status under the Guidelines and was in complete compliance for average annual monthly amounts for all parameters. There was one exceedence of the maximum daily limit for oil and grease and three exceedences of the maximum daily limit for total suspended matter. One test for oil and grease, four for sulfide, and one for ammonia nitrogen were not reported. The pH and toxicity requirements were met at all times.

The refinery improved its overall performance from 1987. Total suspended matter deposits increased, but oil and grease and ammonia nitrogen deposits decreased. The refinery complied 100% of the time for monthly amounts, 100% of the time for one-day amounts, and 99.7% of the time for maximum daily amounts. The average annual monthly deposits for 1992 were well below the limits for all parameters. The refinery submitted 99.5% of the requested tests.

4.4.3 Shell--Corunna

A biological oxidation unit (activated sludge) is used to treat the refinery wastewater along with the wastewater from its chemical plant. The effluent is then discharged into the Talfourd Creek (to the St. Clair River). In 1992, the refinery exceeded the maximum daily amount only once for total suspended matter. The pH and toxicity requirements were met at all times. The refinery's performance improved greatly since 1987. The refinery fully complied in 1992 for monthly and one-day amounts, and complied 99.9% of the time for maximum daily amounts. All average annual monthly deposits were well below the Guideline limits. The refinery submitted 100% of all the requested tests.

4.3.4 Petro-Canada--Oakville

This Petro-Canada refinery has an activated sludge process with effluent discharged into Lake Ontario. The refinery, which has an expanded status under the Guidelines, fully complied for the monthly, one-day, and maximum daily amounts for all parameters. The pH and toxicity requirements were met at all times. The refinery submitted 100% of the requested tests.

4.4.5 Suncor--Sarnia

The refinery treats its wastewater in a secondary treatment system and discharges the effluent into the St. Clair River. The wastewater facility was upgraded in 1986. A second aeration basin for biological treatment has been added to treat contaminated storm water and a new concrete floor was installed in the aeration basin. Both the new and old aeration basins have sub-surface diffusers for biological treatment. A second impounding basin was constructed to hold storm overflow for reworking through the treatment system. Polyethylene liners were installed in both impounding basins to prevent erosion and leachate.

The refinery, which is subject to the Guidelines and has an expanded status, had an excellent performance in 1992. The refinery complied 100% for the monthly, one-day, and maximum daily amounts for all parameters. All five parameters had very low average annual monthly deposits compared to the Guidelines. The pH and toxicity requirements were met at all times. The Suncor refinery submitted all the requested tests.

4.4.6 Esso--Nanticoke

The Imperial Oil refinery at Nanticoke is subject to the Regulations. The refinery has an activated sludge unit followed by a tertiary treatment consisting of an effluent filtration unit. The treated effluent is discharged into Lake Erie. In 1992, the Esso refinery complied 100% for the monthly, one-day, and maximum daily amounts for all parameters. Two tests for oil and grease and one for ammonia nitrogen were not reported. The pH and toxicity requirements were met at all times. The refinery provided 99.7% of required tests.

4.4.7 Novacor--Corunna

The Novacor refinery is subject to the Regulations. Wastewaters from the refinery and the petrochemical plant are both treated in the same system which consists of a biological oxidation unit followed by a tertiary system (activated carbon filter). The effluent is then discharged into the St. Clair River. In 1992, the refinery fully complied for all parameters. Eighteen sulfide tests were not reported. The pH and toxicity requirements were met at all times. The Novacor refinery submitted 98.5% of the required tests.

4.4.8 Assessment Summary

The 1992 deposit levels are provided in Figures 14 to 18. The range of pH measurements for each refinery is presented in Figure 19. The frequency of compliance with the regulated parameters for the refineries is provided in Table 6. Petro-Canada--Mississauga has the highest deposits of oil and grease and total suspended matter, Esso--Sarnia has the highest deposits of phenols, and Petro-Canada--Oakville has the highest deposits of ammonia nitrogen. The Novacor refinery has the lowest deposits of oil and grease and total suspended matter and the highest deposits of sulfide, Esso--Nanticoke has the lowest deposits of phenols, and Shell--Corunna has the lowest deposits of sulfide and ammonia nitrogen.

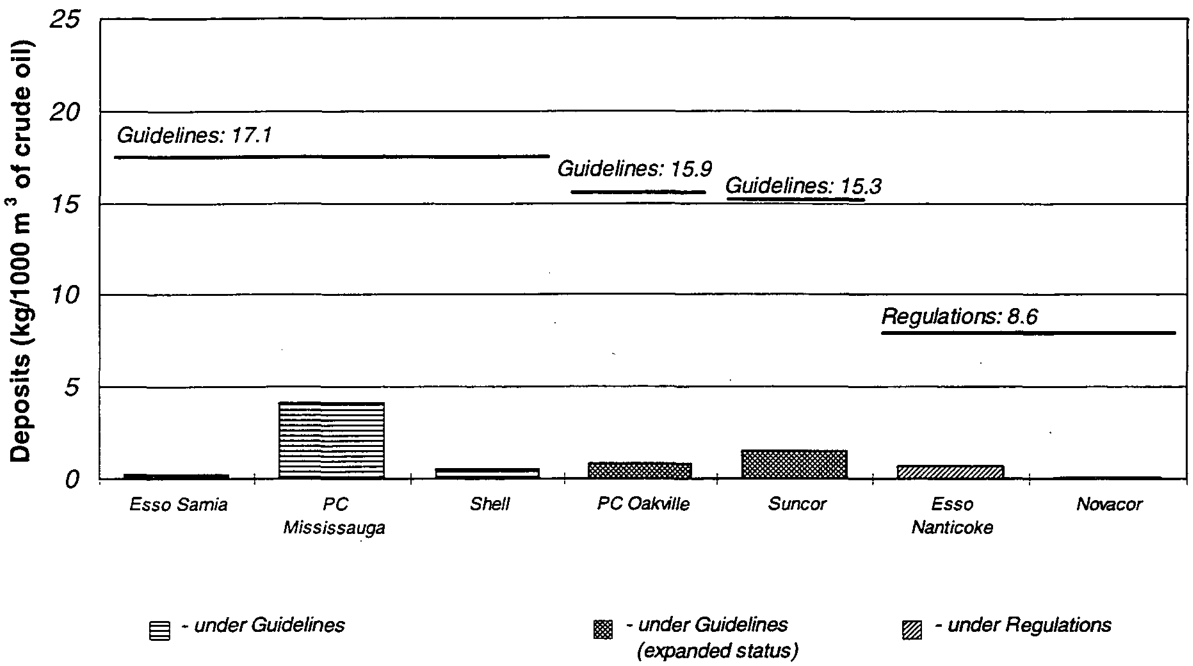


Figure 14 Oil and Grease - Ontario Region 1992

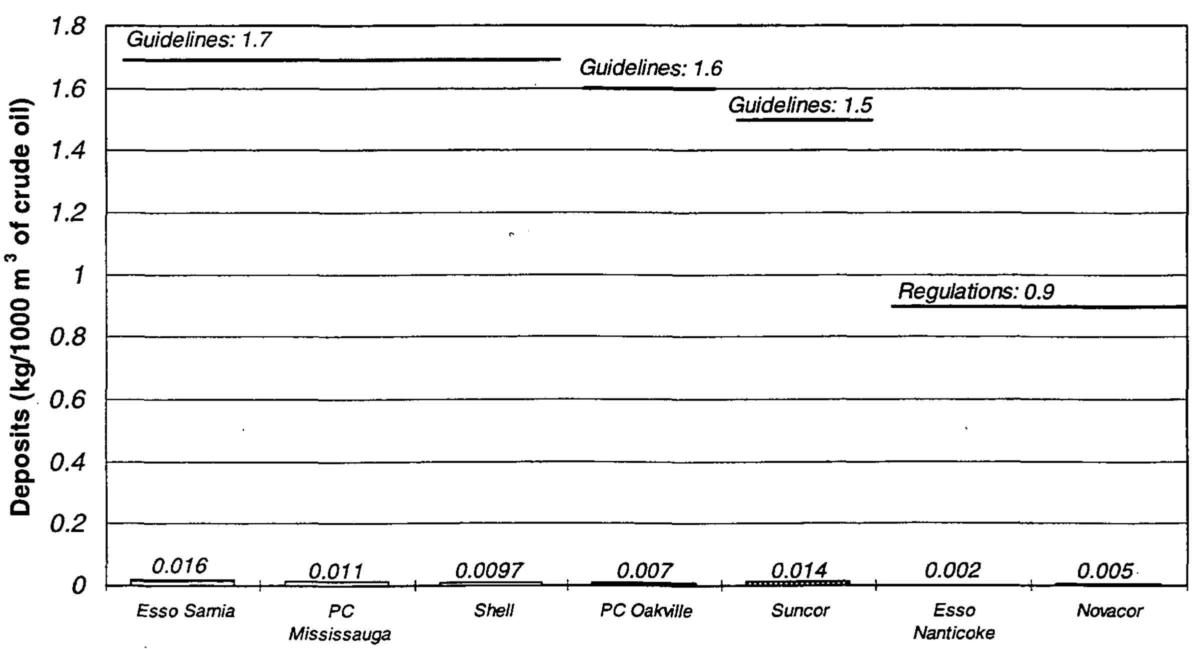


Figure 15 Phenols - Ontario Region 1992

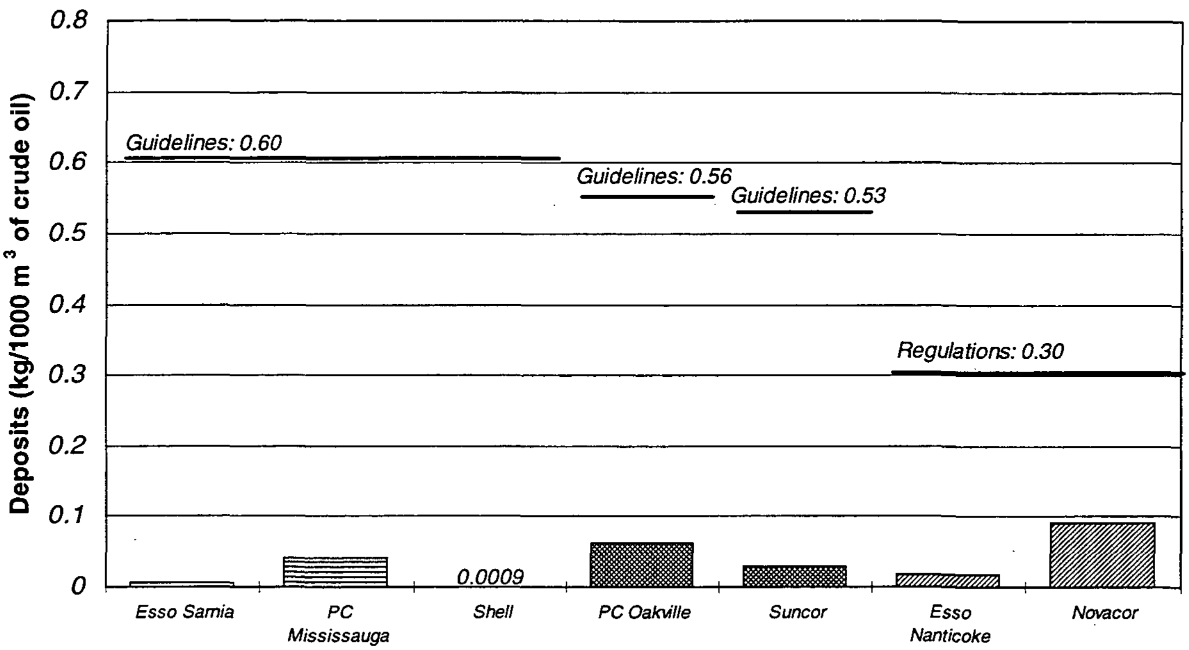


Figure 16 Sulfide - Ontario Region 1992

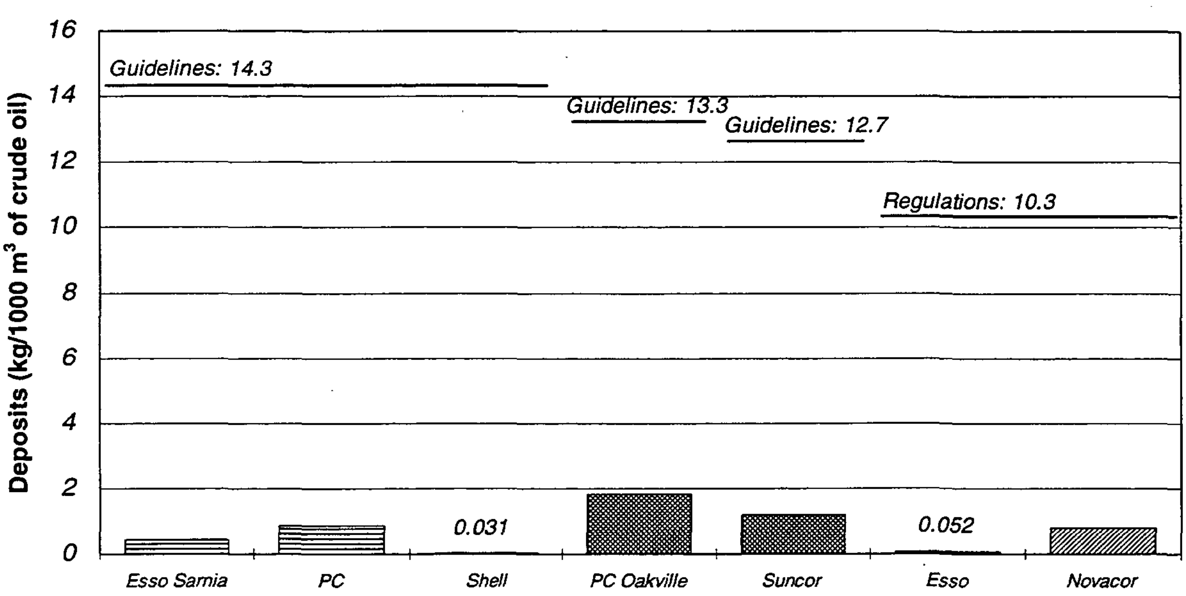


Figure 17 Ammonia Nitrogen - Ontario Region 1992

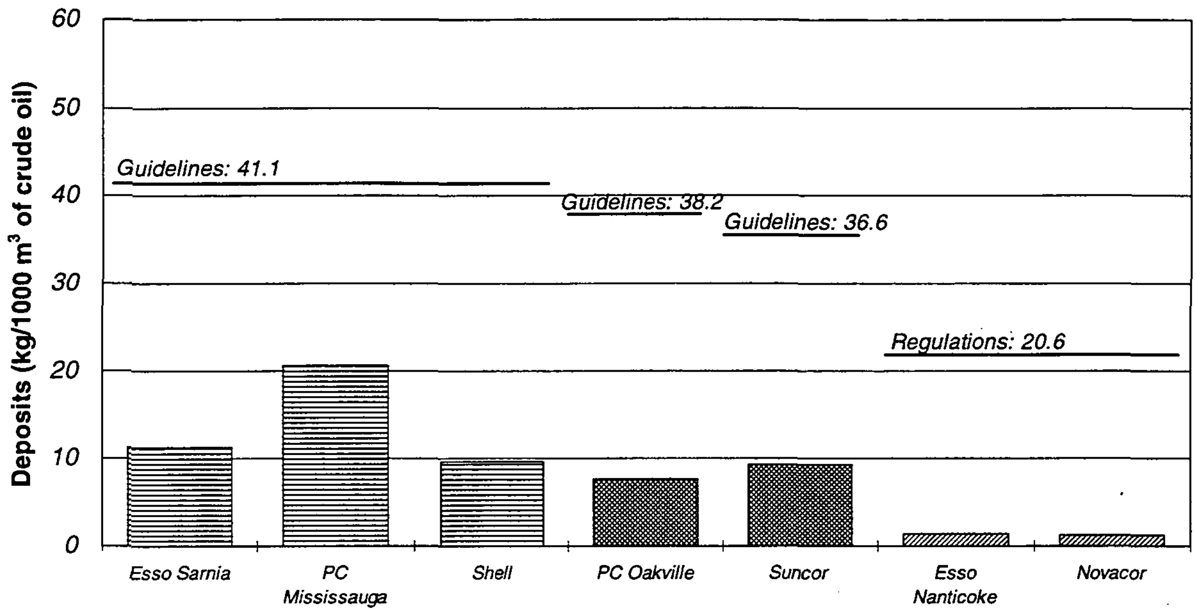


Figure 18 **Total Suspended Matter - Ontario Region 1992**

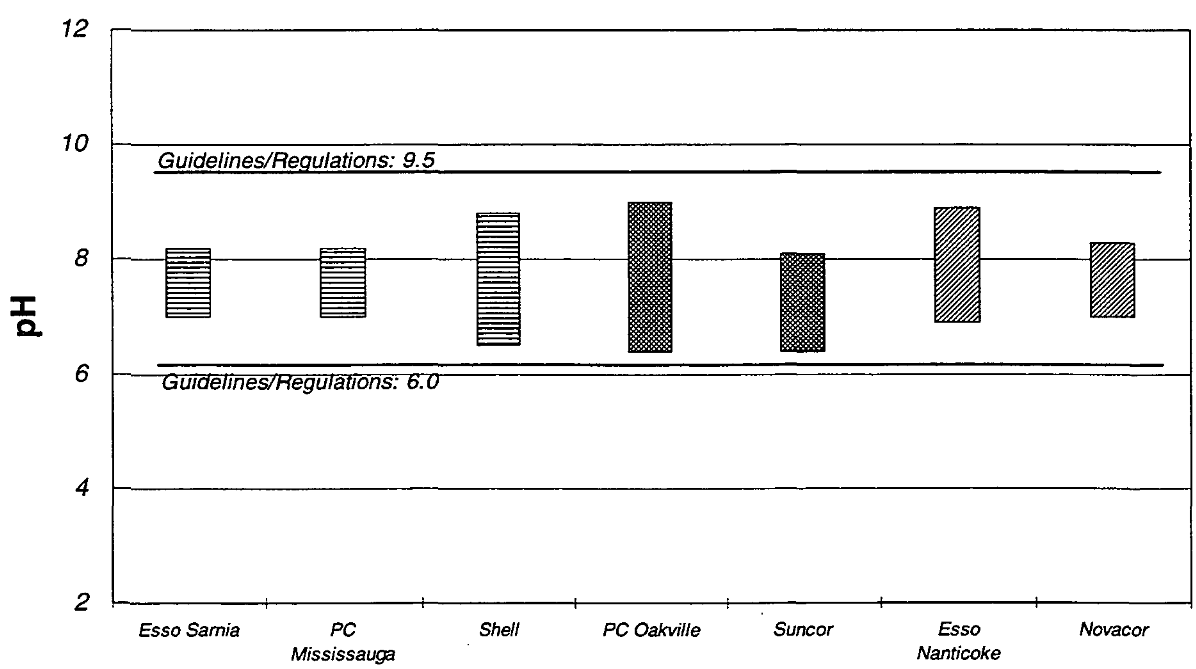


Figure 19 **pH Levels - Ontario Region 1992**

Table 6 Percent Compliance of Refineries with Parameters - Ontario Region

	Percent Compliance																
	Oil and Grease %			Phenols %			Sulfide %			Ammonia Nitrogen %			Total Suspended Matter %			pH %	Toxicity %	Tests Reported %
Refinery	M	O	D	M	O	D	M	O	D	M	O	D	M	O	D			
Esso Sarnia	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Petro-Canada Mississauga	100	100	99.4	100	100	100	100	100	100	100	100	100	100	100	98.1	100	100	99.5
Shell Canada Corunna	100	100	100	100	100	100	100	100	100	100	100	100	100	100	99.4	100	100	100
Petro-Canada Oakville	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Suncor Sarnia	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Esso Nanticoke	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	99.7
Novacor Corunna	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	98.5

M - Monthly amount
O - One-day amount
D - Maximum daily amount

4.5 Prairie and Northern Region

In 1992, nine refineries were operating in the Region : Moose Jaw Asphalt -- Moose Jaw, Parkland--Bowden, Co-op--Regina, Esso--Norman Wells, Petro-Canada--Edmonton, Esso--Strathcona, Husky--Lloydminster, Shell--Scotford, and Turbo--Balzac. Five refineries are subject to the Guidelines: two of existing status (Moose Jaw Asphalt--Moose Jaw, Parkland--Bowden) and three of expanded status (Co-op--Regina, Esso--Norman Wells and Petro-Canada--Edmonton). Four refineries are subject to the Regulations (Esso--Strathcona, Husky--Lloydminster, Shell--Scotford, and Turbo--Balzac). Data from the Turbo and Husky refineries were not assessed as these refineries use deep-well injection for their wastewaters. Data from the Moose Jaw Asphalt refinery were not assessed as its effluent is spread over land. The Parkland refinery did not submit data as no effluent was discharged during 1992. The performance of individual refineries for 1992 is summarized in Appendix A, Table A-4.

4.5.1 Moose Jaw Asphalt--Moose Jaw

This refinery has a primary treatment system and effluent is further treated at the municipal treatment plant which spreads its effluent over land. The refinery submitted data but they were not assessed as effluent was not discharged to a body of water.

4.5.2 Parkland--Bowden

This refinery had no effluent discharge for 1992.

4.5.3 Co-op--Regina

The Consumers' Co-operative Refineries Ltd. provides primary treatment for its wastewater before it is discharged into the Regina municipal sewer. Primary, secondary, and tertiary treatments are also provided at the City of Regina Sewage Treatment Plant. The on-site treatment produced an effluent in 1992 that met the limits in the Guidelines 67% of the time for oil and grease, 92% of the time for sulfide, 75% of the time for total suspended matter for the monthly amounts, and 100% of the time for phenols and ammonia nitrogen. Of the 24 tests results that were submitted for pH, two were over the prescribed amount. The quality of effluent at the refinery fence did not improve from 1987. Discharges of oil and grease, sulfide, and total suspended matter have increased.

4.5.4 Esso--Norman Wells

This Imperial Oil refinery has an API separator as a primary treatment system and the effluent is discharged into the Mackenzie River. The refinery is subject to the Guidelines and has an expanded status. In 1992, the refinery was in compliance 97.9% of the time for the monthly amounts, 100% of the time for the one-day amounts, and 99.9% of the time for the maximum daily amounts. For oil and grease, the monthly amount and the maximum daily amount were exceeded once due to a combination of high run-off, high river turbidity, a small oil spill, and composite sampler problems. The refinery complied 100% for phenols, sulfide, and ammonia nitrogen for the monthly, one-day, and maximum daily amounts. The water license issued to this refinery requires that it measure pH only three times a week and submit toxicity tests on a quarterly basis. Toxicity tests were not submitted. Total suspended matter was not assessed since the refinery was exempted based on an 18-week survey which found that total suspended matter in the refinery's effluent was the result of high solid in the intake water.

Overall, the refinery's performance improved from 1987. All average monthly deposits for the year, except total suspended matter, which does not have to be reported, were well below the Guideline limits, except for one exceedence of the oil and grease monthly amount, which was less than 25% above the limit. As required under their water license, the refinery submitted 99.5% of all requested tests.

4.5.5 Petro-Canada--Edmonton

The Petro-Canada refinery in Edmonton, which has a primary treatment system and a retention pond, discharged its effluent into the North Saskatchewan River. Some wastewaters such as oily water from process areas are treated and deep-well injected. The refinery has an expanded status and is subject to the Guidelines. The refinery performed very well in 1992. There was 100% compliance for all five parameters for the monthly, one-day, and maximum daily amounts. The refinery did not report one test each for phenols, sulfide, and toxicity. The pH and toxicity requirements were met at all times. The refinery reported 99.7% of all the requested tests. All average monthly deposits for the year were well below the Guideline limits.

4.5.6 Esso–Strathcona

This Imperial Oil refinery in Strathcona is subject to the Regulations. The refinery has a secondary treatment system consisting of an aerated lagoon and the effluent is discharged into the North Saskatchewan River. In addition, the refinery is authorized by Alberta Environment to use deep-well injection for brine and other process waters. Based on a good history of compliance, the Alberta District of Environment Canada decided that quarterly reporting of bioassay testing was sufficient.

In 1992, the Strathcona refinery was in compliance 100% of the time for all parameters. The pH and toxicity requirements were met at all times. While in operation, the refinery reported 100% of the required tests. All average annual monthly deposits were well below the Regulation limits. Compared to 1987, deposits of phenols, sulfide, ammonia nitrogen, and total suspended matter increased, while deposits of oil and grease decreased.

4.5.7 Husky–Lloydminster

No data were submitted as this refinery used deep-well injection for all of its wastewater.

4.5.8 Shell–Scotford

The Scotford refinery is subject to the Regulations. It processes synthetic crude oil and disposes of its oily process wastewater by deep-well injection; run-off and boiler blow-down water are discharged on a batch basis to the North Saskatchewan River. In 1992, the refinery fully complied for all five parameters and the pH and toxicity requirements were met at all times. This refinery submitted 100% of the required tests. Overall, the refinery's performance improved from 1987; oil and grease, and total suspended matter were reduced, while phenols deposits increased.

4.5.9 Turbo–Balzac

No data were submitted for process water as this refinery uses deep-well injection for all of its wastewater. However, the refinery submitted monthly data for storm water discharged into McDonald Lake. Although the refinery was officially "mothballed" on May 12, 1992, it continued to submit data to Environment Canada for the remainder of the year.

4.5.10 Assessment Summary

A comparison of the average monthly deposits from each refinery in 1992 is provided in Figures 20 to 24 for all parameters; the range of pH measurements for each refinery is presented in Figure 25. The frequency of compliance with the regulated parameters for each refinery is presented in Table 7. The Co-op refinery has the highest deposits for all five parameters. This refinery's effluent receives further treatment at a municipal treatment plant. The Shell refinery has the lowest deposits for total suspended matter and the Petro-Canada refinery has the lowest deposits for all other parameters.

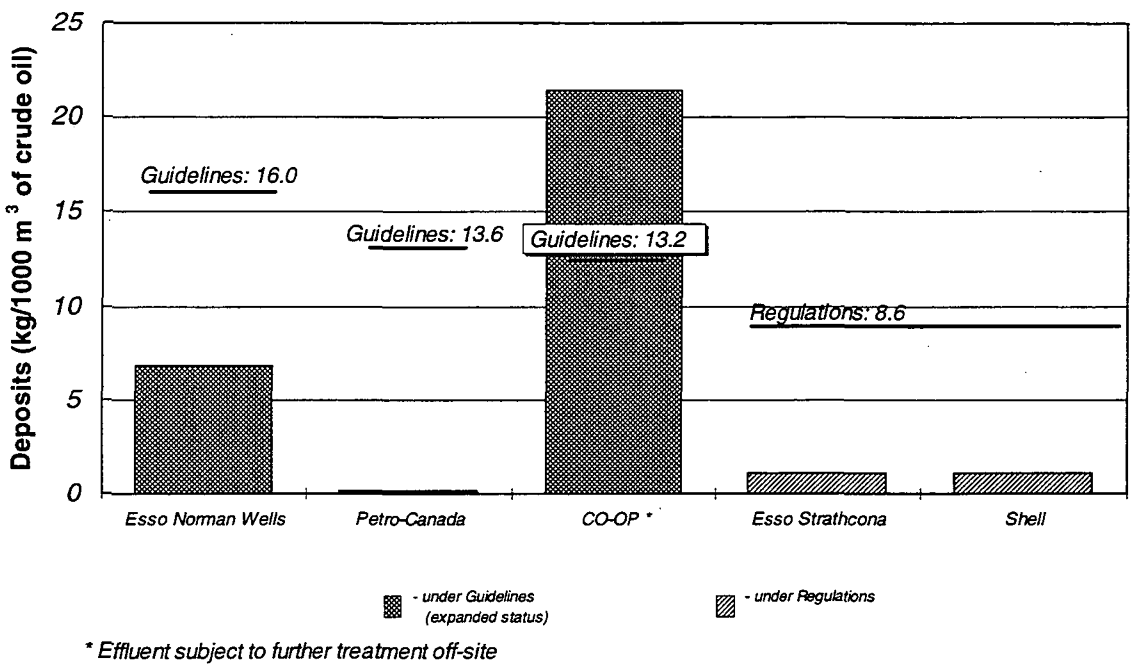


Figure 20 **Oil and Grease - Prairie and Northern Region 1992**

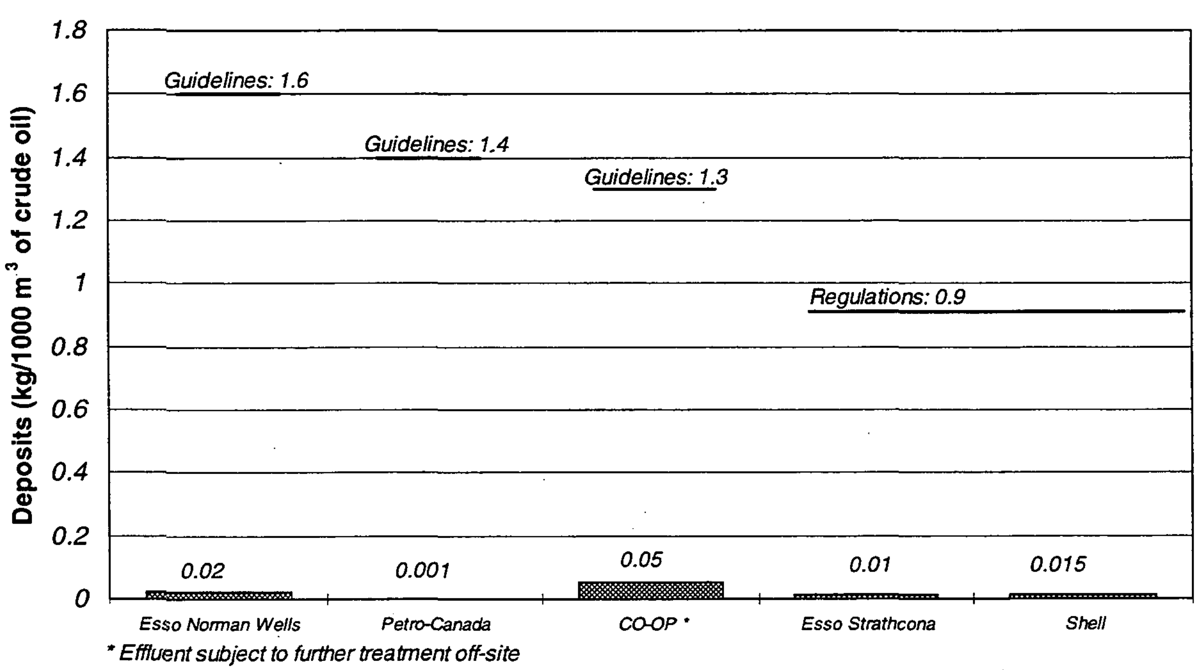


Figure 21 **Phenols - Prairie and Northern Region 1992**

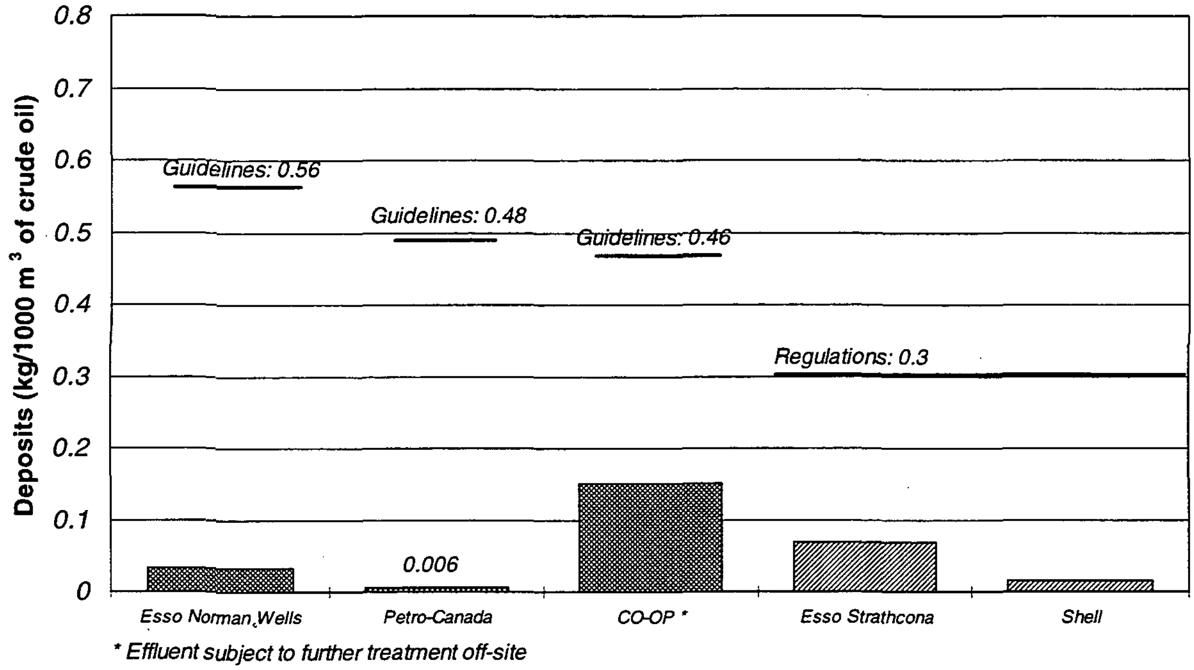


Figure 22 **Sulfide - Prairie and Northern Region 1992**

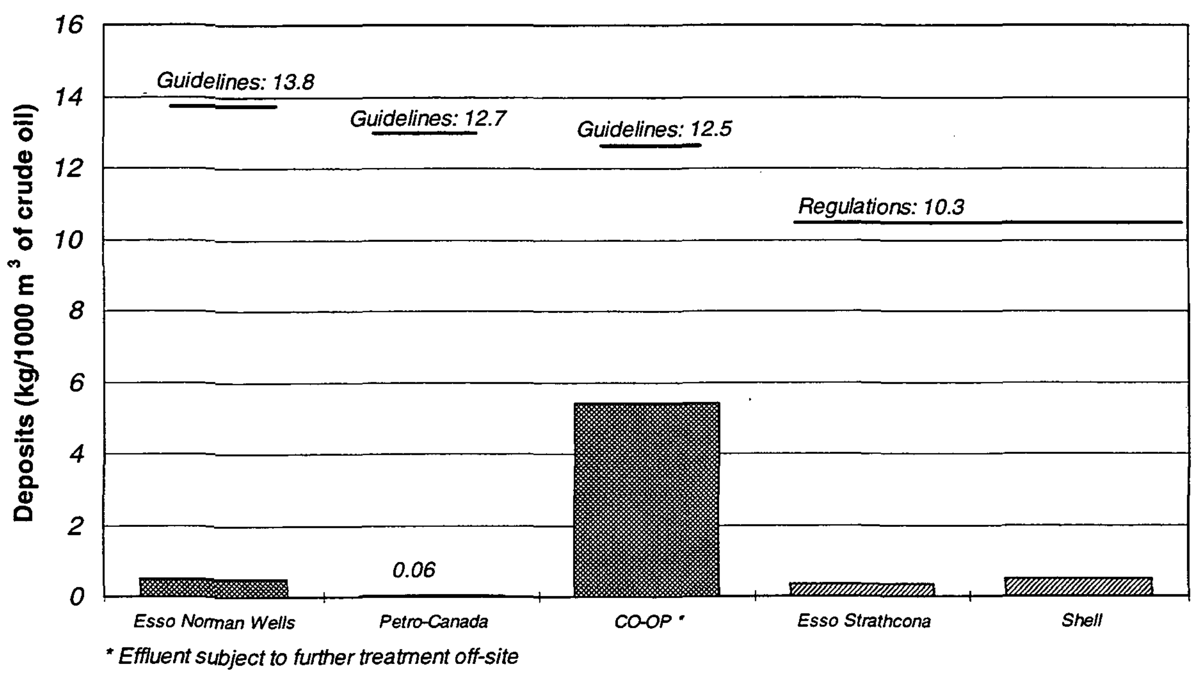


Figure 23 **Ammonia Nitrogen - Prairie and Northern Region 1992**

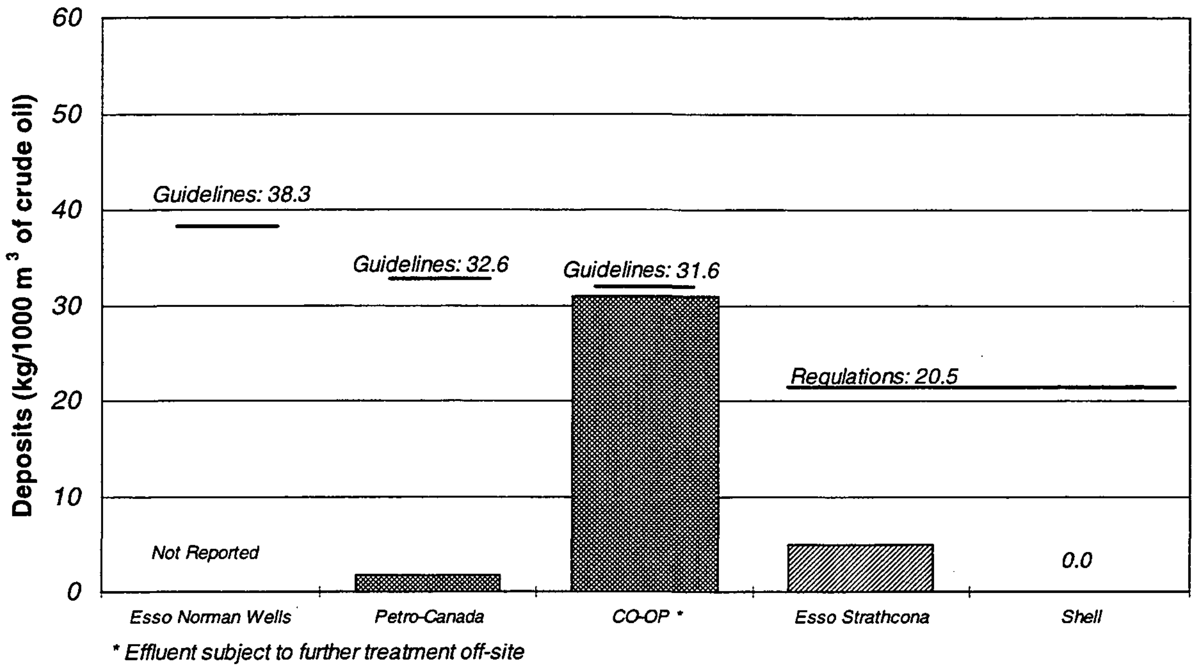


Figure 24 Total Suspended Matter - Prairie and Northern Region 1992

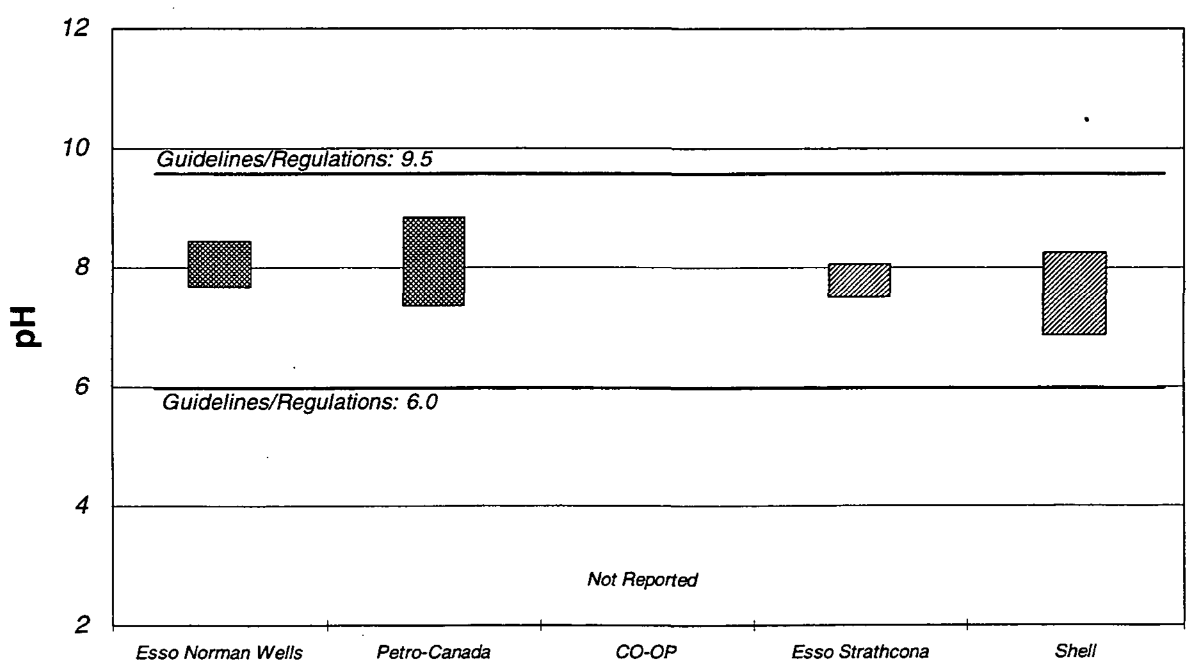


Figure 25 pH Levels - Prairie and Northern Region 1992

Table 7 **Percent Compliance of Refineries with Parameters - Prairie and Northern Region**

	Percent Compliance																	
	Oil and Grease %			Phenols %			Sulfide %			Ammonia Nitrogen %			Total Suspended Matter %			pH %	Toxicity %	Tests Reported %
Refinery	M	O	D	M	O	D	M	O	D	M	O	D	M	O	D			
Moose Jaw Asphalt Moose Jaw	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Parkland Bowden	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CO-OP Regina	66.7	NR	NR	100	NR	NR	99.7	NR	NR	100	NR	NR	75.0	NR	NR	NR	NR	7.2
Esso Norman Wells	91.7	100	99.4	100	100	100	100	100	100	100	100	100	NR	NR	NR	100	NR	99.5
Petro-Canada Edmonton	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	99.7
Esso Strathcona	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Husky Lloydminister	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Shell Scotford	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Turbo Balzac	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

M - Monthly amount
O - One-day amount
D - Maximum daily amount
NR - Not reported
ND - No deposits

4.6 *Pacific and Yukon Region*

In 1992, five refineries were operating in British Columbia: Esso--Ioco, Husky--Prince George, Petro-Canada--Port Moody, Shell--Burnaby, and Chevron--North Burnaby. They were all subject to the Guidelines. Four refineries had an existing status, while the Chevron refinery had an expanded status. The performance of individual refineries in this region for 1992 is summarized in Appendix A, Table A-5.

4.6.1 Esso--Ioco

This Imperial Oil refinery is subject to the Guidelines and treats its process effluent with an API separator followed by an activated sludge biological treatment system. The treated process effluent is then discharged directly to the Greater Vancouver Regional District (GVRD) sewer system. The effluent from two storm water systems, segregated from process water, is treated separately and discharged into Burrard Inlet. The refinery fully complied for all five parameters for the monthly, one-day, and maximum daily amounts. A total of 108 tests each for oil and grease and total suspended matter, 109 for phenols, 107 each for sulfide and ammonia nitrogen, and 317 for pH were not reported. All 12 toxicity tests were submitted and passed. This refinery reported data according to the frequency required by the GVRD and the provincial Ministry of Environment, which is 26.4% of that requested by the Guidelines. Deposits of oil and grease, phenols, ammonia nitrogen, and total suspended matter decreased since 1987. Sulfide deposits increased slightly but remained less than 10% of the Guideline limits.

4.6.2 Husky--Prince George

The Husky refinery treats its wastewater with a secondary treatment system (activated sludge) before sending it to a nearby pulp mill for biological treatment. The refinery is subject to the Guidelines. In 1985, the refinery commissioned a sour water stripper and in 1986, divided its aeration lagoon into biox and settling zones. In 1992, the Husky refinery was in compliance 95% of the time for the monthly amounts, 100% of the time for the one-day amounts, and 98.5% of the time for the maximum daily amounts at the refinery fence. The monthly amount was exceeded three times: for sulfide (0 to 24% in excess), for ammonia nitrogen (25 to 49% in excess), and for total suspended matter (more than 200% in excess). The maximum daily amount was exceeded four times. The refinery failed to report 104 results for oil and grease, 115 for phenols, 113 for sulfide, 105 for ammonia nitrogen, 145 for total suspended matter, and 310 for pH. All toxicity tests were submitted and passed.

Overall, the refinery's performance did not improve from 1987. Deposits increased in all parameters. Nonetheless, the refinery was well below the Guideline limits. The refinery provided monthly effluent quality reports throughout the year but only submitted 23.3% of the requested tests.

4.6.3 Petro-Canada--Port Moody

This Petro-Canada refinery segregates its storm water from process water and treats each one separately with a primary treatment system. The process effluent is forwarded to the GVRD sewer, while storm water is discharged into Burrard Inlet. The refinery is subject to the Guidelines. In 1992, this refinery was in compliance 93.3% of the time for the monthly amounts, 100% of the time for the one-day amounts, and 97.8% of the time for the maximum daily amounts. The monthly amount was exceeded four times: once for phenols (50 to 99% in excess) and three times for sulfide (100 to 199% in excess once and 200% twice). The refinery failed to report 105 results for each parameter, 314 pH results, and all 12 toxicity results. The maximum daily amounts were exceeded seven times: once for phenols and three times each for sulfide and pH.

The performance of the refinery is not quite as good as it was in 1987. The refinery deposits increased for all parameters, except for total suspended matter. Despite this increase, all average monthly deposits for the year were below the Guideline limits. The refinery reported 26.8% of the requested tests.

4.6.4 Shell–Burnaby

This Shell refinery processes its wastewater in an intermediate treatment system (air flotation unit) and then discharges directly to the GVRD sewer system where it is subsequently treated at the municipal treatment plant. The number of tests reported by the refinery is as per GVRD guidelines, which is less than 25% of the federal Guidelines. Stormwater is treated separately at the refinery and discharged into Burrard Inlet. The refinery is subject to the Guidelines. In 1992, the refinery was in full compliance for the monthly, one-day, and maximum daily amounts, but failed to report the following tests: 107 each for oil and grease, phenols, ammonia nitrogen, and total suspended matter; 148 for sulfide; and 6 for toxicity. Sulfide deposits increased since 1987, while all deposits for other parameters decreased. The average monthly deposits for the year for the refinery were well below the Guideline limits.

4.6.5 Chevron–North Burnaby

The Chevron refinery is the only one in the Region with an expanded status under the Guidelines. The refinery uses two segregated treatment systems to process storm water which is discharged into Burrard Inlet and is fully in compliance with the Guidelines. The process wastewater system includes an air flotation unit and the effluent is discharged into the GVRD sewer. The refinery has implemented a wastewater upgrading program including construction of a new sulphur plant to replace the existing facility, which is the largest single source of BOD and total suspended matter in the process wastewater. In addition, a secondary treatment plant will be completed in 1995.

For oil and grease in the process effluent, the Chevron refinery complied 58.3% of the time for the monthly amounts, 98.7% of the time for the one-day amounts, and 84.6% of the time for the maximum daily amounts. For phenols, the refinery complied 66.7% of the time for the monthly amounts, 98.7% of the time for the one-day amounts, and 84.6% of the time for the maximum daily amounts. For sulfide, the refinery complied 41.7% of the time for the monthly amounts, 100% of the time for the one-day amounts, and 90.4% of the time for the maximum daily amounts. For ammonia nitrogen, the refinery complied 100% of the time for the monthly and one-day amounts and 95.0% of the time for the maximum daily amounts. For total suspended matter, the refinery complied 58.3% of the time for the monthly amounts, 98.1% of the time for the one-day amounts, and 82.7% of the time for the maximum daily amounts. Oil and grease levels exceeded the limits during a pond cleaning operation in which water laden with oil and grease was sent to the induced air flotation unit. The wastewater treating system could not handle the subsequent heavy loading of oil and grease. There was 67.3% compliance for pH tests and 100% compliance for toxicity tests. The refinery failed to report the following tests: 105 each for oil and grease, phenols, sulfide, and total suspended matter; 117 for ammonia nitrogen; 314 for pH; and 9 for toxicity.

The refinery was in compliance 65% of the time for monthly amounts, 99.1% of the time for one-day amounts, and 83.8% of the time for maximum daily amounts. The overall performance of the refinery was not as good as in 1987. Average monthly deposits for the year of oil and grease, sulfide, and total suspended matter increased and deposits of phenols and ammonia nitrogen decreased. The average monthly deposits for the year for oil and grease, phenols, and total suspended matter were exceeded. The refinery reported only 26.1% of all the requested tests.

4.6.6 Assessment Summary

A comparison of the average monthly deposits from each refinery in 1992 is provided in Figures 26 to 30 for all parameters; the range of pH measurements for each refinery is provided in Figure 31. The frequency of compliance with the regulated parameters for each refinery is presented in Table 8. The Shell refinery has the highest deposits for ammonia nitrogen, while the Chevron refinery has the highest deposits for all other parameters. The Esso refinery has the lowest deposits for all five parameters.

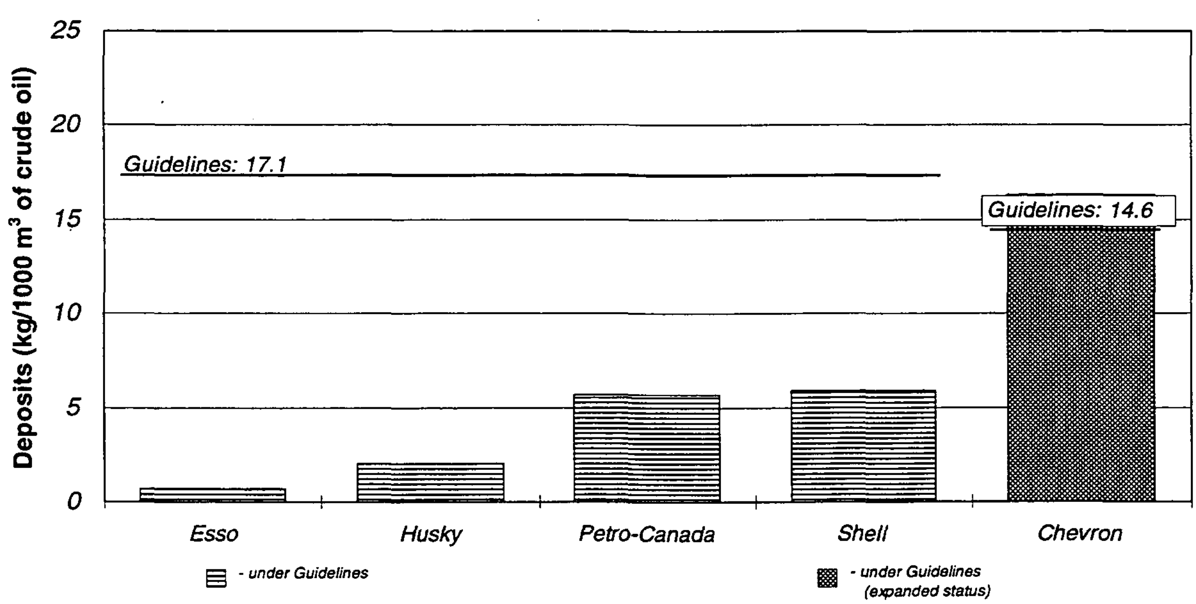


Figure 26 Oil and Grease - Pacific and Yukon Region 1992

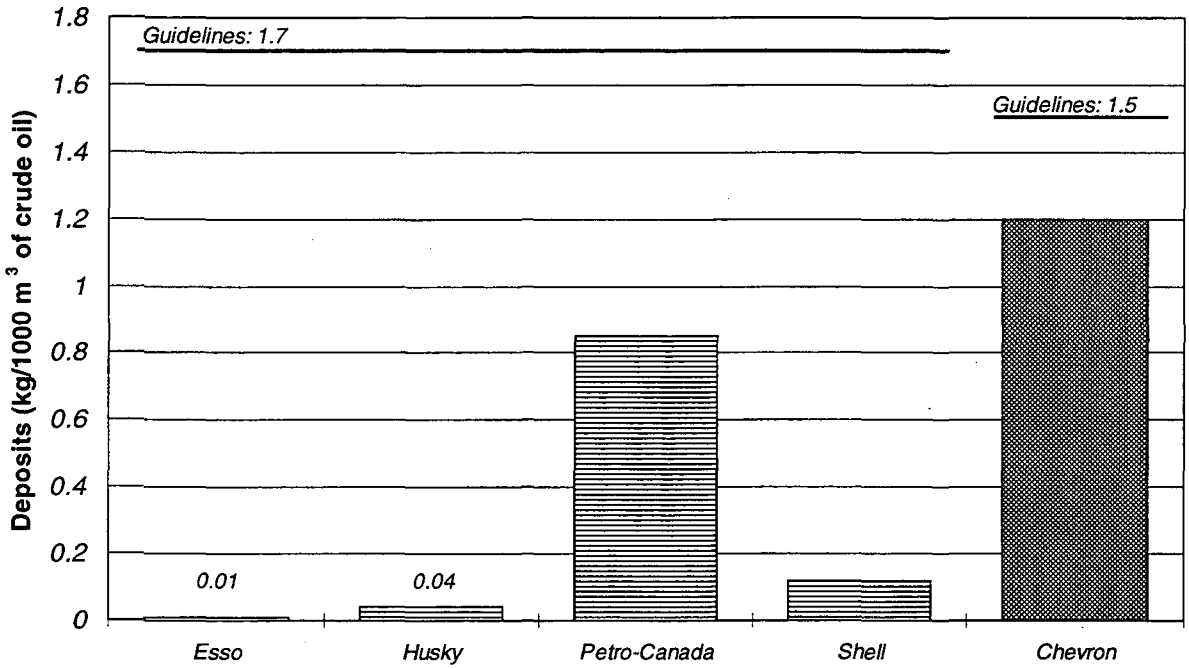


Figure 27 **Phenols - Pacific and Yukon Region 1992**

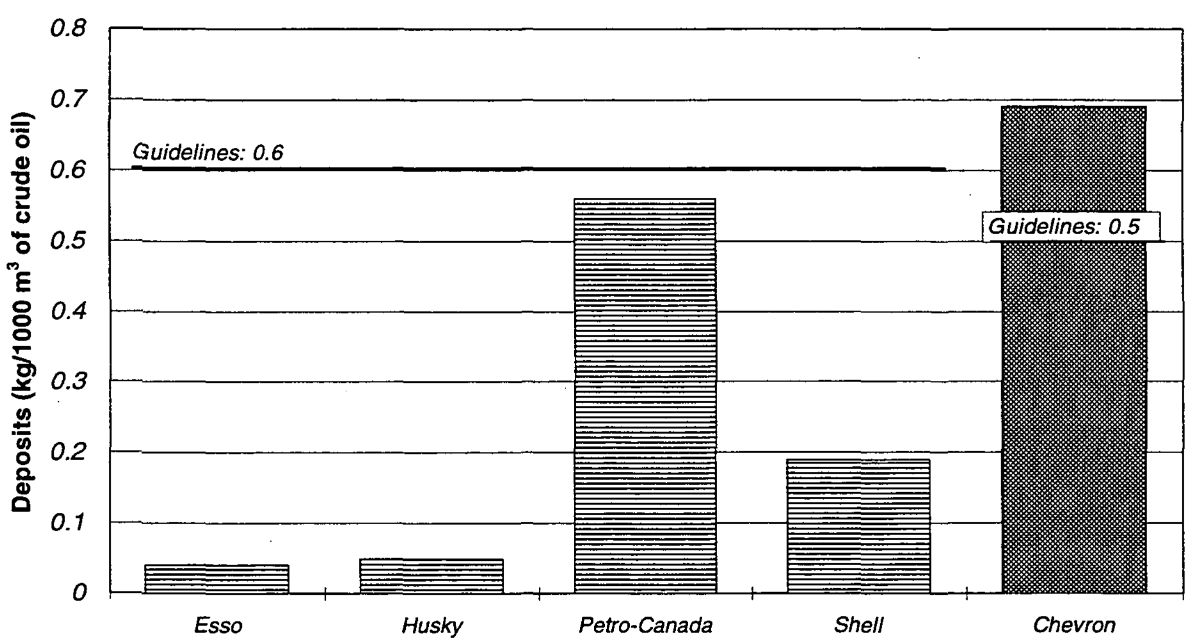


Figure 28 **Sulfide - Pacific and Yukon Region 1992**

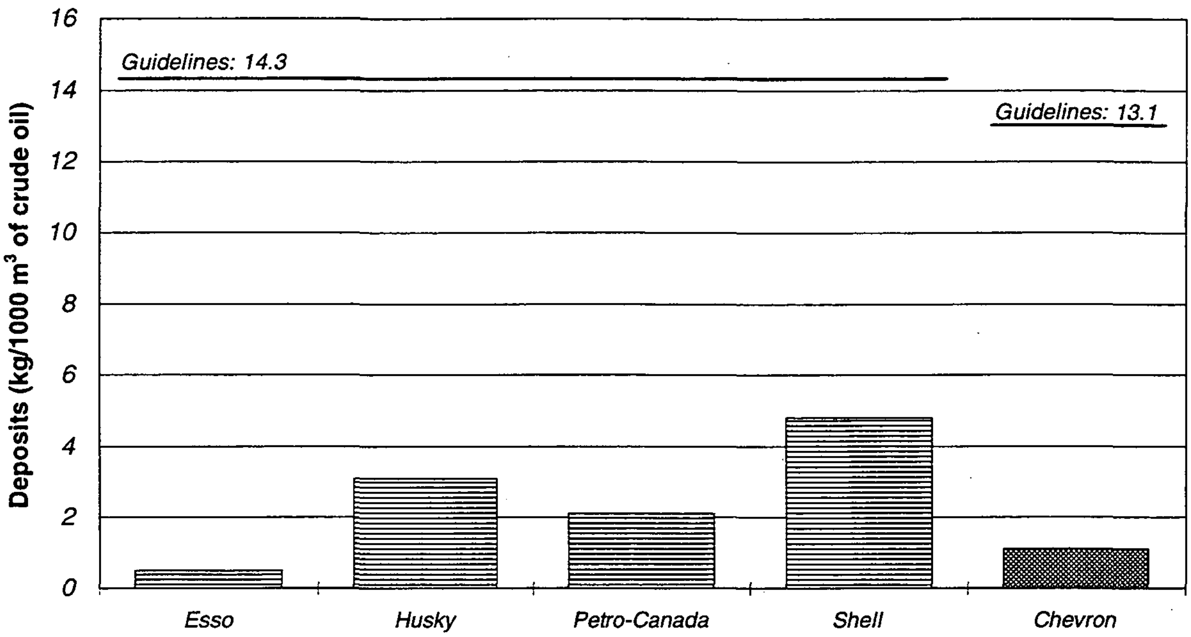


Figure 29 Ammonia Nitrogen - Pacific and Yukon Region 1992

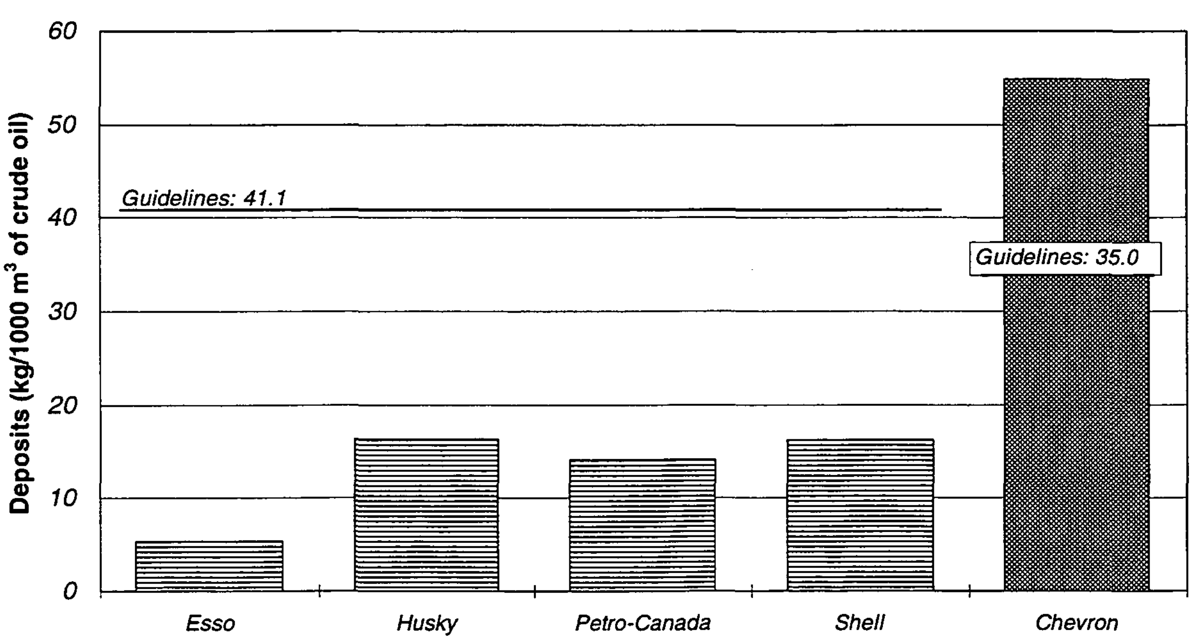


Figure 30 Total Suspended Matter - Pacific and Yukon Region 1992

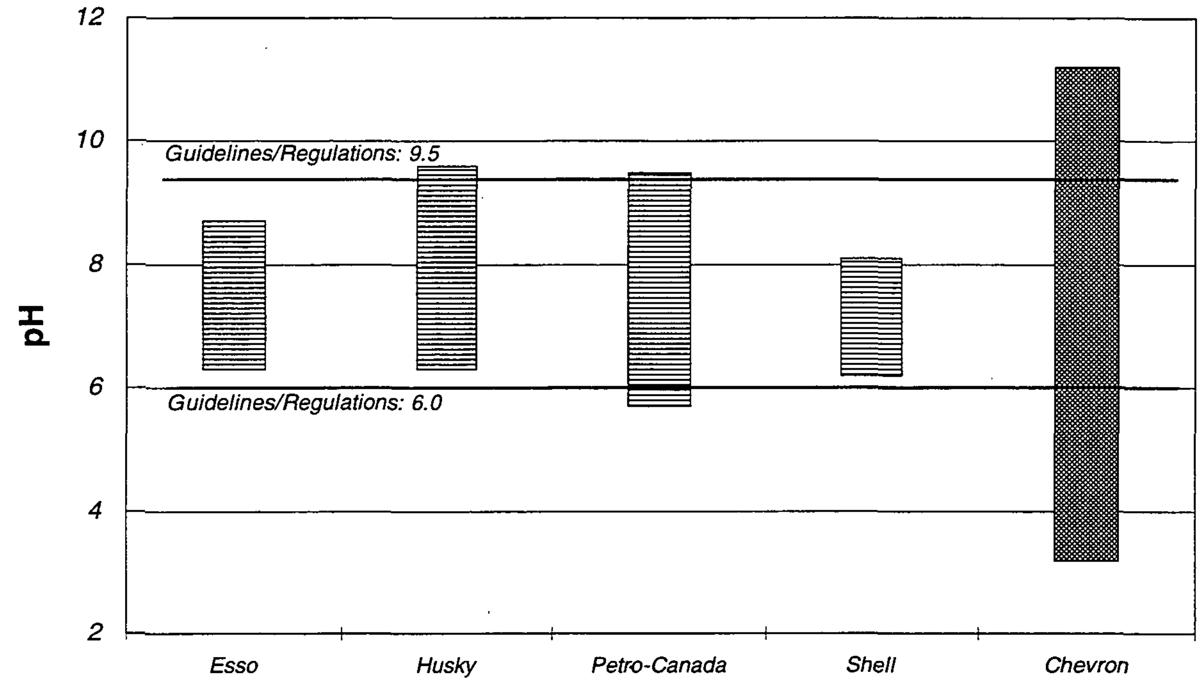


Figure 31 pH Levels - Pacific and Yukon Region 1992

Table 8 Percent Compliance of Refineries with Parameters - Pacific and Yukon Region

	Percent Compliance																
	Oil and Grease %			Phenols %			Sulfide %			Ammonia Nitrogen %			Total Suspended Matter %			pH %	Toxicity %	Tests Reported %
Refinery	**M**	**O**	**D**	**M**	**O**	**D**	**M**	**O**	**D**	**M**	**O**	**D**	**M**	**O**	**D**			
Esso Ioco	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	26.4
Husky Oil Prince George	100	100	100	100	100	100	91.7	100	100	91.7	100	98.1	91.7	100	91.7	96.4	100	23.3
Petro-Canada Port Moody	100	100	100	91.7	100	98.1	75.0	100	94.2	100	100	100	100	100	100	94.2	NR	26.8
Shell Canada Burnaby	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	22.8
Chevron North Burnaby	58.3	98.7	84.6	66.7	98.7	84.6	41.7	100	90.4	100	100	95.0	58.3	98.1	82.7	67.3	100	26.1

M - Monthly amount O - One-day amount D - Maximum daily amount NR - Not reported

Regional Assessment

5.1 Atlantic Region

In 1992, refineries in Atlantic Region were in compliance 99.2% of the time for the monthly amounts, 99.9% of the time for the one-day amounts, and 99.8% of the time for the maximum daily amounts. The Esso and Irving refineries were in compliance 98.3% of the time for the monthly amount, while Ultramar and Newfoundland Processing Ltd. refineries were in full compliance. The overall performance of each refinery in Atlantic Region is presented in Appendix A, Table A-1. As shown in this table, all the deposits that exceeded the monthly amount were less than 25% above the limit. Three of the four times the one-day amount was exceeded occurred at the Irving refinery in St. John. There was full compliance for sulfide, ammonia nitrogen, and total suspended matter for the monthly amounts and full compliance for sulfide of the one-day amount. The monthly amounts for oil and grease and phenols were met 97.9% of the time. The limit for the toxicity level was met 97.9% of the time and pH results complied 99.9% of the time, although only 80.3% of the pH tests were submitted.

From 1987 to 1992, compliance of the Region's refineries increased from 96 to 99.2% for the monthly amounts. The average monthly deposits for the years 1975 to 1992 are presented in Figures 32 to 36. The overall performance of the Region's refineries improved since 1987, with three parameters (phenols, sulfide, and total suspended matter) showing a reduction in deposits and two parameters (oil and grease, and ammonia nitrogen) showing an increase. Of all the requested tests, 93.2% were submitted.

5.2 Quebec Region

In 1992, refineries in Quebec Region were in full compliance for the monthly and one-day amounts, and complied 99.9% of the time for the maximum daily amounts. The Petro-Canada refinery in Montreal accounted for the only time when the maximum daily amounts were exceeded in the Region. The Shell refinery in Montréal-Est and the Ultramar refinery in St-Romuald had very good performances in 1992, complying with all the requirements of the Guidelines.

From 1987 to 1992, the compliance of the Region's refineries increased from 91 to 100% for the monthly amounts, and from 98.1 to 100% for the one-day amounts. The overall performance of refineries in the Region has improved greatly since 1987; the deposits decreased drastically from 1987 and were below the Guideline limits. The average monthly deposits for the years 1975 to 1992 are presented in Figures 37 to 41. On average, refineries in the Region submitted 99.3% of the requested tests.

5.3 Ontario Region

In 1992, refineries in Ontario Region were in compliance 100% of the time with the monthly amounts, 100% of the time with the one-day amounts, and 99.9% of the time with the maximum daily amounts. The Esso and Suncor refineries in Sarnia and the Petro-Canada refinery in Oakville had the best overall performances in the Region. These refineries submitted all the requested tests and were in full compliance for all parameters. The deposits of sulfide and total suspended matter increased in the Region since 1987, while deposits of oil and grease, and ammonia nitrogen decreased. Deposits of phenols remained unchanged. All the average monthly deposits for the year were below the authorized limits. The average monthly deposits for the years 1975 to 1992 are presented in Figures 42 to 46. On average, refineries in the Region submitted 99.7% of all the requested tests.

5.4 Prairie and Northern Region

In 1992, refineries in Prairie and Northern Region were in compliance 96.9% of the time with the monthly amounts, 100% of the time with the one-day amounts, and 99.9% of the time with the maximum daily amounts. The Esso refinery in Strathcona and the Shell refinery in Scotford had the best overall performances in 1992. These refineries submitted all required tests and were in full compliance for all parameters. Although it did not report three tests, the Petro-Canada refinery in Edmonton also had an excellent performance. It was in full compliance with all parameters and had the lowest toxic load according to the Chimiotox Index (see Figures 73 and 74). Also, the average monthly deposits for the year were well below the Regulation limits. The Co-op refinery in Regina accounted for two of the three times that the maximum daily amount was not met and eight of the nine times the monthly amount was not met. The refinery's effluent, however, receives further treatment at the City of Regina Sewage Treatment Plant. As shown in Table A-4 of Appendix A, the monthly amounts were exceeded three times by 0 to 24%, once by 25 to 49%, once by 50 to 99%, three times by 100 to 199%, and once by more than 200%. The average monthly deposits of oil and grease and sulfide increased since 1987 and the deposits of phenols, ammonia nitrogen, and total suspended matter decreased. The average monthly deposits for the years 1975 to 1992 are presented in Figures 47 to 51. Refineries in the Region reported 85.3% of the requested tests.

5.5 Pacific and Yukon Region

In 1992, refineries in Pacific and Yukon Region were in compliance 90.7% of the time with the monthly amounts, 99.8% of the time with the one-day amounts, and 95.9% of the time with the maximum daily amounts. The compliance of the refineries in the Region decreased from 1987 for all limits. For the monthly amounts, the Esso and the Shell refineries were in compliance 100% of the time, while the Husky refinery was in compliance 95.0% of the time, the Petro-Canada refinery 93.3% of the time, and the Chevron refinery 65.0% of the time. As shown in Table A-5 of Appendix A, the monthly amounts were exceeded eight times by 0 to 24%, four times by 25 to 49%, twice by 50 to 99%, four times by 100 to 199%, and ten times by 200%. The Petro-Canada refinery failed to submit toxicity test results, while the Chevron and Shell refineries submitted only three and six tests, respectively. Both the Husky Oil refinery in Prince George and the Esso refinery in Ioco submitted and passed all requested toxicity tests. There was compliance 91.5% of the time for pH, but only 14.2% of the tests were submitted.

The refineries in this Region did not improve their performance since 1987 and showed the worst performance in comparison with refineries in other Regions. The average monthly deposits for the years 1975 to 1992 are shown in Figures 52 to 56. Average monthly deposits of oil and grease, phenols, sulfide, and total suspended matter increased overall, while ammonia nitrogen deposits decreased. As a result of different provincial reporting requirements, refineries did not submit data as often as specified in the Guidelines. On average, only 25.1% of the requested tests were submitted.

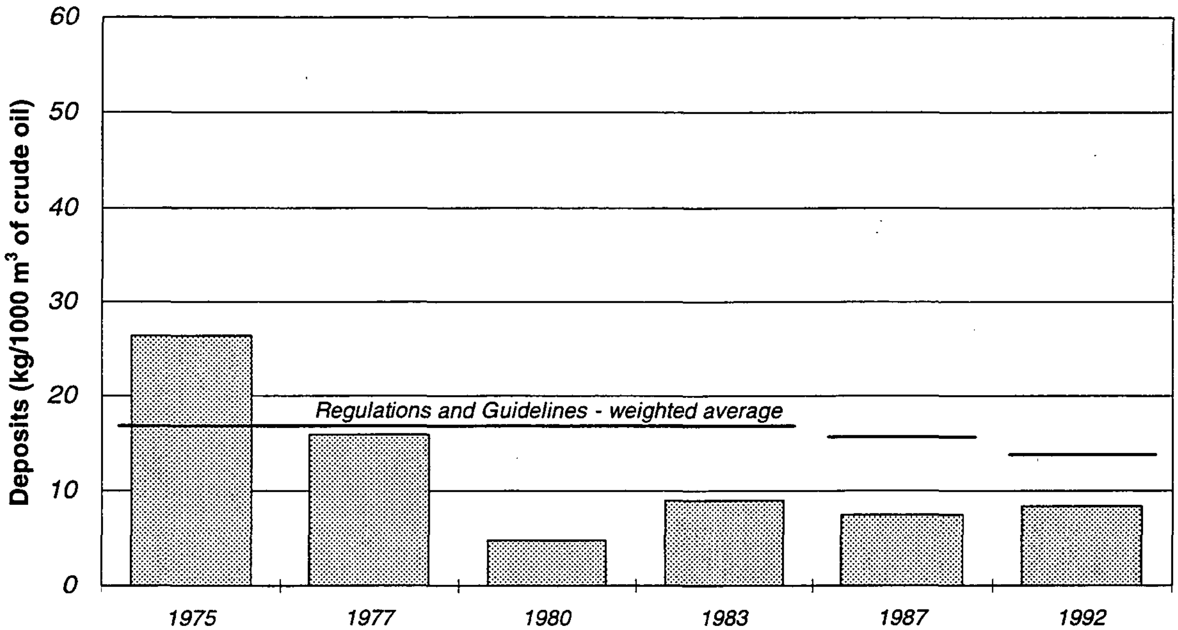


Figure 32 Oil and Grease - Atlantic Region 1975 to 1992

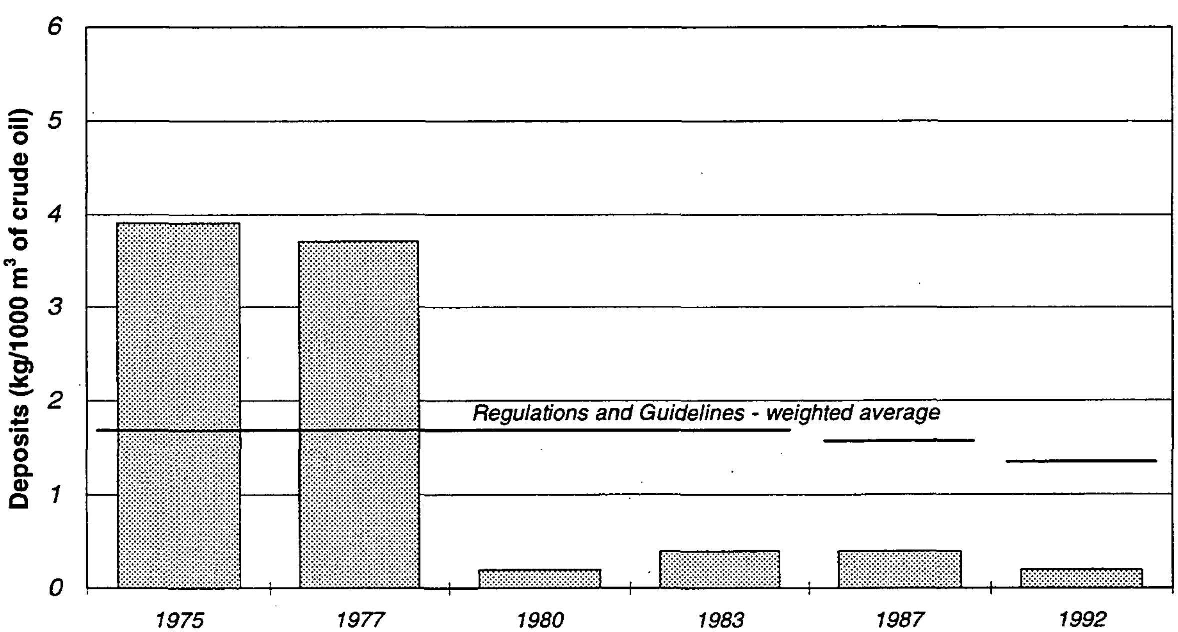


Figure 33 Phenols - Atlantic Region 1975 to 1992

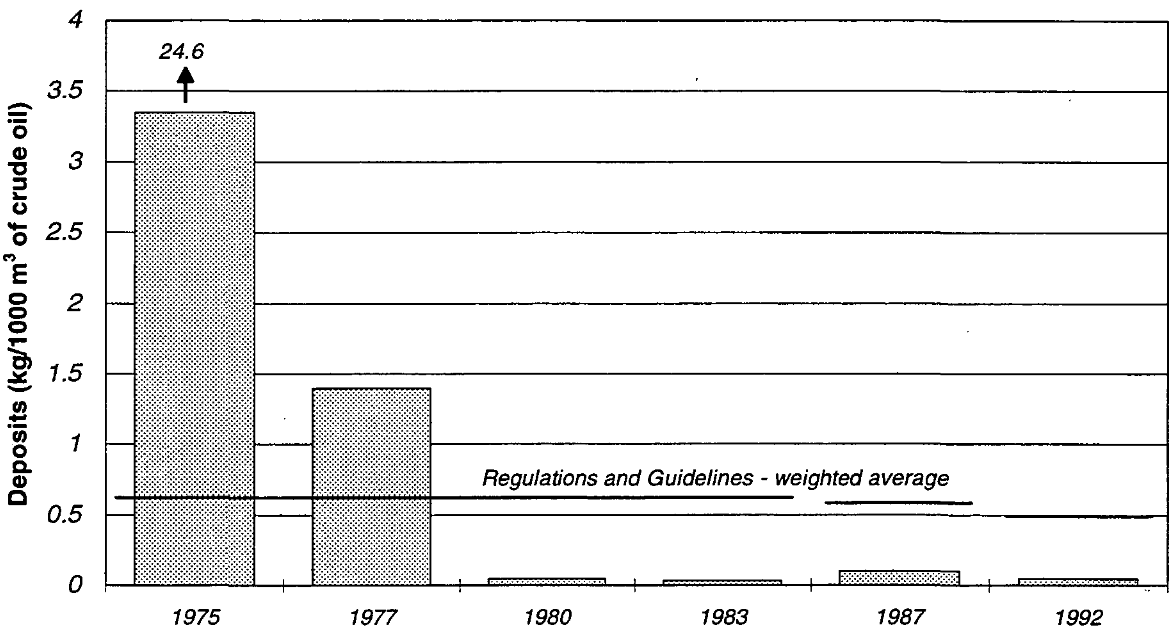


Figure 34 Sulfide - Atlantic Region 1975 to 1992

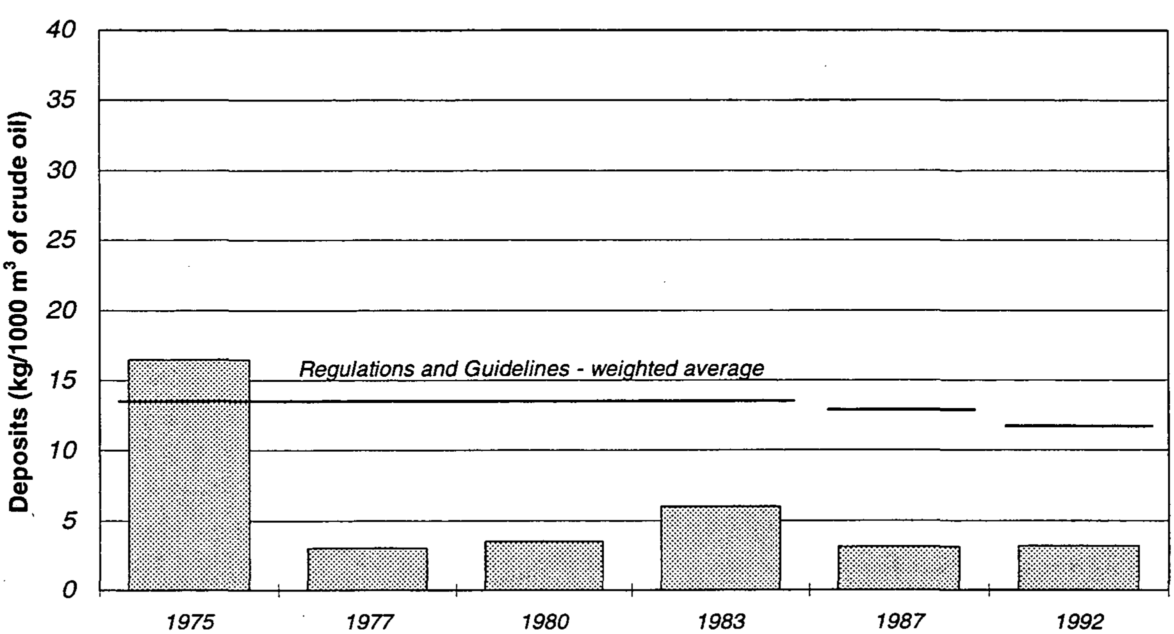


Figure 35 Ammonia Nitrogen - Atlantic Region 1975 to 1992

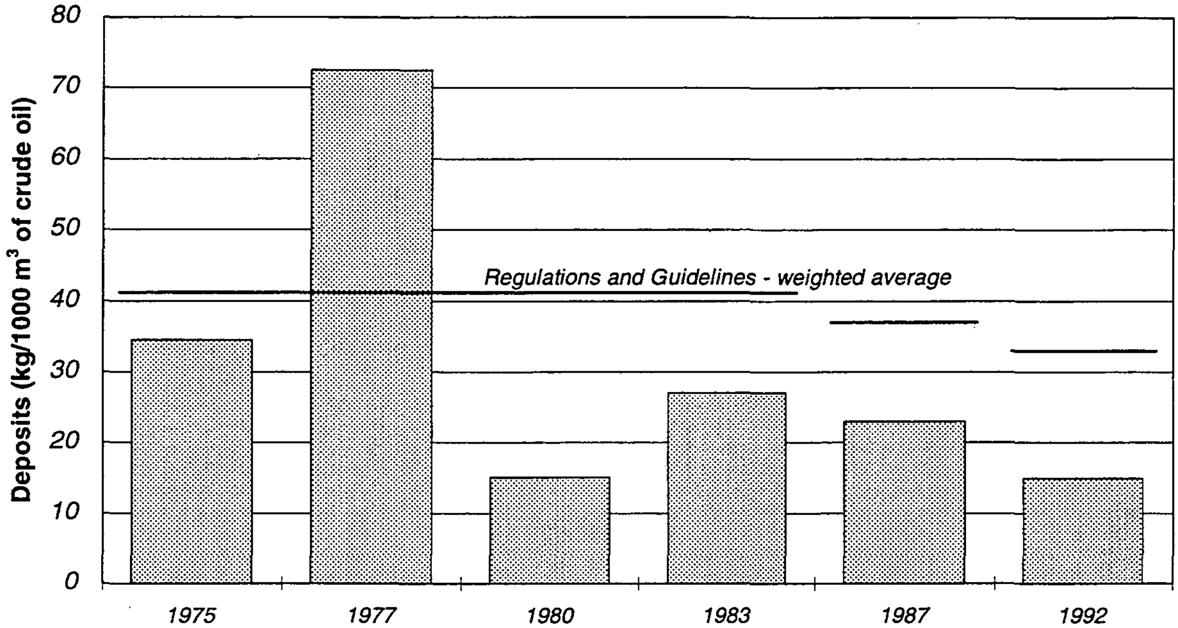


Figure 36 **Total Suspended Matter - Atlantic Region 1975 to 1992**

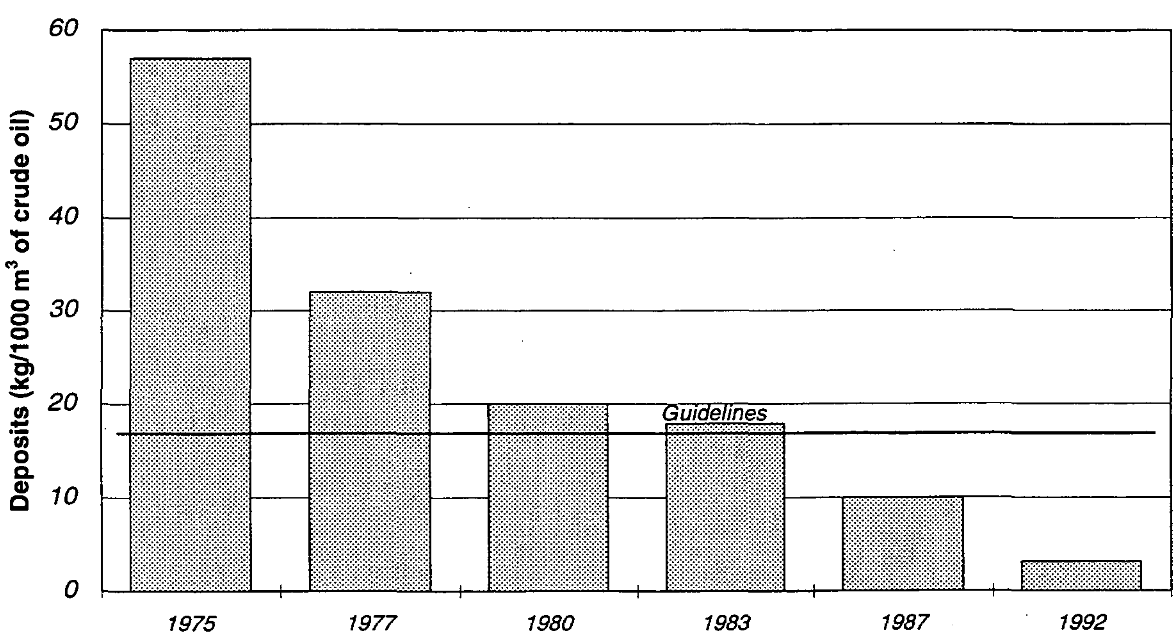


Figure 37 **Oil and Grease - Quebec Region 1975 to 1992**

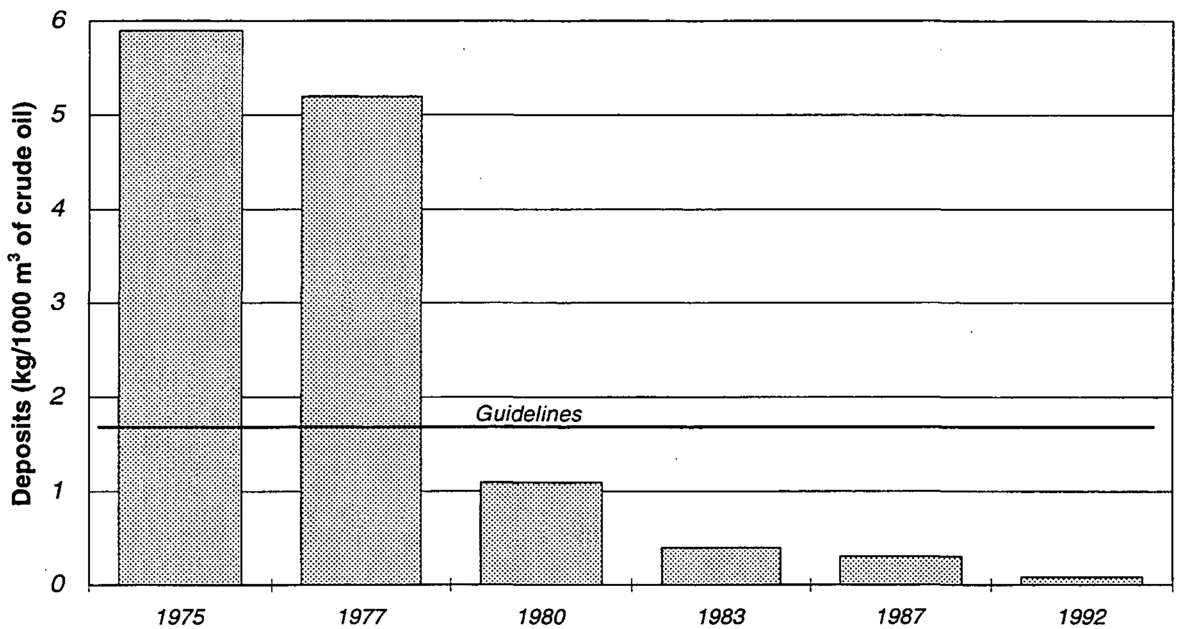


Figure 38 Phenols - Quebec Region 1975 to 1992

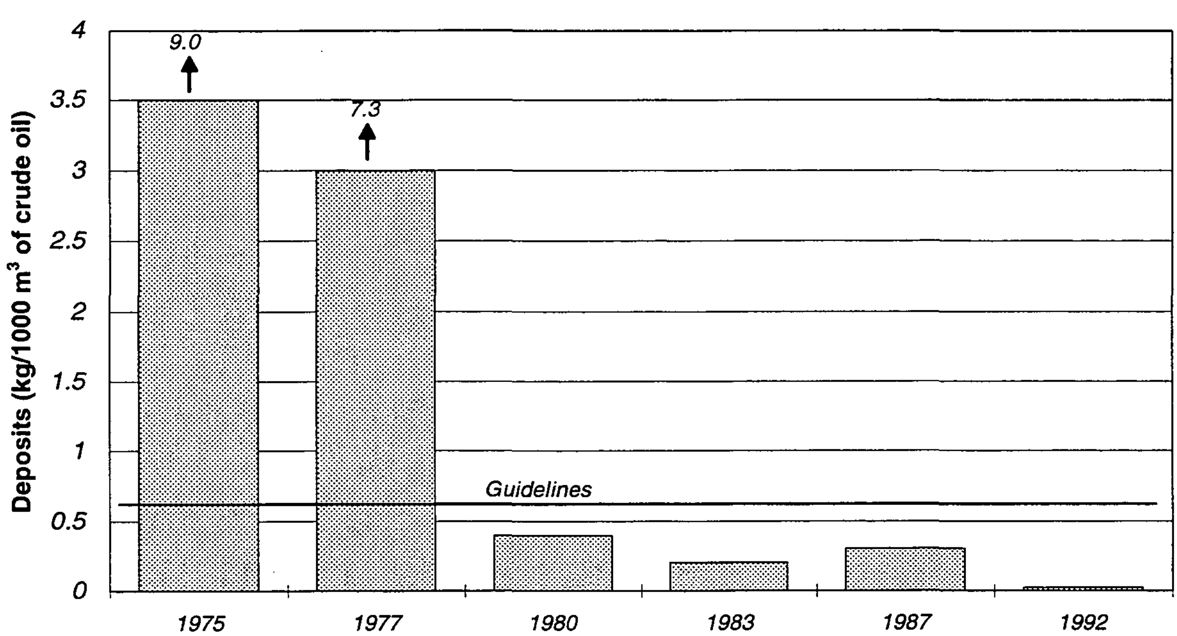


Figure 39 Sulfide - Quebec Region 1975 to 1992

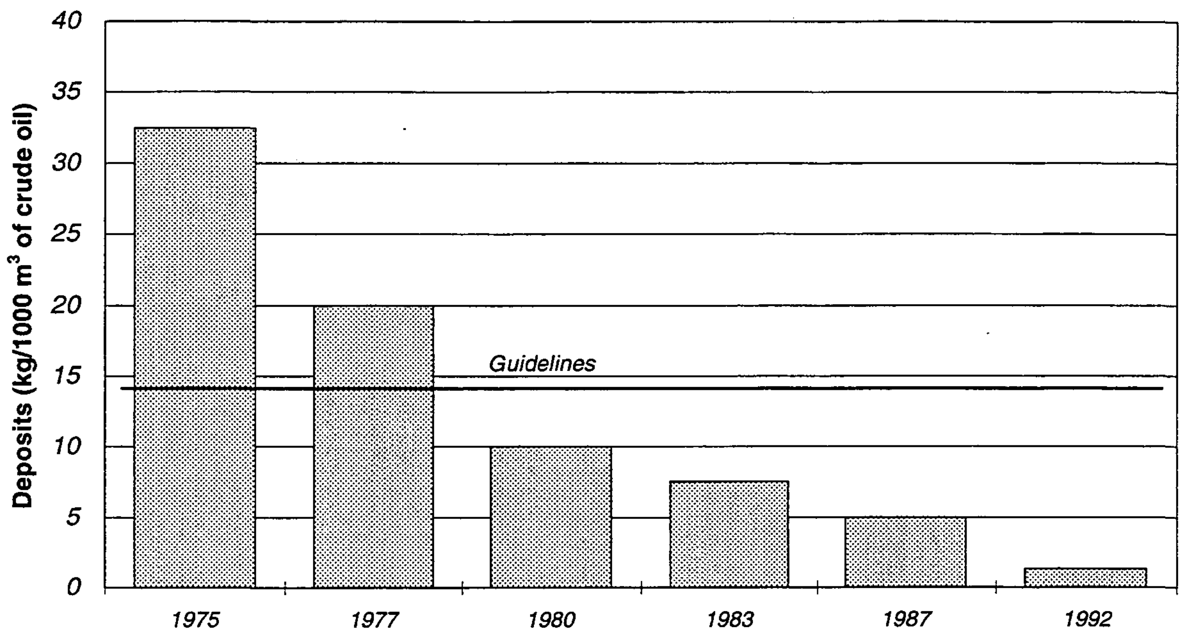


Figure 40 Ammonia Nitrogen - Quebec Region 1975 to 1992

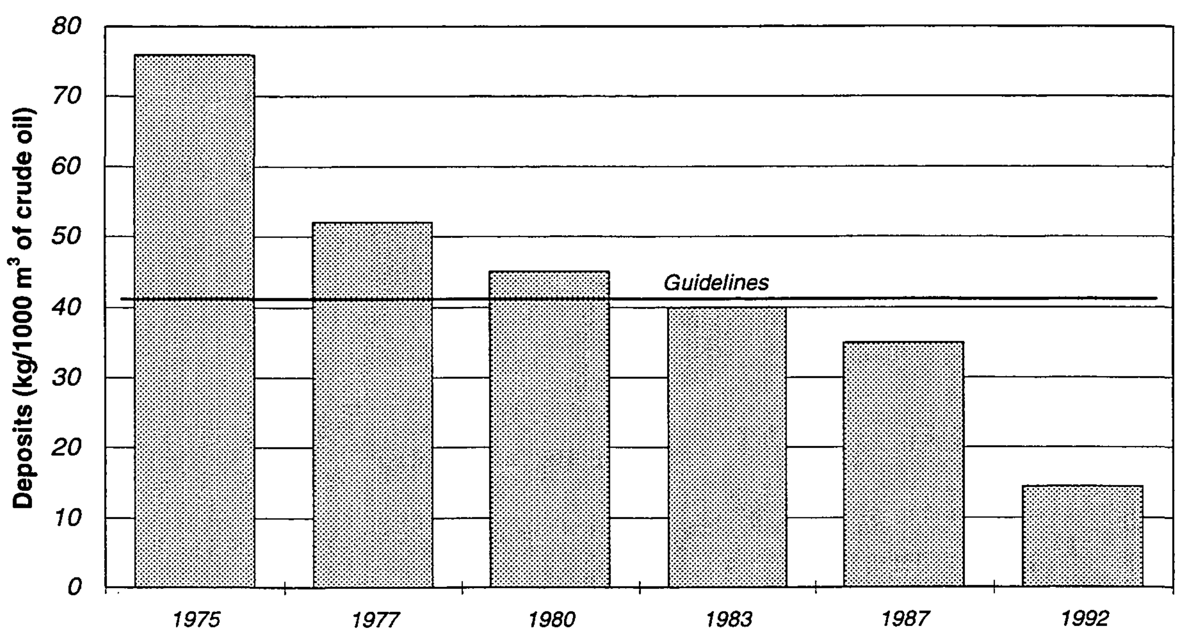


Figure 41 Total Suspended Matter - Quebec Region 1975 to 1992

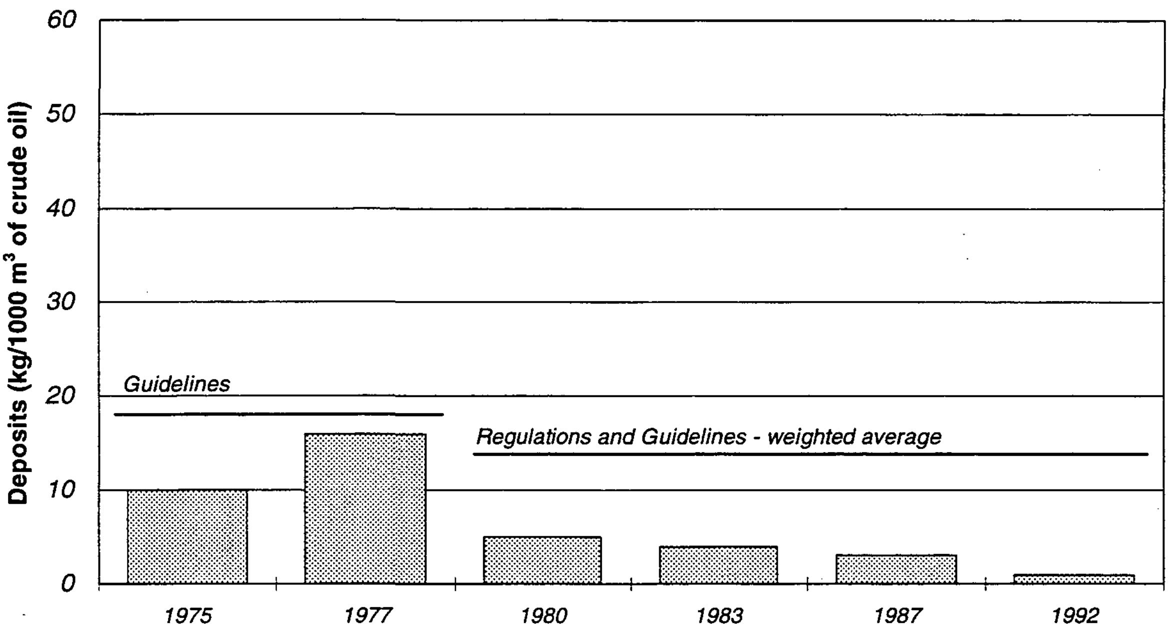


Figure 42 **Oil and Grease - Ontario Region 1975 to 1992**

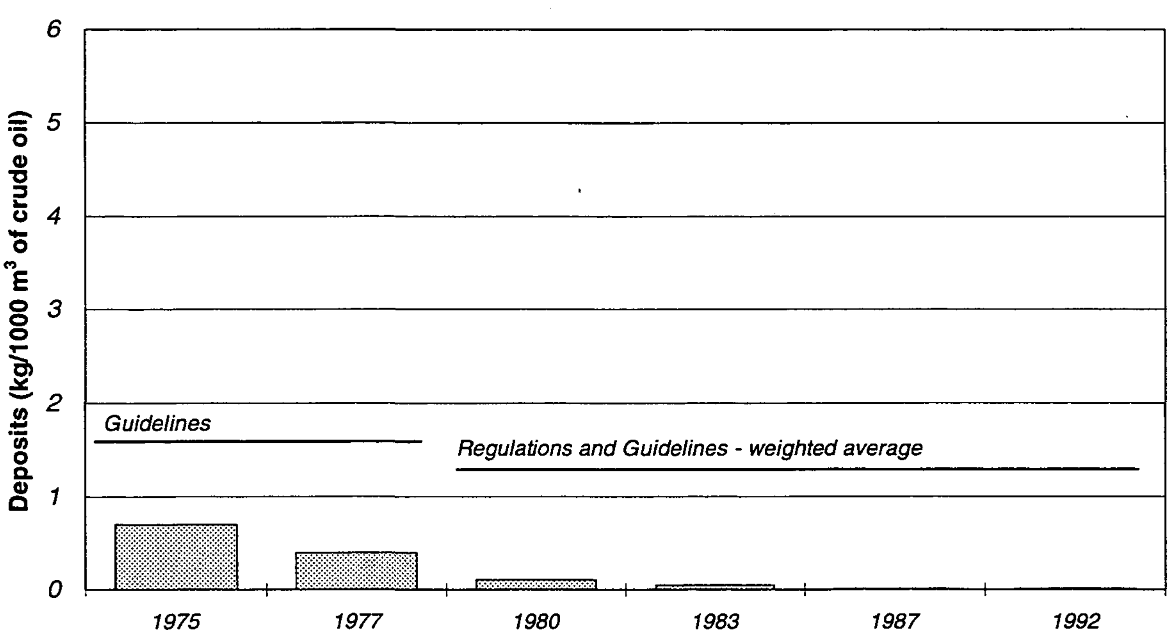


Figure 43 **Phenols - Ontario Region 1975 to 1992**

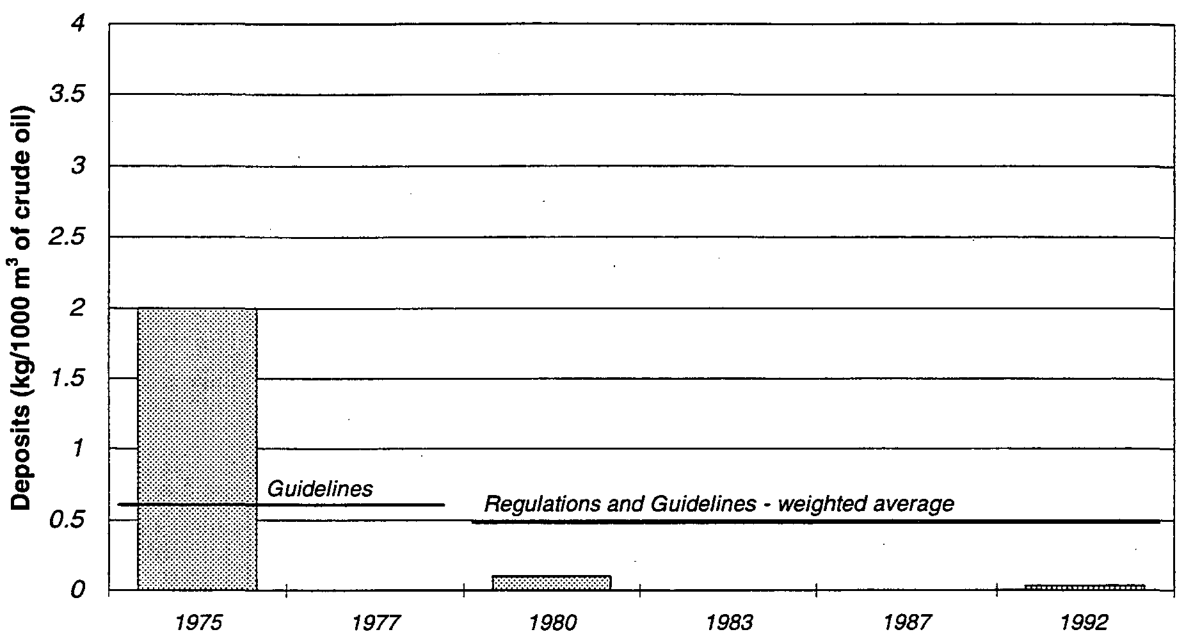


Figure 44 Sulfide - Ontario Region 1975 to 1992

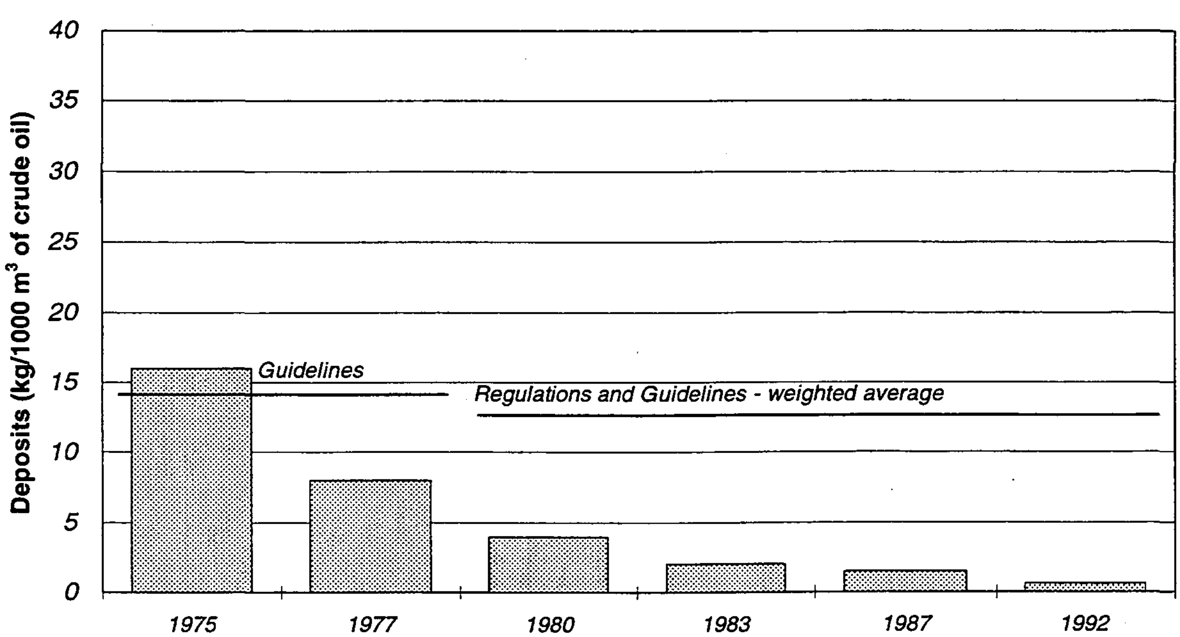


Figure 45 Ammonia Nitrogen - Ontario Region 1975 to 1992

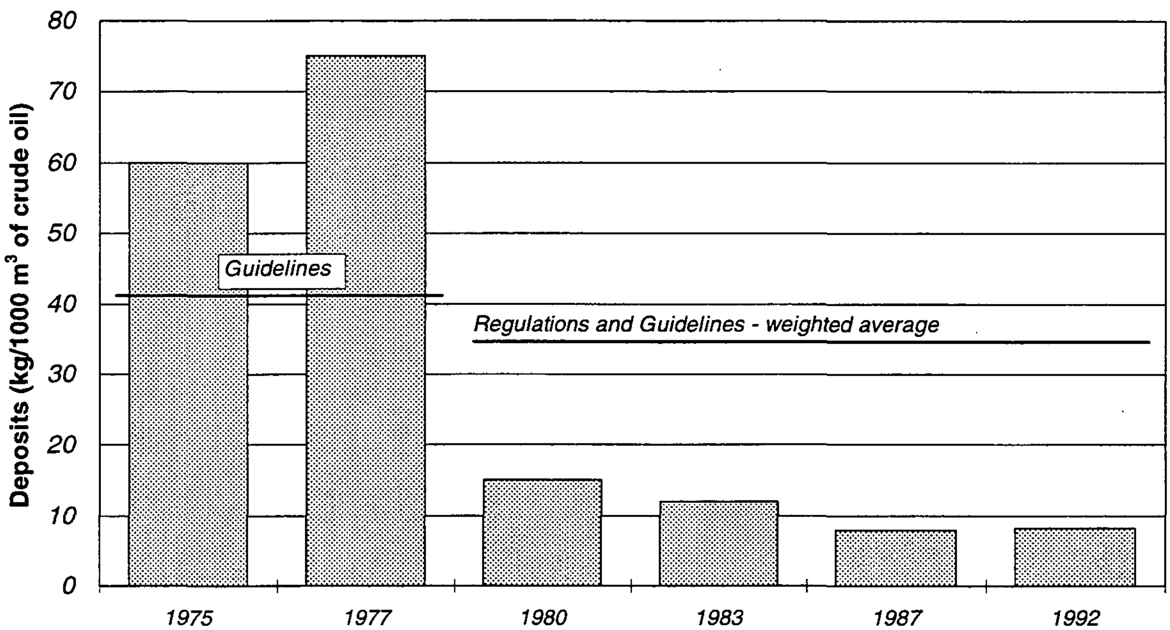


Figure 46 **Total Suspended Matter - Ontario Region 1975 to 1992**

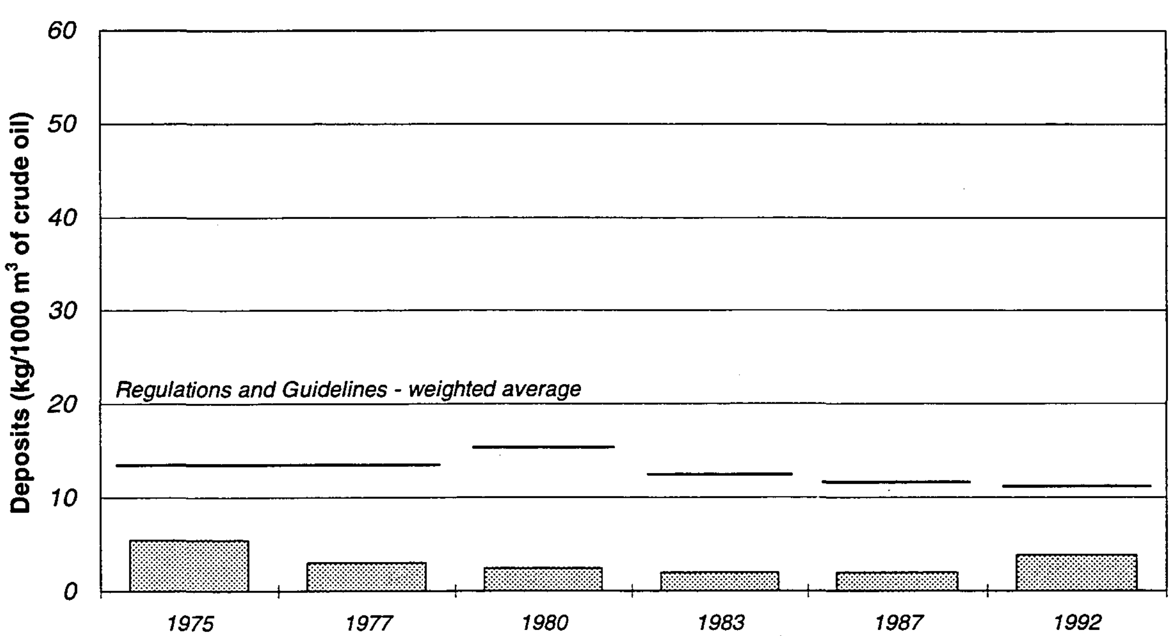


Figure 47 **Oil and Grease - Prairie and Northern Region 1975 to 1992**

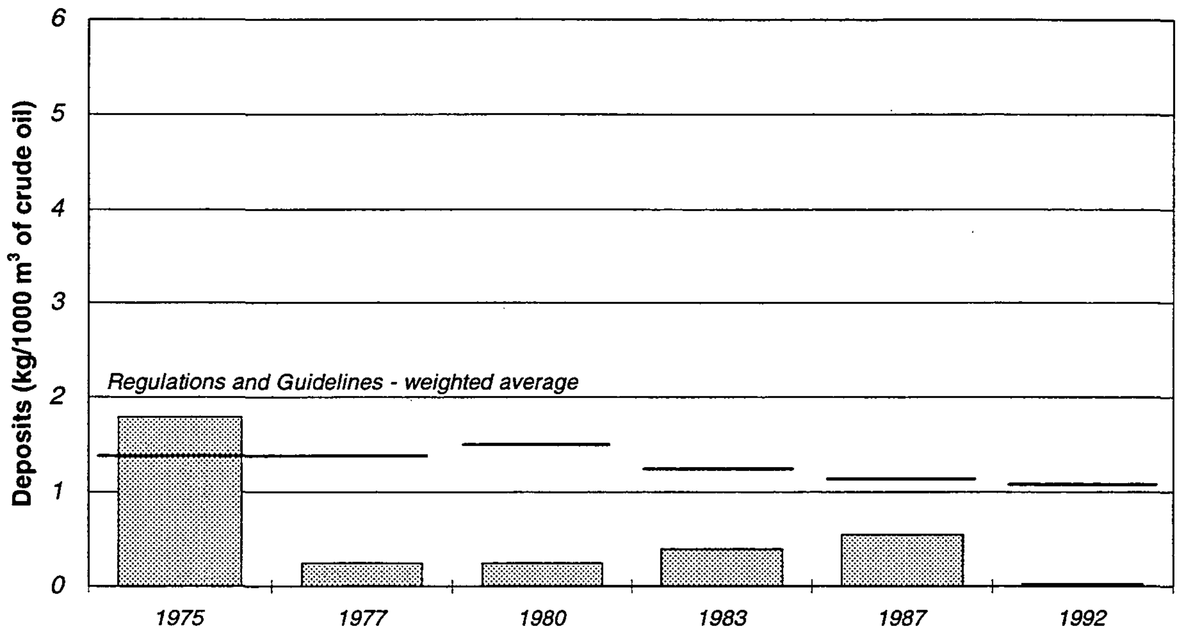


Figure 48 Phenols - Prairie and Northern Region 1975 to 1992

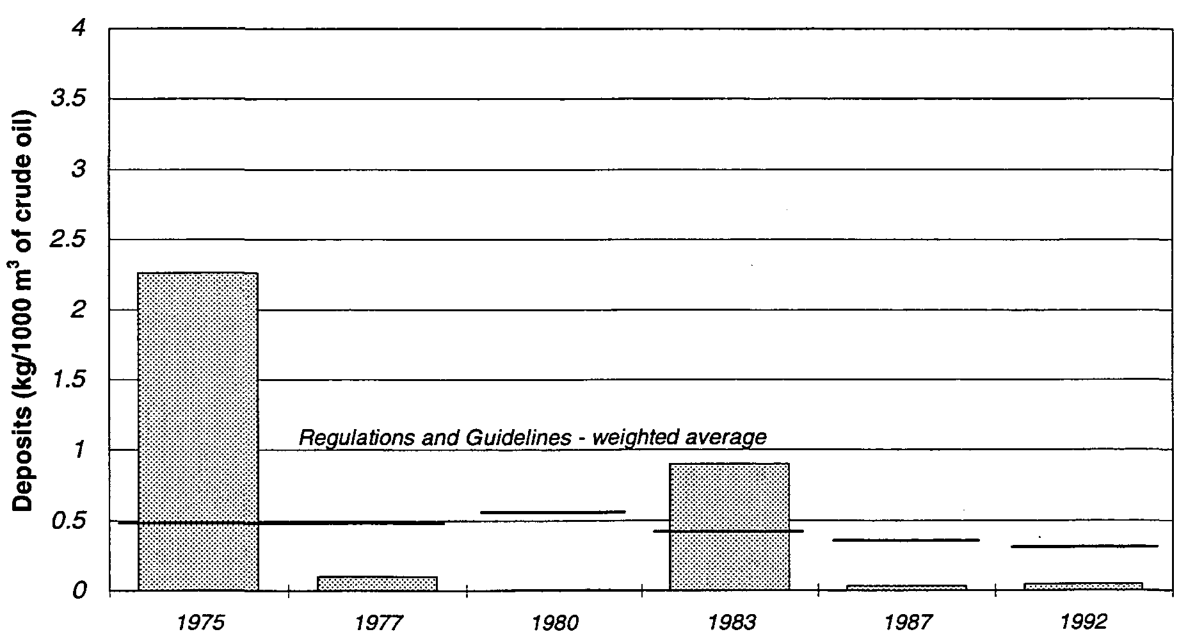


Figure 49 Sulfide - Prairie and Northern Region 1975 to 1992

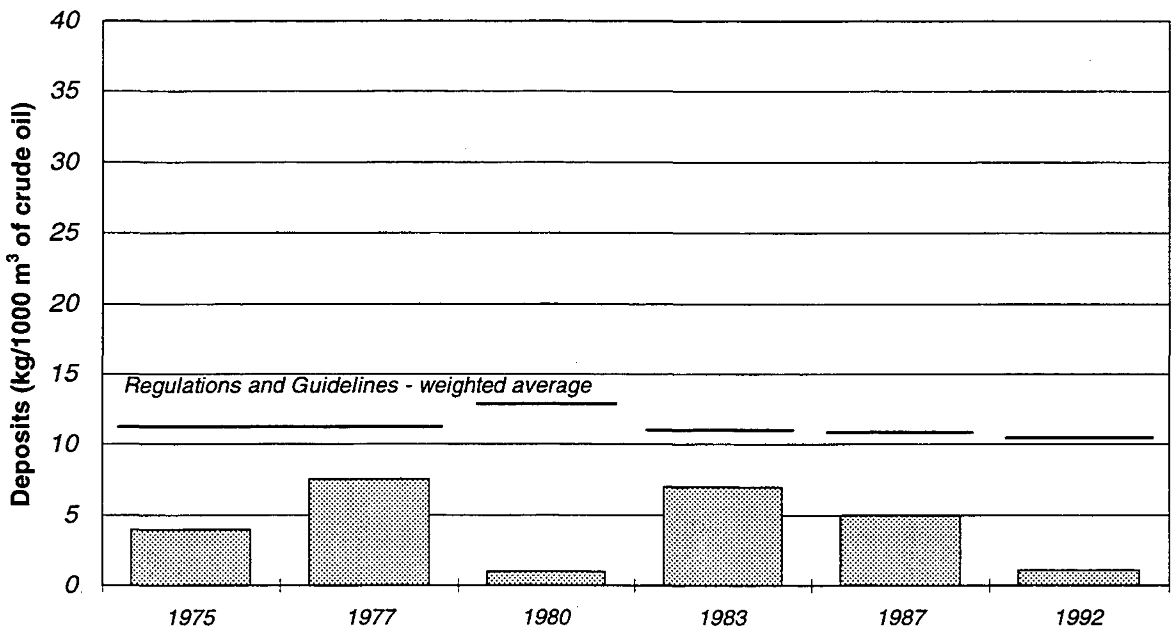


Figure 50 Ammonia Nitrogen - Prairie and Northern Region 1975 to 1992

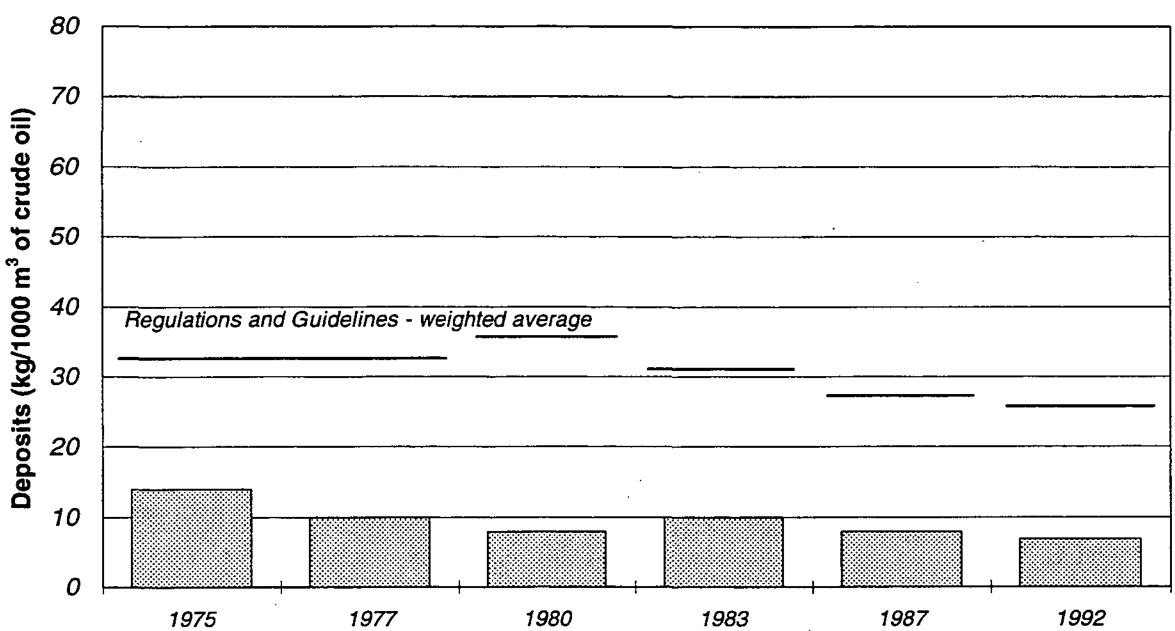


Figure 51 Total Suspended Matter - Prairie and Northern Region 1975 to 1992

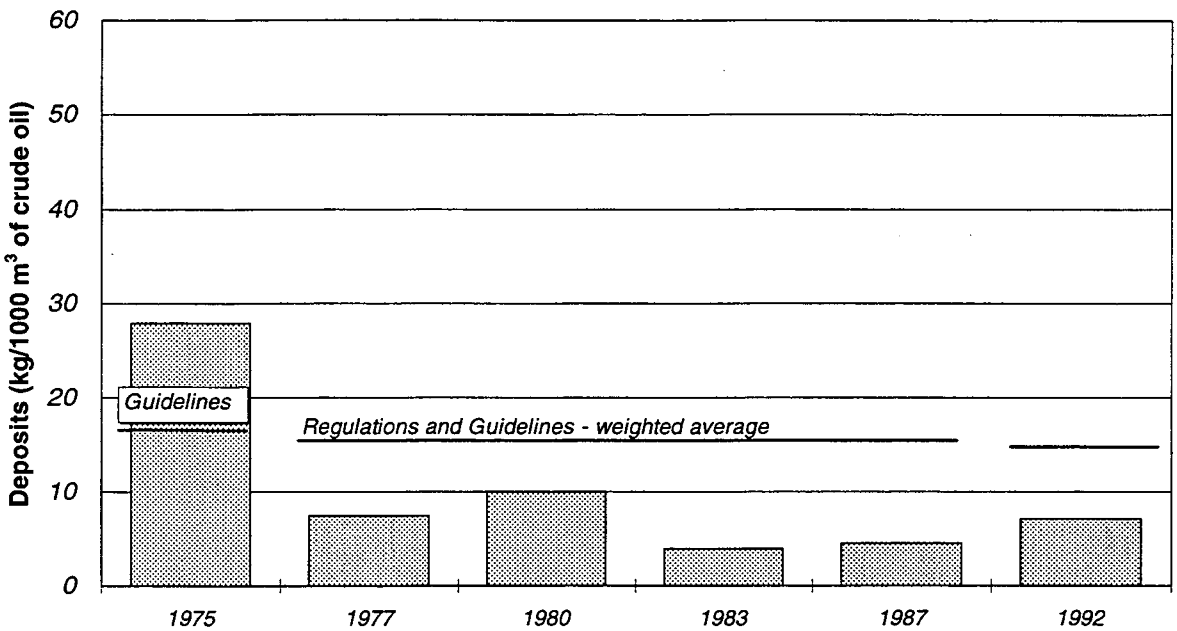


Figure 52 **Oil and Grease - Pacific and Yukon Region 1975 to 1992**

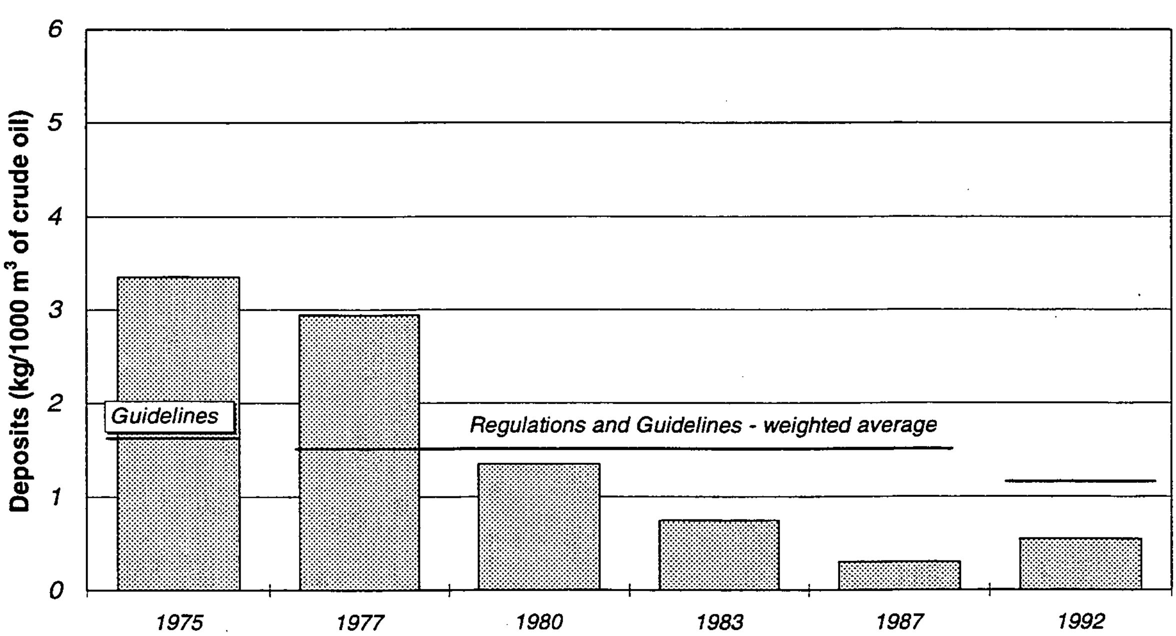


Figure 53 **Phenols - Pacific and Yukon Region 1975 to 1992**

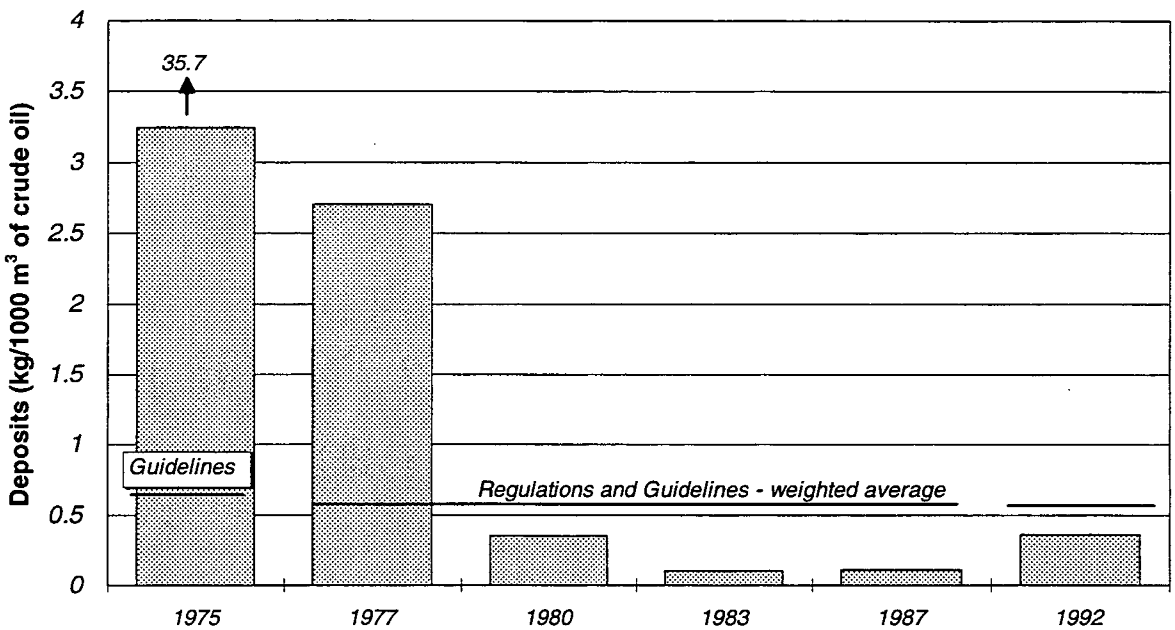


Figure 54 **Sulfide - Pacific and Yukon Region 1975 to 1992**

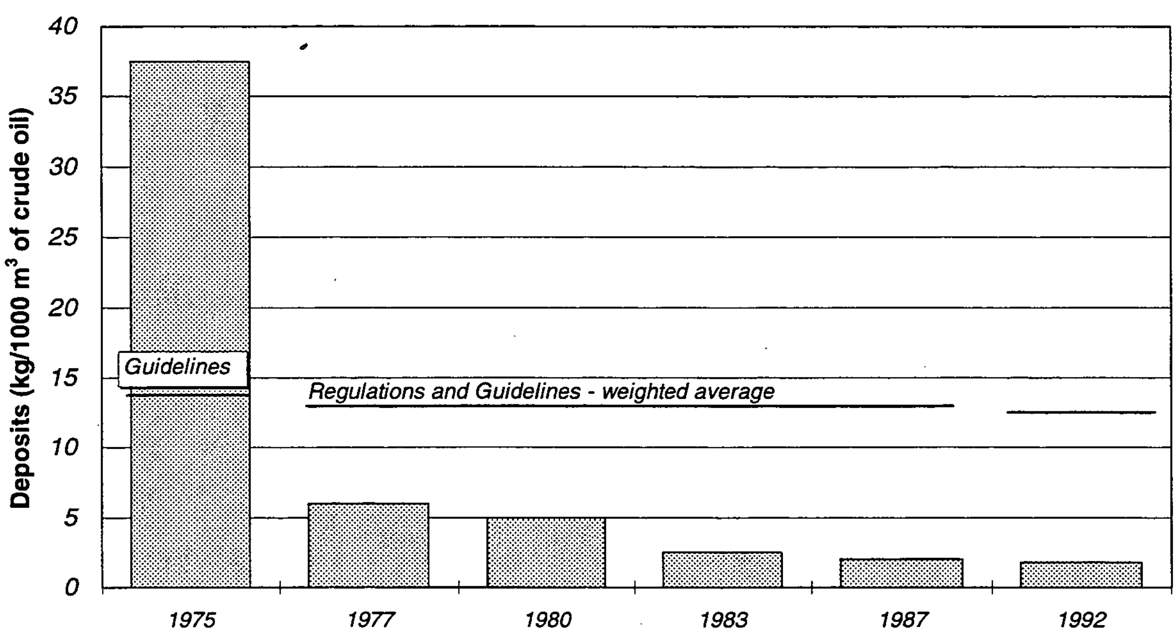


Figure 55 **Ammonia Nitrogen - Pacific and Yukon Region 1975 to 1992**

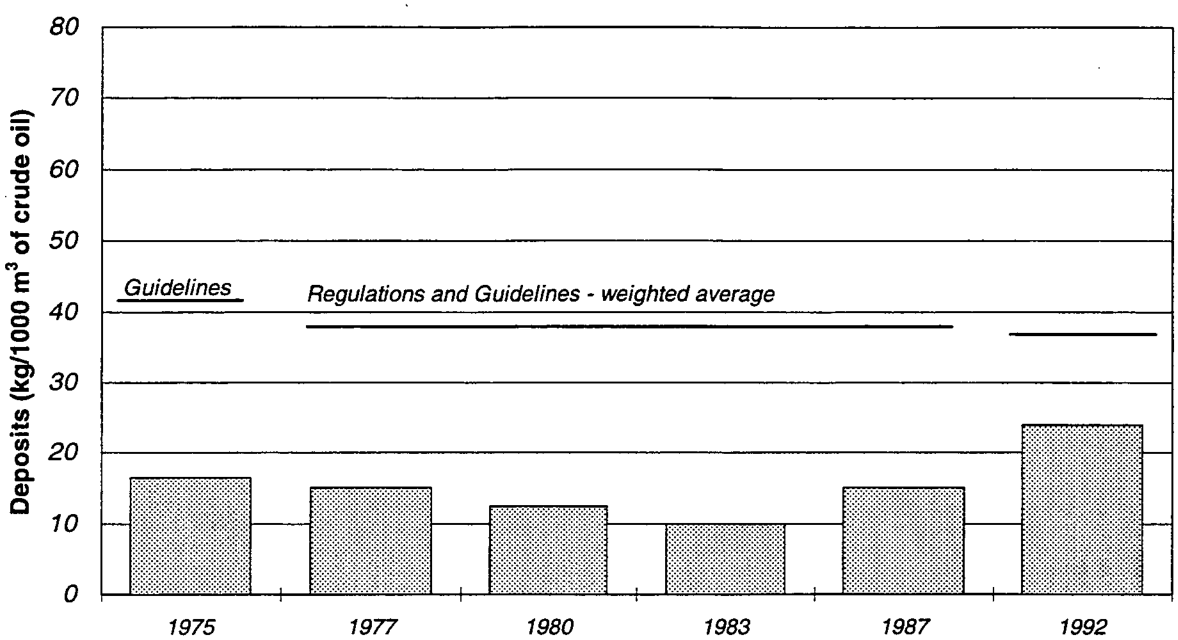


Figure 56 Total Suspended Matter - Pacific and Yukon Region 1975 to 1992

National Assessment

In 1992, 28 refineries were operating in Canada. Fourteen had an existing status, seven had an expanded status, and seven had a new status. Since the last status report in 1987, there are two less refineries in operation. The Petro-Canada refinery in Taylor, B.C. has closed and the Turbo refinery in Balzac was "mothballed" in May 1992.

In 1992, seven refineries (five in the Pacific and Yukon Region and two in the Prairie and Northern Region) provided primary, intermediate, and/or secondary treatment on-site, and further treatment (sometimes secondary) off-site. One of these refineries (Moose Jaw Asphalt--Moose Jaw) was not assessed as its effluent is sent to a municipal treatment plant which spreads it over land. Five refineries (Esso--Strathcona, Petro-Canada--Edmonton, Husky--Lloydminster, Turbo--Balzac, and Shell--Scotford) use deep-well injection for disposing of process wastewater (but not storm water). One refinery (Parkland--Bowden) has no discharge at all. The remaining refineries have primary and/or secondary treatment systems and discharge their treated wastewater to surface waters. Four refineries in Ontario and Quebec treat the effluents of adjacent petrochemical plants which are not subject to the refinery Regulations and Guidelines.

On average, only 79.7% of the tests requested in the federal Regulations and Guidelines were submitted for 1992 due to different provincial reporting requirements. The Prairie and Northern Region, which reported 85.3% of the tests, and the Pacific and Yukon Region, which reported only 25.1%, contributed to this low average.

The performance of each region in 1992 is summarized in the tables provided in Appendix A. It should be noted that as the levels of deposits prescribed in the Regulations and Guidelines apply only to effluents from individual refineries, there is no "authorized level," regionally or nationally. These weighted limits stipulated in the Regulations or Guidelines are useful, however, in assessing the performance of the refineries as a whole within the various regions or within the country. The deposits presented in the figures in this section and in the tables of Appendix A were obtained by calculating the weighted average of the authorized monthly amounts (calculated according to the Regulations and Guidelines). These weighted deposits are compared to the "actual deposits", which are an average of the arithmetic monthly averages of daily deposits. The refineries are not required to meet these averages; they were calculated only to provide an indication of the refineries' annual performance.

6.1 Refinery Performance

Of the 24 refineries assessed in 1992, 13 refineries were in compliance with all limits 100% of the time and seven refineries complied with all limits more than 99% of the time for the data submitted. Further treatment was provided off-site at the remaining four refineries; the quality of the effluent from each refinery was assessed at the refinery fence line as none of the four refineries ever received approval for off-site treatment. Such approval is only granted when Environment Canada is satisfied that the off-site facility provides treatment equivalent to that required by the Regulations and Guidelines. The three refineries with the lowest performance in relation to monthly amounts were: the Chevron refinery in North Burnaby, in compliance 65.0% of the time, the Co-op refinery in Regina, in compliance 86.7% of the time, and the Petro-Canada refinery in Port Moody, in compliance 93.3% of the time. The overall performance of refineries in each region is provided in Table 9.

6.2 Performance of Refineries Subject to Regulations

In 1992, two of the seven refineries used deep-well injection for their wastewater. The remaining five regulated refineries complied with both the monthly amounts and the one-day amounts 100% of the time, and with the maximum daily amount 99.9% of the time. A regional breakdown by parameters of compliance with the monthly limits set in the Regulations is provided in Table 10.

All the average monthly deposits for the refineries subject to the Regulations were below the limits. On average, 95.5% of the required tests were reported, excluding the two refineries using deep-well injection for all of their wastewater. While two of the refineries reported all of the required tests, Newfoundland Processing Ltd. provided 82.2% of the required tests.

6.3 Performance of Refineries Subject to Guidelines

In 1992, the 21 refineries subject to the Guidelines complied 96.5% of the time with the monthly amounts, 99.9% of the time with the one-day amounts, and 99.5% of the time with the maximum daily amounts. Moose Jaw Asphalt was not assessed as its effluent was spread over land after municipal treatment. The Parkland refinery had no deposits and is therefore not accounted for in these statistics. A regional breakdown of compliance by parameter with the monthly limits set in the Guidelines is provided in Table 11.

Refineries in Ontario and Quebec Regions had the best level of performance, complying with the monthly amounts 100% of the time. Refineries in Pacific and Yukon Region are responsible for 71.8% of the times monthly amounts were exceeded. Sulfide is the parameter of most concern, followed closely by oil and grease, and total suspended matter. The limit most frequently met by refineries was the one for ammonia nitrogen. For refineries subject to the Guidelines, the monthly amounts were exceeded 13 times by 0 to 24%, five times by 25 to 49%, three times by 50 to 99%, seven times by 100 to 199%, and 11 times by more than 200%. Refineries subject to the Guidelines provided 74.4% of the requested tests.

Table 9 Overall Compliance of Refineries with Federal Regulations and Guidelines - 1992

Refinery	Performance				
	% of Time in Compliance			% of Tests Reported	Comments
	M	O	D		
Esso (Dartmouth)	98.3	99.9	99.7	100	
Ultramar (Dartmouth)	100	100	100	92.9	
Irving (St. John)	98.3	99.6	99.7	99.4	
Newfoundland Processing Ltd.	100	100	99.8	82.2	
Atlantic	99.2	99.9	99.8	93.7	
Petro-Canada (Montreal)	100	100	99.9	98.7	
Shell Canada (Montréal-Est)	100	100	100	100	
Ultramar (St-Romuald)	100	100	100	99.1	
Quebec	100	100	99.9	99.3	
Esso (Sarnia)	100	100	100	100	
Petro-Canada (Mississauga)	100	100	99.7	99.5	
Shell Canada (Corunna)	100	100	99.9	100	
Petro-Canada (Oakville)	100	100	100	100	
Suncor (Sarnia)	100	100	100	100	
Esso (Nanticoke)	100	100	100	99.7	
Novacor (Corunna)	100	100	100	98.5	
Ontario	100	100	99.9	99.7	
Moose Jaw (Moose Jaw)	ND	ND	ND	ND	Batch releases, off-site treatment
Parkland (Bowden)	ND	ND	ND	ND	No effluent discharge
CO-OP (Regina)	86.7	NR	91.7	7.2	Monthly averages only, off-site treatment
Esso (Norman Wells)	97.9	100	99.9	99.5	TSM not reported
Petro-Canada (Edmonton)	100	100	100	99.7	
Esso (Strathcona)	100	100	100	100	
Husky (Lloydminister)	ND	ND	ND	ND	Wastewater deep-well injected
Shell (Scotford)	100	100	100	100	Batch releases
Turbo (Balzac)	ND	ND	ND	ND	Wastewater deep-well injected
Prairie and Northern	96.9	100	99.9	85.3	Averages of the following refineries: Co-op, Esso (N.W.), Petro-Canada, Esso (Strath.), and Shell
Esso (Ioco)	100	100	100	26.4	Off-site treatment
Husky (Prince George)	95.0	100	98.5	23.3	Off-site treatment
Petro-Canada (Port Moody)	93.3	100	97.8	26.8	Off-site treatment
Shell Canada (Burnaby)	100	100	100	22.8	Batch releases, off-site treatment
Chevron (North Burnaby)	65.0	99.1	83.8	26.1	Off-site treatment
Pacific and Yukon	90.7	99.8	95.9	25.1	
NATIONAL	97.3	99.9	99.6	79.7	

M - Monthly amount
O - One-day amount
D - Maximum daily amount

NR - Not reported
ND - No deposit

Table 10 Regional Compliance of Average Monthly Amounts for 1992 with the Monthly Limits Set in Regulations

Region	Percentage of time in compliance (%)					
	Oil and Grease	Phenols	Sulfide	Ammonia Nitrogen	Total Suspended Matter	Average
Atlantic	100	100	100	100	100	100
Ontario	100	100	100	100	100	100
Prairie and Northern	100	100	100	100	100	100
Average	100	100	100	100	100	

Table 11 Regional Compliance of Average Monthly Amounts for 1992 with the Monthly Limits Set in Guidelines

Region	Percentage of time in compliance (%)					
	Oil and Grease	Phenols	Sulfide	Ammonia Nitrogen	Total Suspended Matter	Average
Atlantic	97.2	97.2	100	100	100	98.9
Quebec	100	100	100	100	100	100
Ontario	100	100	100	100	100	100
Prairie and Northern	86.1	100	97.2	100	87.5	94.6
Pacific and Yukon	91.7	91.7	81.7	98.3	90.0	90.7
Average	95.2	97.3	94.8	99.6	95.8	

6.4 Trends in National Performance (1975 to 1992)

Overall, the national performance of refineries has been gradually improving since 1980. Canadian refineries complied with the monthly amounts 91% of the time in 1980, 92% in 1983, 94% in 1987, and 97% in 1992.

The national average monthly deposits for the year (expressed as kg/1000 m^3 of crude oil) from 1975 to 1992 are presented in Figures 57 to 61. Levels of deposits continued to decrease in 1992 with all parameters improving from levels in 1987, except for sulfide which remained at almost the same level. Since 1980, the average monthly deposits for the year have been below the weighted levels stipulated in the Regulations and Guidelines for all parameters.

6.5 National Deposits - 1992

Although the federal Regulations and Guidelines limit the deposits of five contaminants on a production basis, the net deposits (kg/day) were calculated to indicate the amount of contaminants discharged into the environment by the petroleum refining industry. The total deposits discharged into the various receiving waters in 1992 are provided in Table 12. Municipal sewers received the highest deposits of oil and grease, phenols, and sulfides, which is partly due to the large deposits by the Chevron and the Co-op refineries. The Little River in St. John received the same amount of oil and grease as the municipal sewers and the largest amount of ammonia nitrogen. The three refineries in Quebec, the only ones

Table 12 Deposits in Receiving Waters

Receiving Water	Number of Refineries	Average Monthly Deposits (kg/d) Oil and Grease	Phenols	Sulfide	Ammonia Nitrogen	Total Suspended Matter
Halifax Harbour	2	118	4.6	0.02	45	294
Little River	1	320	5.9	3.2	76	434
Placentia Bay	1	47	1.2	0.47	64	130
St. Lawrence River	3	163	3.4	1.3	69	754
St. Clair River	4	22	0.48	1.3	28	387
Lake Ontario	2	30	0.12	0.83	21	181
Lake Erie	1	10	0.02	0.28	0.81	22
North Saskatchewan River	3	30	0.24	1.8	9.1	139
Mackenzie River	1	4.1	0.02	0.02	0.30	NR
Burrard Inlet	1	4.6	0.05	0.26	3.3	34
Fraser River	1	3.4	0.07	0.09	6.2	28
Municipal Sewers	4	320	12.4	8.8	66	720
Total	24	1073	28	18	389	3123

NR - Not reported

discharging directly into the St. Lawrence River, deposited the largest amount of total suspended matter.

The national average monthly deposits of the parameters from 1975 to 1992 are presented in Table 13. As shown, there has been a general downward trend. Since 1980, the discharge levels of contaminants have been reduced ranging from 60% for total suspended matter to 86% for phenols. When the 1992 deposits are compared to the 1987 levels, reductions range from 12% for oil and grease to 64% for phenols.

Table 14 presents a regional breakdown by contaminant of the contribution to national deposits as compared to the national reference crude rate. The following findings are derived from a comparison of the percent contribution to the national deposits and the percent contribution to the national reference crude rates (RCR). In Atlantic Region, percent deposits are higher than percent RCR for oil and grease, phenols, and ammonia nitrogen; in Quebec Region, percent deposits are lower than RCR for all parameters except total suspended matter; in Ontario Region, percent deposits are lower than RCR for all parameters; in Prairie and Northern Region, percent deposits are lower than RCR for all parameters; and in Pacific and Yukon Region, percent deposits are higher than RCR for all parameters.

Table 13 Summary of Total National Average Monthly Deposits - Regulated Parameters

Parameter	Average Monthly Deposits (kg/d)						1992 Percentage Reduction since	
	1975	1977	1980	1983	1987	1992	1980	1987
Oil and Grease	9000	6000	2980	1923	1080	955	68	12
Phenols	900	900	200	97	77	28	86	64
Sulfide	3400	900	50	63	21	17	66	19
Ammonia Nitrogen	6700	3500	1533	1205	726	358	77	51
Total Suspended Matter	15900	15900	7175	5154	4039	2843	60	30
Total	35900	27200	11938	8442	5943	4201	65	29
Reference Crude Rate (1000 m^3/d)	320	320	320	256	248	259	19	-4

Table 14 Percent Reference Crude Rate Compared to National Deposits - 1992

	Percent of National Deposits				
	Atlantic	Quebec	Ontario	Prairie and Northern	Pacific and Yukon
Reference Crude Rate (%)	21	19	28	23	9
Deposits (%)					
Oil and Grease	***28***	16	5	23	***28***
Phenols	***28***	12	2	11	***47***
Sulfide	15	6	13	16	***50***
Ammonia Nitrogen	***30***	17	8	12	***33***
Total Suspended Matter	19	***25***	13	12	***31***
Average	24	15	8	15	38

* The numbers in bold italics indicate the parameters that exceed the percent of national RCR in each region.

6.6 Comparison of 1992 Annual Deposits by Region

Regional monthly deposits for all parameters in kg/1000 m^3 are provided in Figures 62 to 67. The highest average monthly deposits (kg/1000 m^3) for 1992 of phenols, sulfide, and total suspended matter were in the Pacific and Yukon Region, while the highest deposits of oil and grease and ammonia nitrogen occurred in the Atlantic Region. The lowest average monthly deposits for oil and grease, phenols, and ammonia nitrogen occurred in Ontario Region, in Quebec Region for sulfide, and in Prairie and Northern Region for total suspended matter. For pH, limits were adhered to in Quebec, Ontario, and Prairie and Northern Regions; the upper limit was exceeded in Atlantic Region. In Pacific and Yukon Region, the upper limit was exceeded and the lower limit was not met.

Regional average monthly deposits for 1992 in kg/day are provided in Figures 68 to 72. The highest average monthly deposits, except for phenols and sulfide, occurred in the Atlantic Region. The highest monthly deposits for phenols and sulfides were in the Pacific and Yukon Region. The lowest deposits for oil and grease, and phenols occurred in Ontario Region, and in Quebec, Pacific and Yukon, and Prairie and Northern Regions for sulfide, ammonia nitrogen, and total suspended matter, respectively.

6.7 Relative Refinery Toxic Load

In order to assess the toxic waste discharged by the petroleum refineries, a toxic waste indicator developed by Environment Canada (Environment Canada, 1992) was applied to each refinery effluent. The toxic waste indicator, called the Chimiotox Index, is used to determine the physicochemical characterization of toxic contaminants in the overall evaluation of a given effluent. Toxic weighting is applied to each pollutant and the sum of Chimiotox units for the individual parameters gives the toxic effluent load.

The toxic weighting factor (Ftox) is obtained using the following formula:

$$Ftox_i = \frac{1\ mg/L}{MSC_i\ mg/L}$$

where, $Ftox_i$	=	toxic weighting factor for parameter i
1 mg/L	=	arbitrary reference
MSC_i	=	most stringent water quality criterion for parameter i

The Ftox of four of the five parameters in the Petroleum Refinery Effluent Regulations and Guidelines was determined as:

Oil and grease	100
Phenols	200
Sulfide	500
Ammonia	0.8

Parameters such as TSM, BOD, and COD do not have a toxic weighting factor as they are not specific substances and are considered "embodied parameters".

Chimiotox units (UC) are calculated by multiplying the pollution load by its toxic weighting factor.

$$Uc_i = load_i \times Ftox_i$$

UC_i	=	Chimiotox unit of parameter i
$Load_i$	=	amount of parameter i discharged (kg/d)
$Ftox_i$	=	toxic weighting factor for parameter i

The sum of the calculated Chimiotox units for an individual effluent gives the Chimiotox Index. The results of the Chimiotox Index allow total toxic load for the regulated parameters from individual Canadian refineries to be compared (Figure 73). In order to take into account the relative size of the refinery, the Chimiotox Index was also calculated using discharges expressed in kg/1000 m^3 of crude oil (Figure 74). The results of individual oil refinery effluents can also be combined to give the relative regional toxic load as shown in kg/day in Figure 75 and in kg/1000 m^3 in Figure 76.

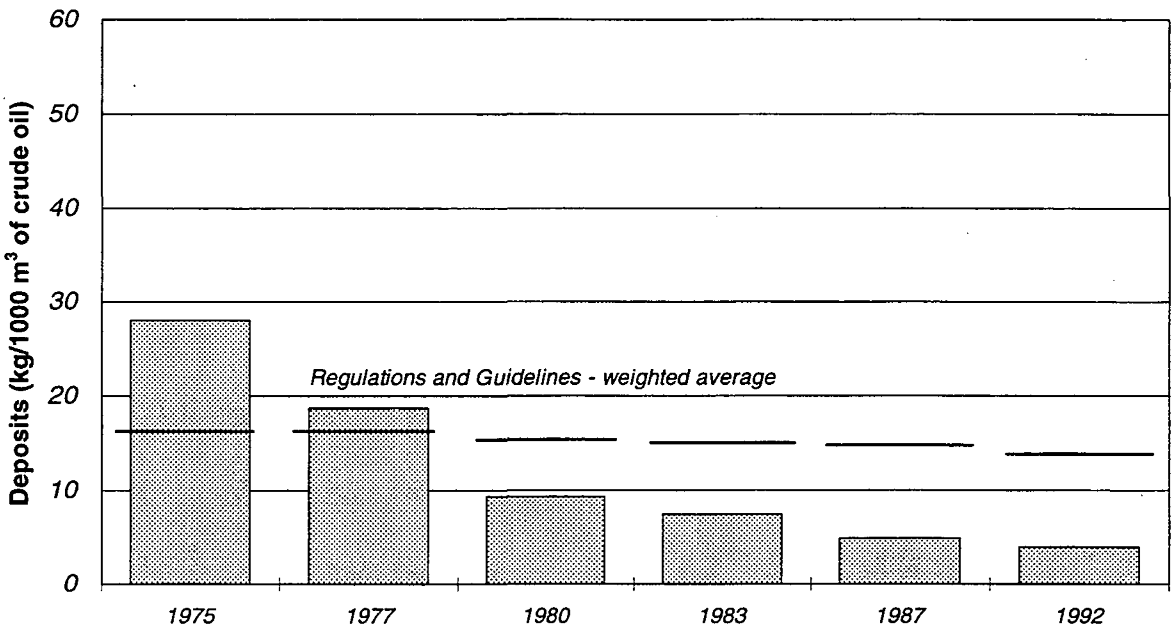


Figure 57 **Oil and Grease - National 1975 to 1992**

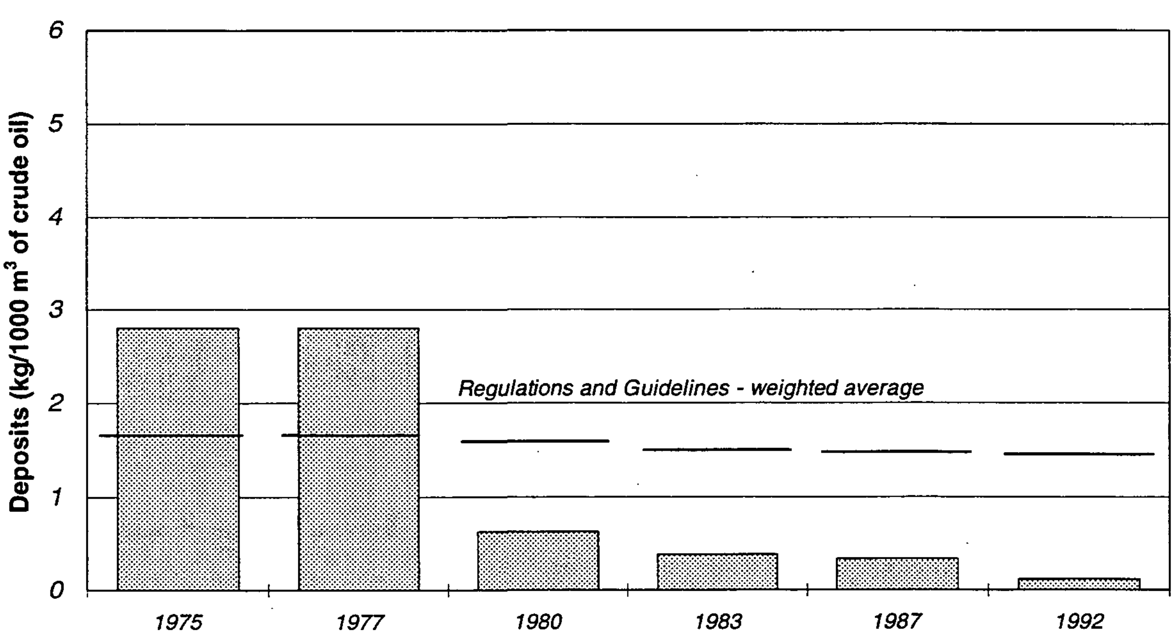


Figure 58 **Phenols - National 1975 to 1992**

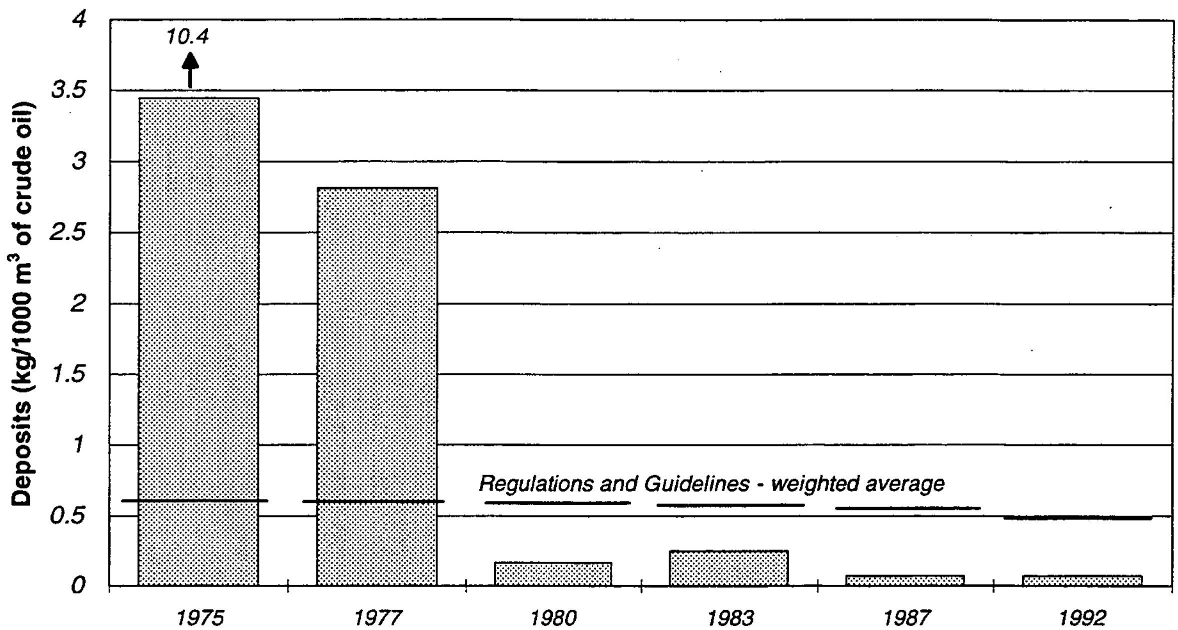


Figure 59 Sulfide - National 1975 to 1992

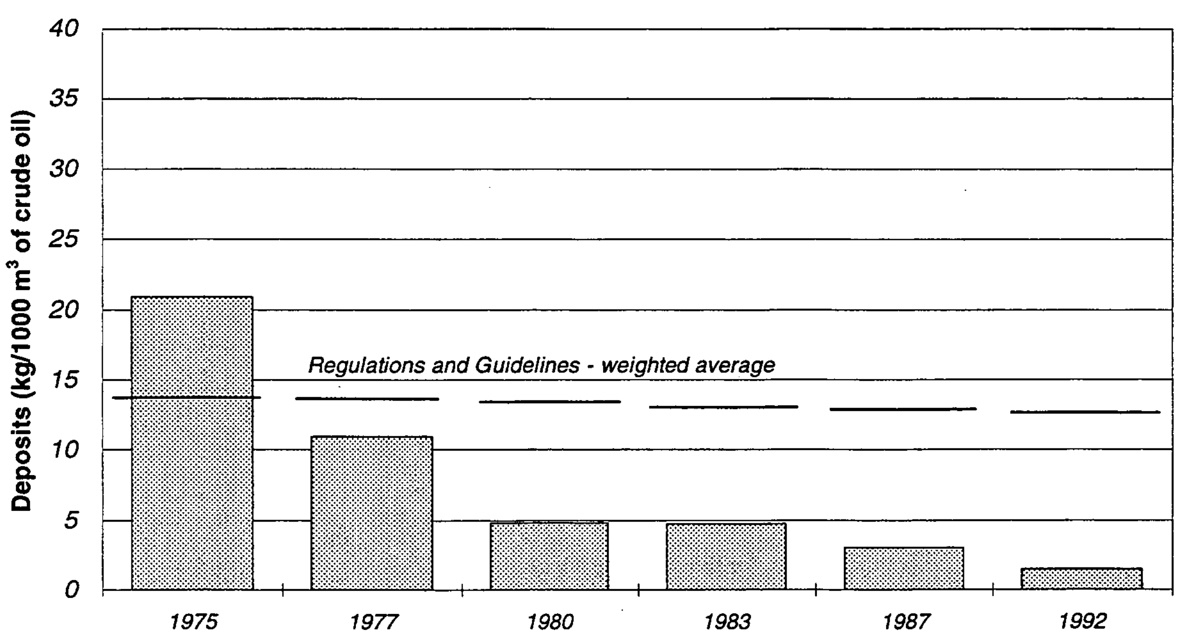


Figure 60 Ammonia Nitrogen - National 1975 to 1992

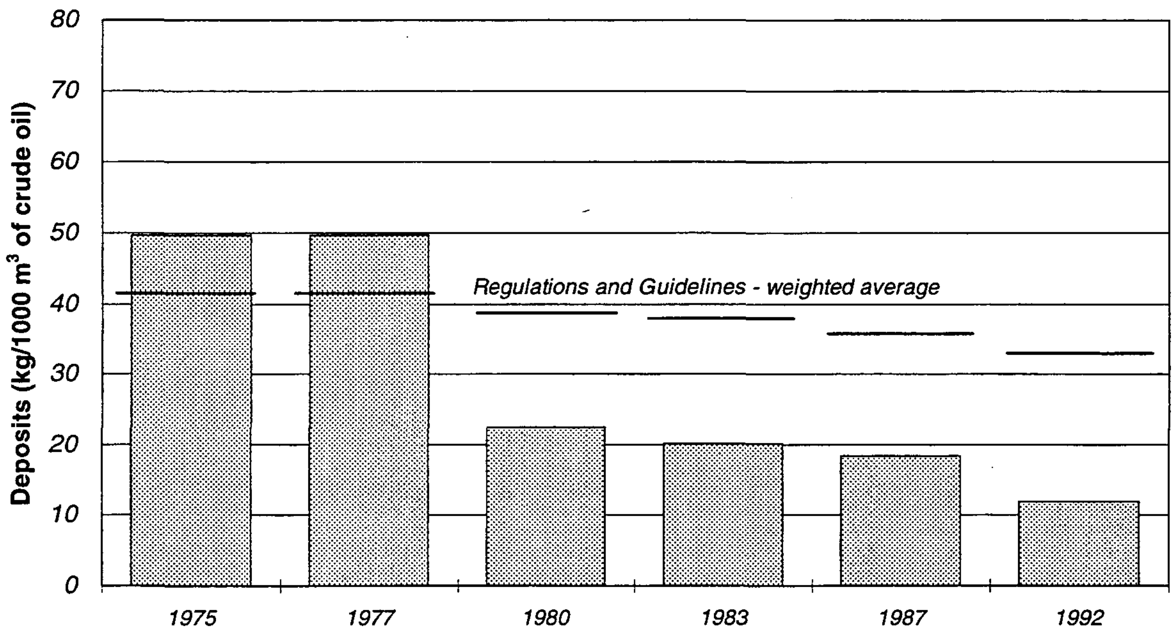


Figure 61 **Total Suspended Matter - National 1975 to 1992**

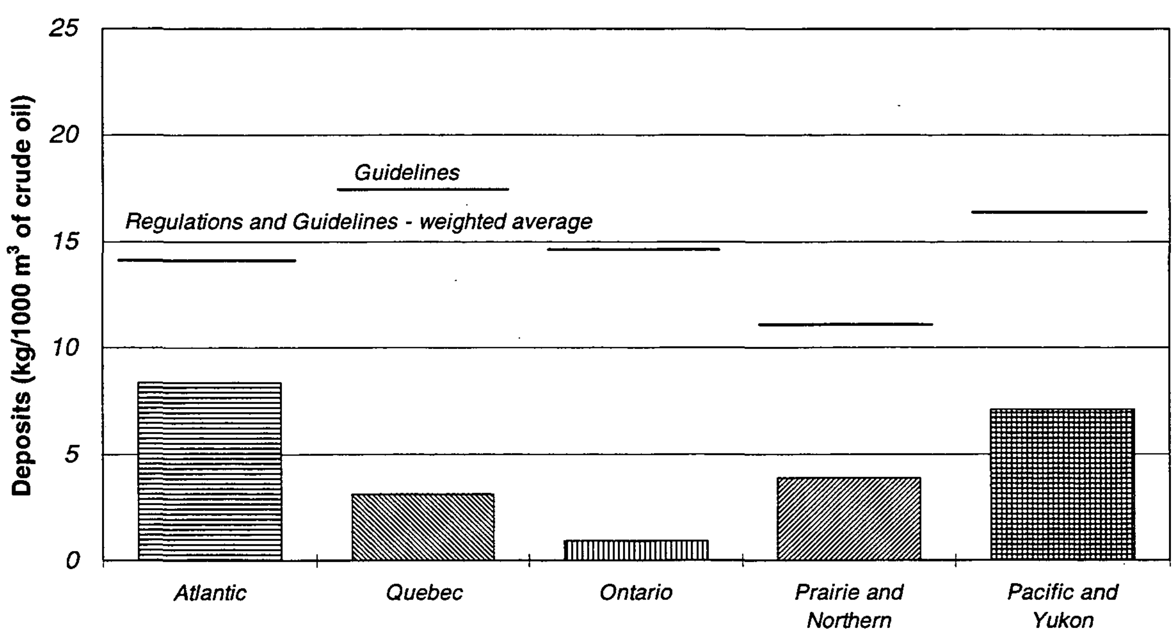


Figure 62 **Regional Oil and Grease Deposits 1992**

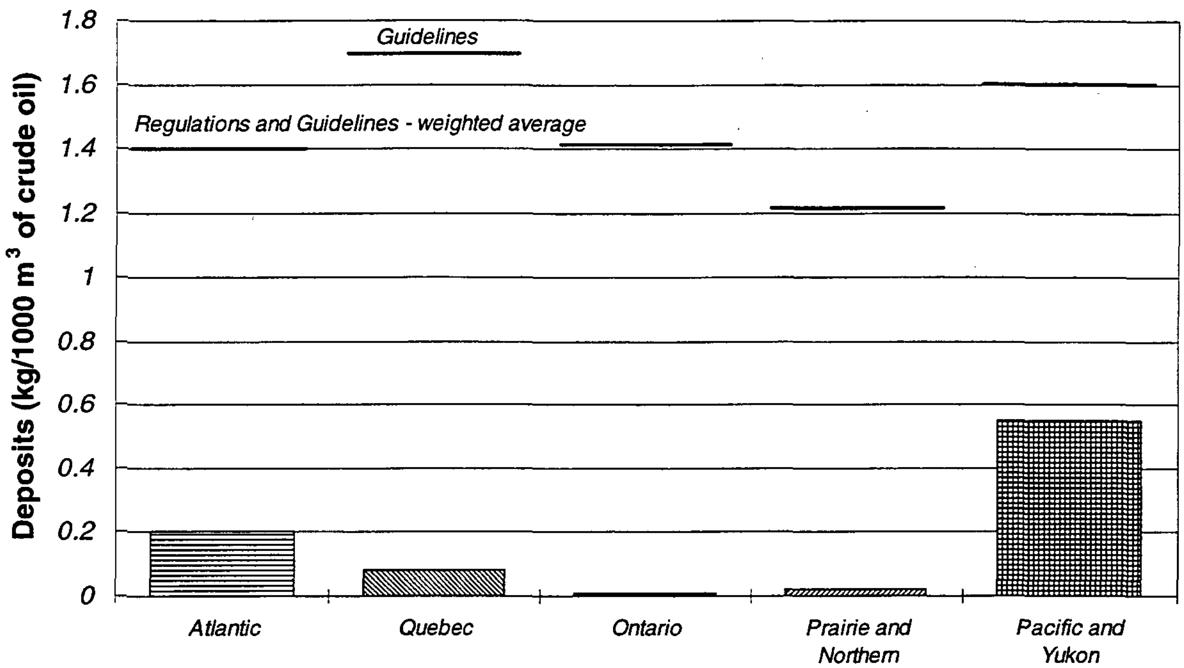


Figure 63 Regional Phenols Deposits 1992

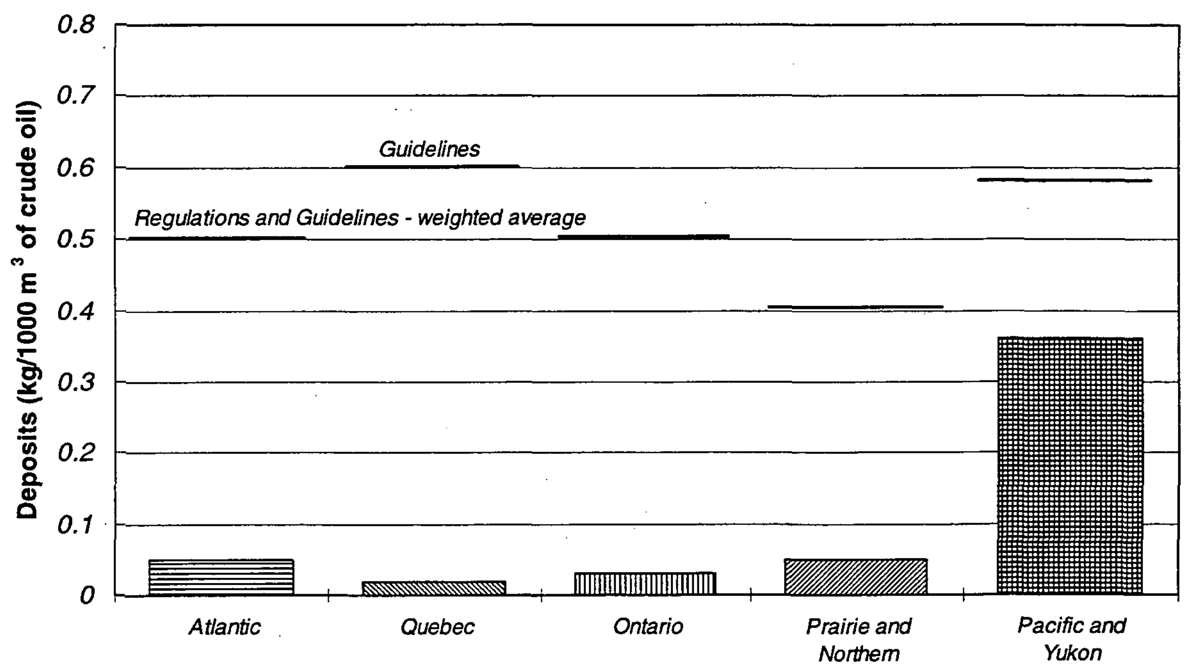


Figure 64 Regional Sulfide Deposits 1992

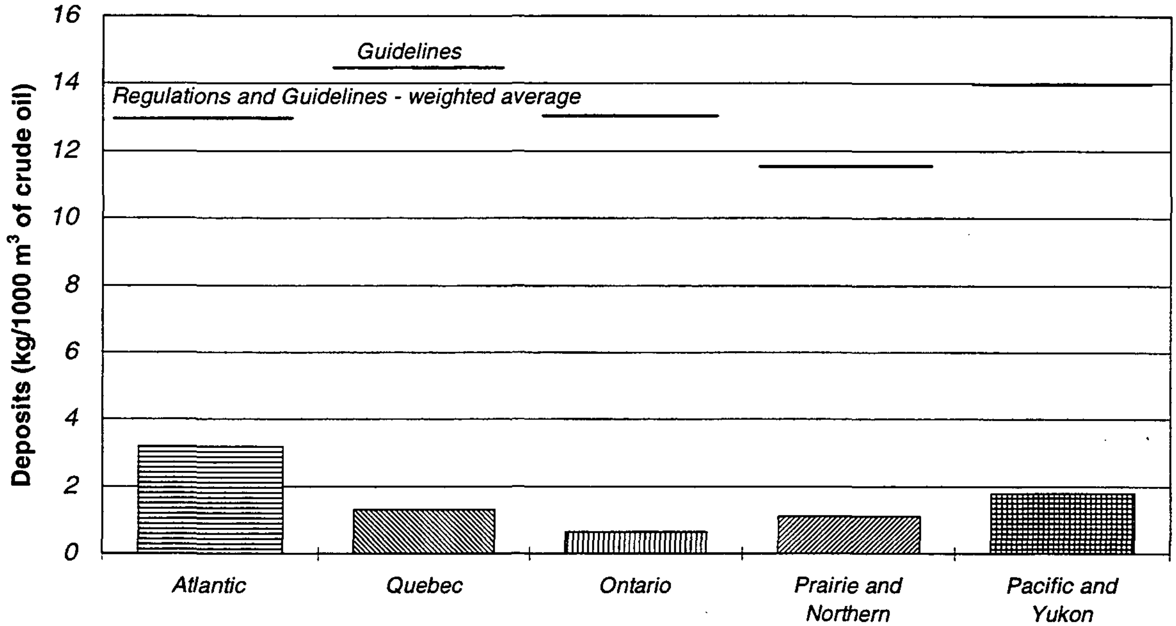


Figure 65 Regional Ammonia Nitrogen Deposits 1992

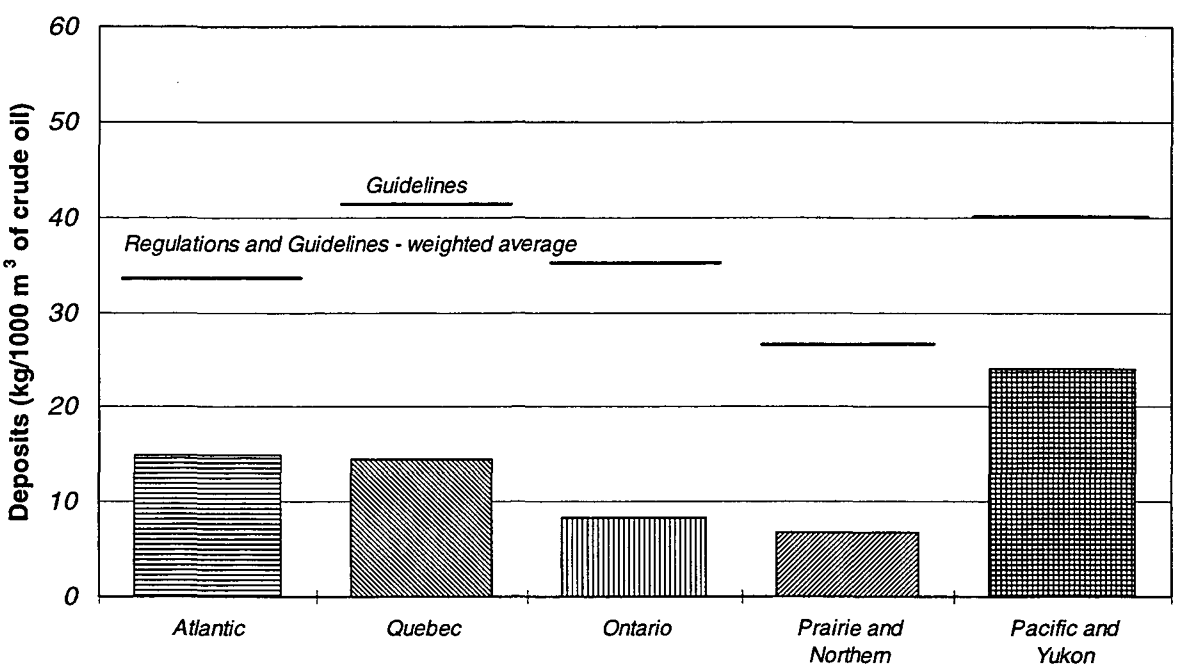


Figure 66 Regional Total Suspended Matter Deposits 1992

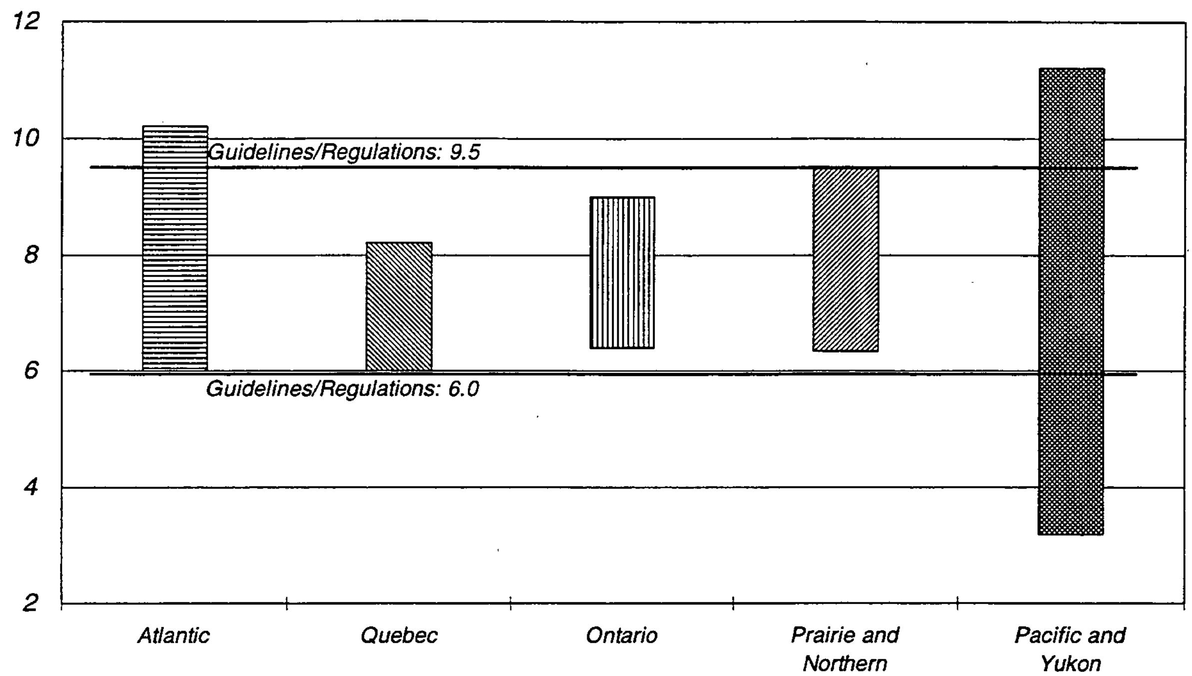


Figure 67 Regional pH Levels 1992

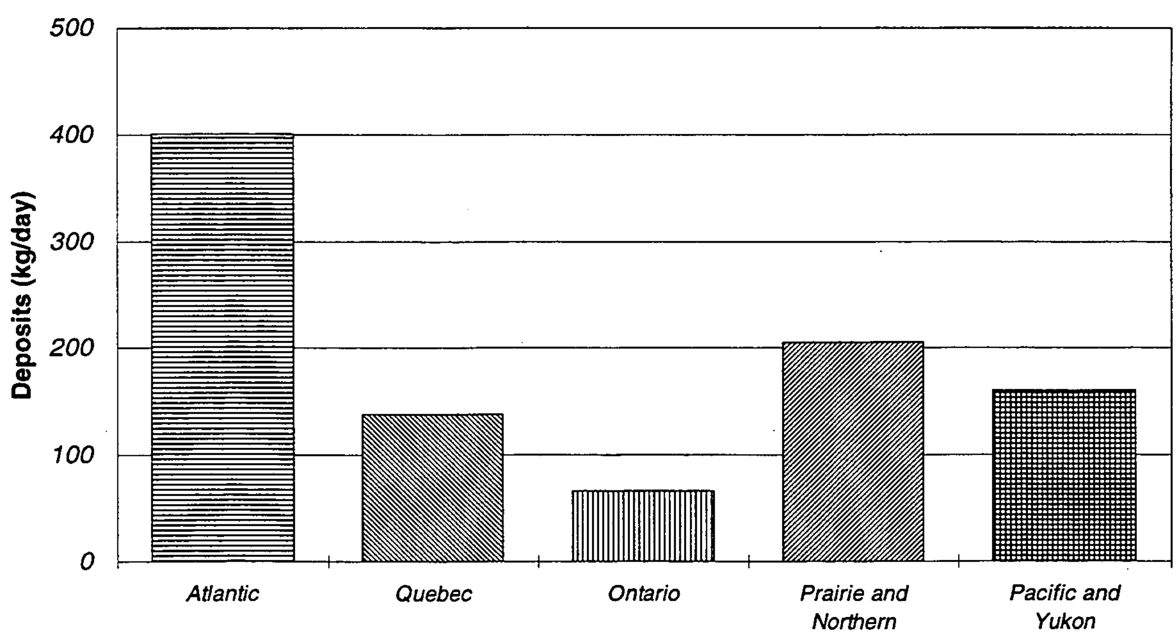


Figure 68 Oil and Grease - Regional Deposits (kg/day) 1992

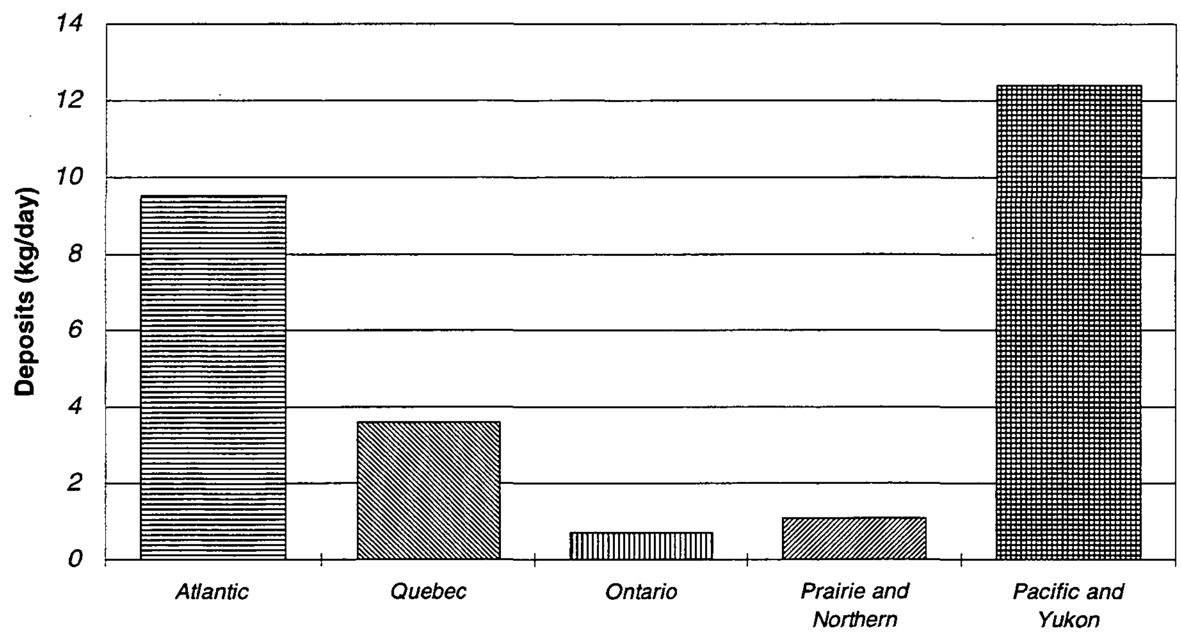


Figure 69 **Phenols - Regional Deposits (kg/day) 1992**

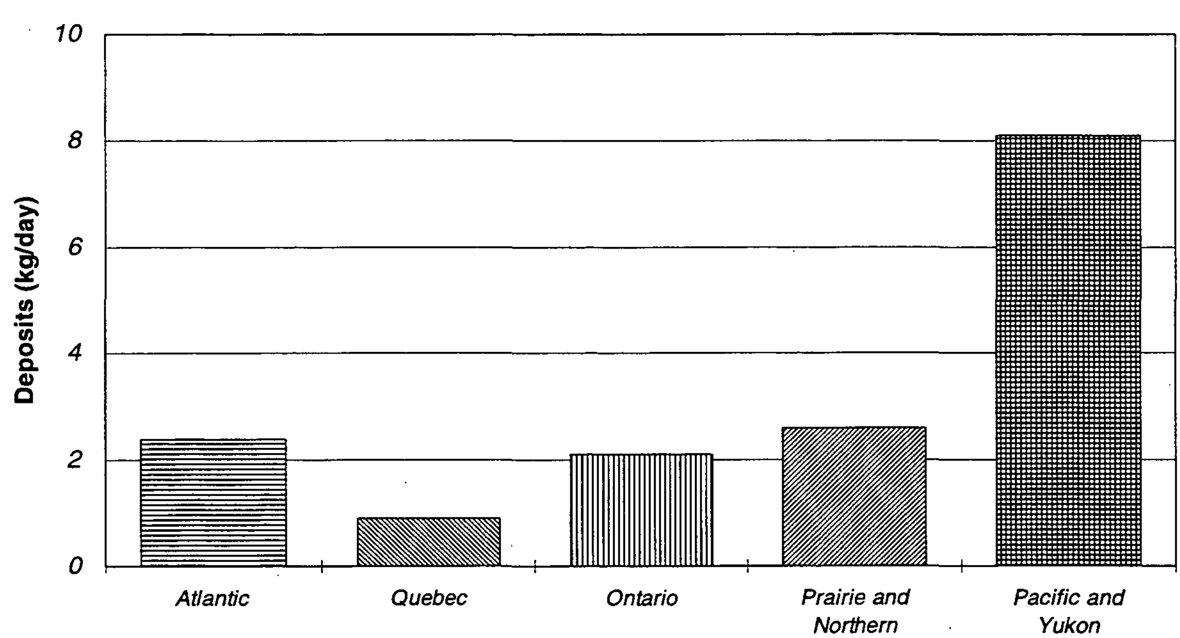


Figure 70 **Sulfide - Regional Deposits (kg/day) 1992**

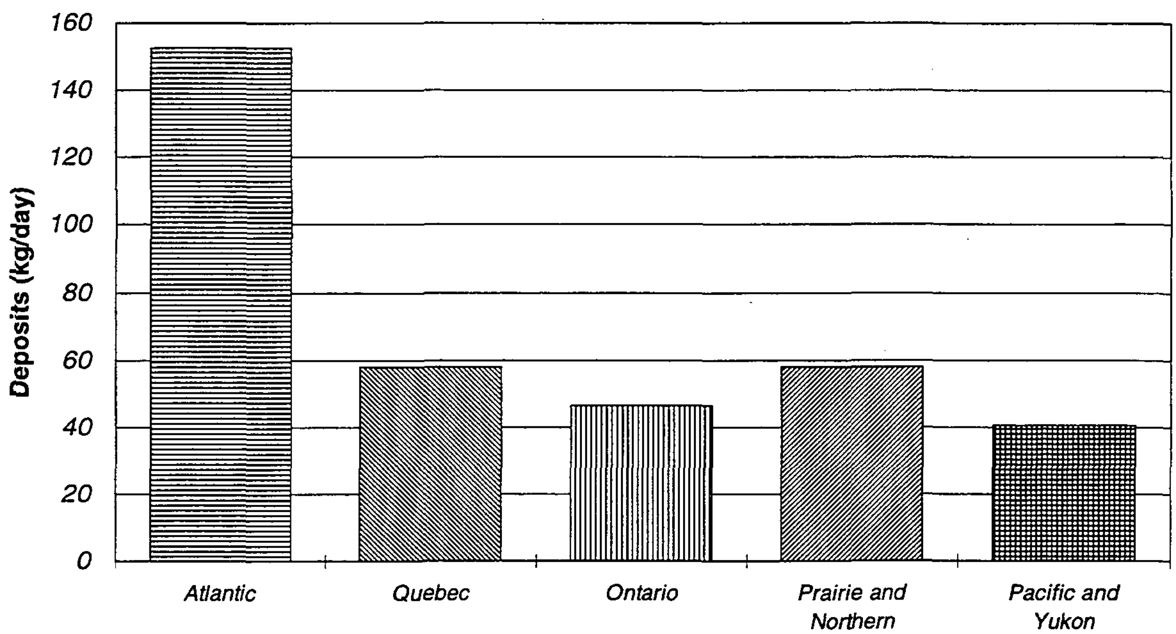


Figure 71 **Ammonia Nitrogen - Regional Deposits (kg/day) 1992**

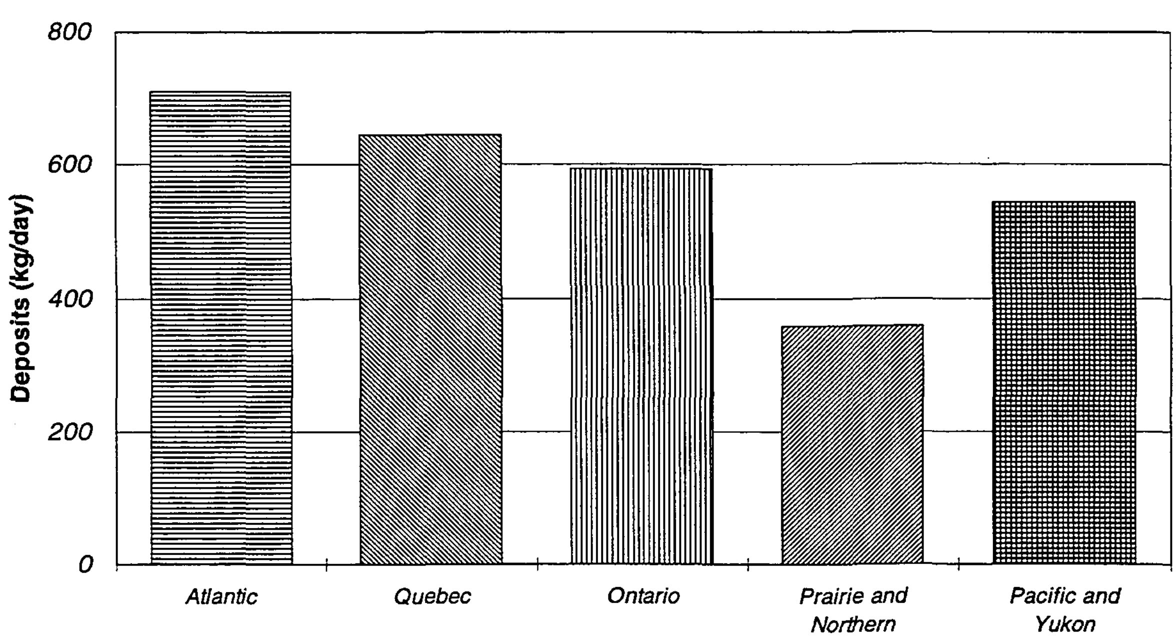
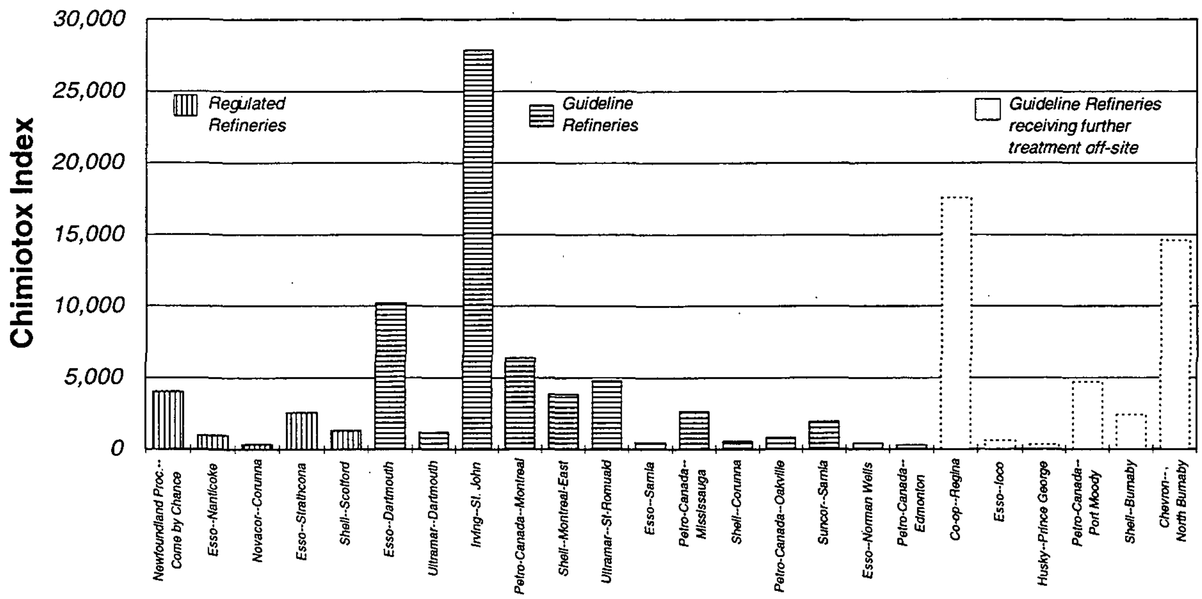
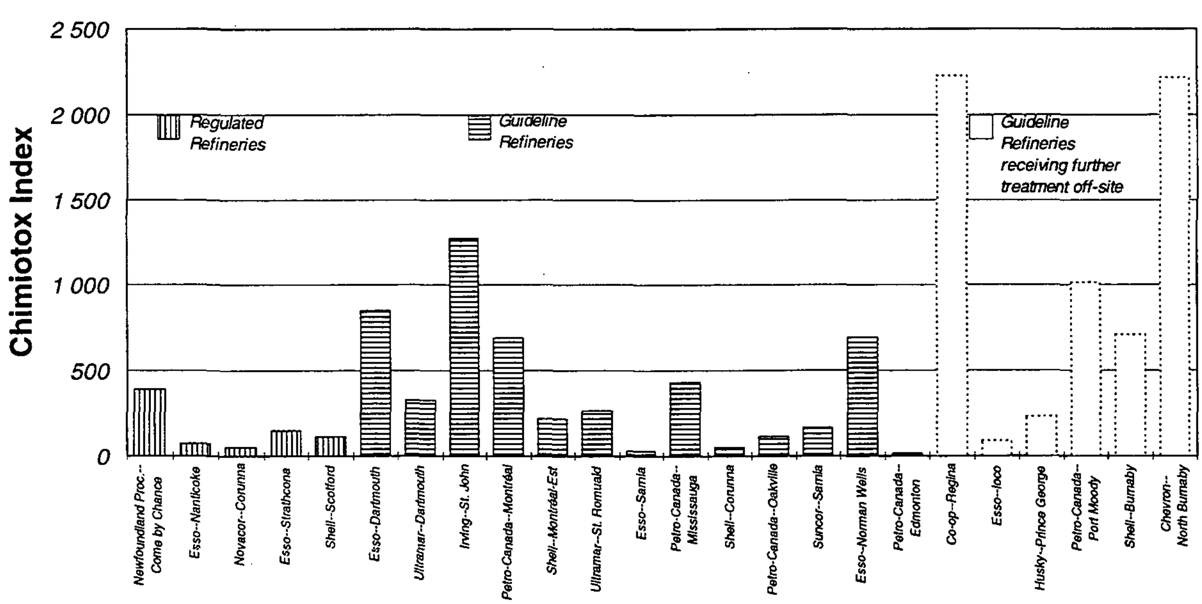


Figure 72 **Total Suspended Matter - Regional Deposits (kg/day) 1992**



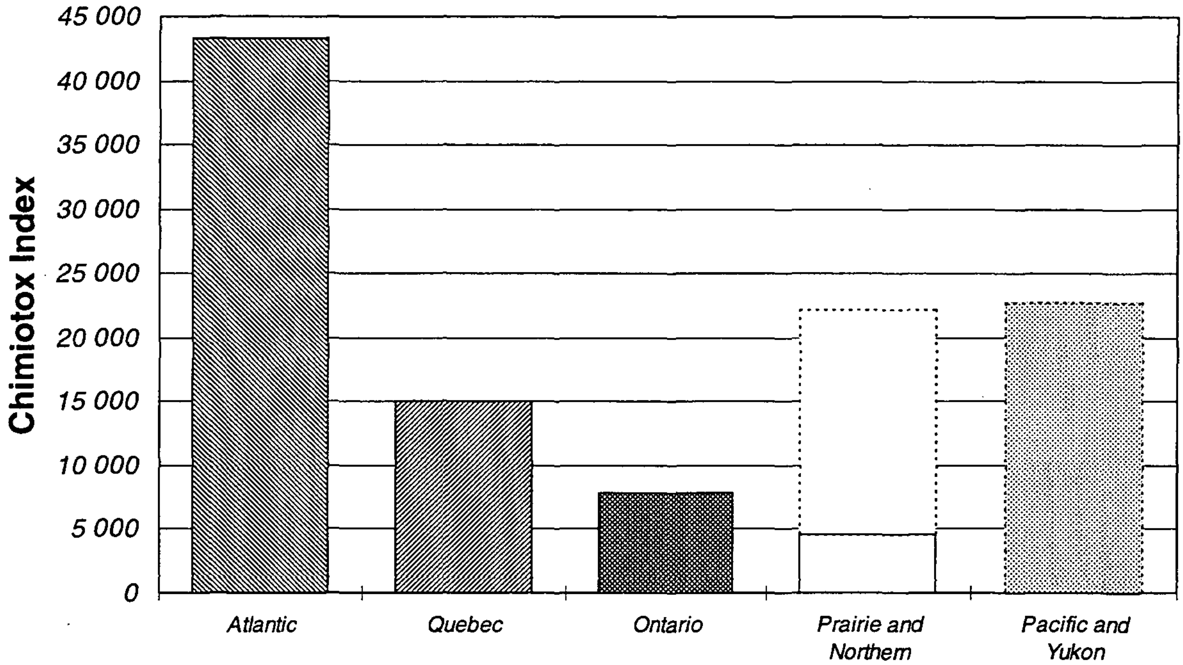
Note: The dotted outline represents the possible range of discharge to surface water bodies due to refineries with off-site treatment facilities.

Figure 73 Refinery Toxic Load (kg/day) 1992



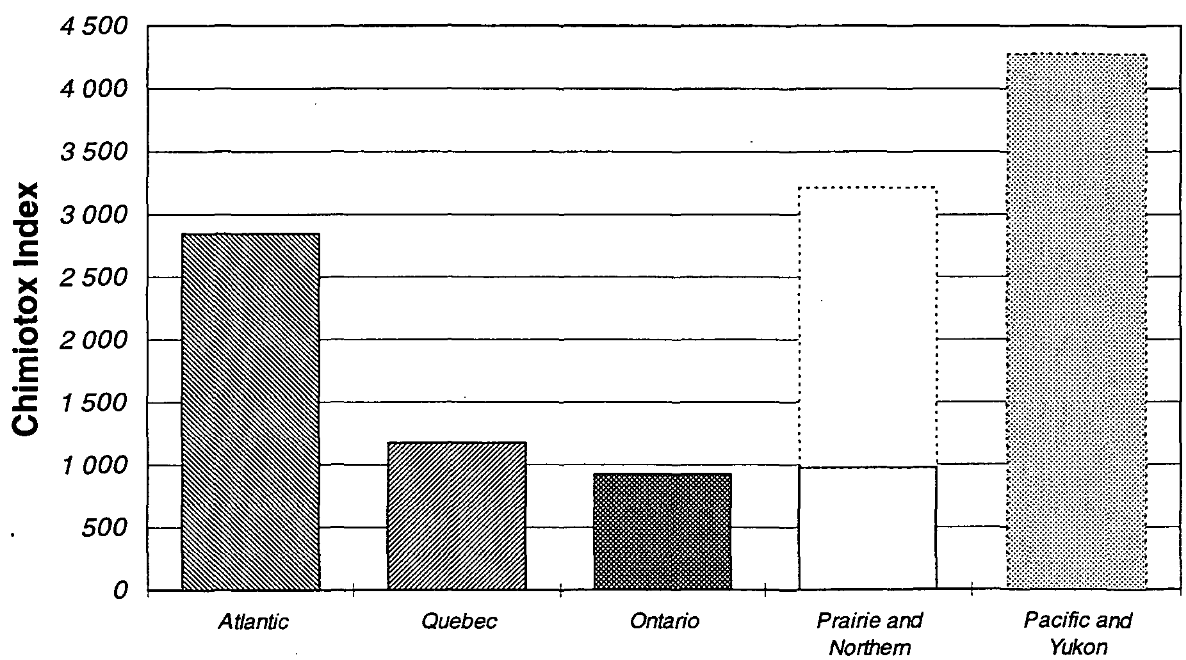
Note: The dotted outline represents the possible range of discharge to surface water bodies due to refineries with off-site treatment facilities.

Figure 74 Refinery Toxic Load (kg/1000 m³ of crude oil) 1992



Note: The dotted outline represents the possible range of discharge to surface water bodies due to refineries with off-site treatment facilities.

Figure 75 Regional Refinery Toxic Load (kg/day) 1992



Note: The dotted outline represents the possible range of discharge to surface water bodies due to refineries with off-site treatment facilities.

Figure 76 Regional Refinery Toxic Load (kg/1000 m^3 of crude oil) 1992

Conclusions and Recommendations

Canadian refineries are to be commended for their performance in complying with the Regulations and Guidelines and for continuously improving the quality of effluent discharges. The following conclusions and recommendations are based on information from Environment Canada Regional Annual Reports, explanations given by the oil refineries on problems encountered in operating their wastewater treatment systems, and available pollution abatement technologies. No detailed feasibility studies were done and economic and legislative limitations or local requirements were not considered.

7.1 Conclusions

1) In general, the refineries continue to improve the quality of their effluent from year to year. Some existing refineries still exceed the Guideline limits (monthly amount, one-day amount, and maximum daily amount) for certain parameters. Refineries subject to the Regulations are generally improving - they benefit from the most up-to-date wastewater treatment technology. Only a few of these refineries exceed the limits in the Regulations.

2) Since 1975, the net discharges of all the parameters have generally decreased. Compared to the 1987 levels, reductions in 1992 range from 11% for oil and grease to 62% for phenols.

3) Most of the refineries have a secondary treatment system or send their effluents off-site for further treatment. It is difficult to assess to what extent the refineries using off-site treatment benefit from these systems as no data are available from the refineries. Since the refineries that send their effluent to off-site treatment have not obtained authorization from Environment Canada, their performance was assessed at the refinery fence.

4) Under good operating conditions, the existing wastewater treatment systems at the refineries should easily meet the limits prescribed in the federal Regulations and Guidelines and attain levels well below the limits.

5) The limits defined in the Regulations and Guidelines are usually exceeded when there are problems or mechanical deficiencies in the wastewater treatment system. Sixty percent of the monthly exceedances can be attributed to oil and grease and sulfides, and one refinery alone is responsible for 53% of the monthly exceedances.

7.2 Recommendations

1) Under the provisions of the federal Petroleum Refinery Effluent Regulations and Guidelines, the refineries must report **all** required tests. It should be noted that, even though the provincial reporting requirements may be different from the federal requirements, **both** requirements must be met. To meet the stricter federal requirements, reporting must be improved in the two western regions.

2) The refineries must also declare a revised Reference Crude Rate when the arithmetic mean of the streamday crude rates during two consecutive months is less than 85% of the last RCR declared.

3) Wastewater treatment systems must be maintained in good operating condition and optimized to remove traditional and organic priority pollutants. To achieve this goal, it is suggested that training (or refresher) courses be provided to operators of the wastewater treatment system and that operating conditions be defined to optimize removal of biodegradable priority pollutant compounds.

4) The federal Petroleum Refinery Effluent Regulations and Guidelines should be reviewed and updated to reflect changes in the industry, current analytical methodology, and changes in focus towards toxic chemicals. Refineries subject to the Guidelines have had 20 years to upgrade their refinery processes, lower their water usage, and operate their wastewater treatment systems efficiently. These refineries could now comply with the regulatory limits without significant problems.

References

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APHA (American Public Health Association), *Standard Methods for the Examination of Water and Wastewater*, 13th edition, published jointly by the American Health Association, American Water Works Association, and the Water Pollution Control Federation (1971).

Environment Canada and Ministère de l'Environnement du Québec, "St. Lawrence Action Plan", CHIMIOTOX, Equipe d'intervention Saint-Laurent Technical Services (September, 1992).

Environment Canada, "Petroleum Refinery Effluent Regulations and Guidelines", Water Pollution Control Directorate, report EPS-1-WP-74-1 (January, 1974).

Federal Government, *Access to Information Act*, R.S.C. 1985, Chap. A-1 (1985).

Fisheries and Oceans Canada, *Fisheries Act*, R.S.C. 1985, Chap. F-14 (1985).

Appendix A

Deposits and Compliance Assessment by Regions

Table A-1 Deposits and Compliance Assessment - Atlantic Region

		Refinery					
		Esso Dartmouth			Ultramar Dartmouth		
A. DEPOSITS (All guidelines and regulated deposits are for monthly averages.)							
Yearly average of daily deposits (kg/1000 m^3 of crude oil)	Guideline *Deposits* Esso, Ultramar	Actual *Deposits*			Actual *Deposits*		
Oil and Grease	17.1	8.0			2.5		
Phenols	1.7	0.24			0.40		
Sulfide	0.6	0.00			0.00		
Ammonia Nitrogen	14.3	3.2			0.70		
Total Suspended Matter	41.1	20.0			6.1		
B. COMPLIANCE ASSESSMENT							
a)	Number of deposits in excess of limits set in Guidelines/Regulations	M	O	D	M	O	D
	Oil and Grease	1	0	2	0	0	0
	Phenols	0	0	0	0	0	0
	Sulfide	0	0	0	0	0	0
	Ammonia Nitrogen	0	0	0	0	0	0
	Total Suspended Matter	0	1	2	0	0	0
	pH			0			0
	Toxicity			0			0
	Total	1	1	4	0	0	0
	Percentage by Region	50.0	25.0	40.0	0	0	0
	Percentage of time in compliance	98.3	99.9	99.7	100	100	100
b)	Number of Monthly Amounts exceeding the limits by:						
	0 to 24%	1			0		
	25 to 49%	0			0		
	50 to 99%	0			0		
	100 to 199%	0			0		
	Over 200%	0			0		
M: Monthly Amount; O: One-day Amount; D: Maximum Daily Amount							
	Actual Crude Rate (1000 m^3/day)	12.0			3.5		
	Reference Crude Rate (1000 m^3/day)	11.6			3.4		
	Status	Existing			Existing		
	Number of months in operation	12			12		
	Number of tests reported	1163			1081		

	Irving St. John			Newfoundland Processing Ltd. Come by Chance			Region	
Guidelines Deposits	Actual Deposits		Regulated Deposits	Actual Deposits		Average Authorized Deposits	Average Actual Deposits	
14.7	11.8		8.6	3.5		14.0	8.4	
1.5	0.20		0.9	0.08		1.4	0.20	
0.5	0.10		0.3	0.04		0.5	0.05	
13.2	2.8		10.3	4.7		12.8	3.2	
35.3	16.0		20.6	9.6		33.6	14.9	
M	O	D	M	O	D	M	O	D
0	1	1	0	0	0	1	1	3
1	1	1	0	0	0	1	1	1
0	0	0	0	0	0	0	0	0
0	1	1	0	0	0	0	1	1
0	0	0	0	0	1	0	1	3
		0			1			1
		1			0			1
1	3	4	0	0	2	2	4	10
50.0	75.0	40.0	0	0	20.0			
98.3	99.6	99.7	100	100	99.8	99.2	99.9	99.8
1			0			2		
0			0			0		
0			0			0		
0			0			0		
0			0			0		
	21.9			10.3			47.7	
	27.1			12.3			54.4	
	Existing 13.2 + Expanded 13.9			New			Existing 44.2 + Expanded 13.9 + 12.3 New	
	12			12				
	1156			935			4335	

Table A-2 Deposits and Compliance Assessment - Quebec Region

		Refinery					
		Petro-Canada Montréal			Shell Montréal-Est		
A. DEPOSITS (All guidelines and regulated deposits are for monthly averages.)							
Yearly average of daily deposits (kg/1000 m³ of crude oil)	Guideline Deposits Petro-Canada, Shell, Ultramar	Actual Deposits			Actual Deposits		
Oil and Grease	17.1	6.2			2.1		
Phenols	1.7	0.23			0.02		
Sulfide	0.6	0.04			0.01		
Ammonia Nitrogen	14.3	3.4			0.49		
Total Suspended Matter	41.1	25.8			12.0		
B. COMPLIANCE ASSESSMENT							
a)	Number of deposits in excess of limits set in Guidelines/Regulations	M	O	D	M	O	D
	Oil and Grease	0	0	1	0	0	0
	Phenols	0	0	0	0	0	0
	Sulfide	0	0	0	0	0	0
	Ammonia Nitrogen	0	0	0	0	0	0
	Total Suspended Matter	0	0	0	0	0	0
	pH			0			0
	Toxicity			0			0
	Total	0	0	1	0	0	0
	Percentage by Region	0	0	100	0	0	0
	Percentage of time in compliance	100	100	99.9	100	100	100
b)	Number of Monthly Amounts exceeding the limits by:						
	0 to 24 %	0			0		
	25 to 49 %	0			0		
	50 to 99 %	0			0		
	100 to 199 %	0			0		
	Over 200 %	0			0		
M: Monthly Amount; O: One-day Amount; D: Maximum Daily Amount							
	Actual Crude Rate (1000 m³/day)	9.3			17.4		
	Reference Crude Rate (1000 m³/day)	12.5			17.5		
	Status	Existing			Existing		
	Number of months in operation	12			12		
	Number of tests reported	1148			1163		

Ultramar St. Romuald			Region		
Actual Deposits			Average Actual Deposits		
2.4			3.1		
0.06			0.08		
0.03			0.02		
1.0			1.3		
11.2			14.5		
M	*O*	*D*	*M*	*O*	*D*
0	0	0	0	0	1
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0
		0			0
		0			0
0	0	0	0	0	1
0	0	0			
100	100	100	100	100	99.9
0			0		
0			0		
0			0		
0			0		
0			0		
17.8			44.5		
18.8			48.8		
Existing			Existing		
12					
1153			3464		

Table A-3 Deposits and Compliance Assessment - Ontario Region

		Refinery		
		Esso Sarnia	Petro-Canada Mississauga	Shell Corunna
A. DEPOSITS	(All guidelines and regulated deposits are for monthly averages.)			
Yearly average of daily deposits (kg/1000 m³ of crude oil)	Guideline Deposits Esso Sarnia, P.C. Miss., Shell	Actual Deposits	Actual Deposits	Actual Deposits
Oil and Grease	17.1	0.22	4.1	0.50
Phenols	1.7	0.02	0.01	0.01
Sulfide	0.6	0.02	0.05	0.00
Ammonia Nitrogen	14.3	0.70	0.86	0.03
Total Suspended Matter	41.1	11.3	20.5	9.7

B. COMPLIANCE ASSESSMENT

a) Number of deposits in excess of limits set in Guidelines/Regulations	Esso M	Esso O	Esso D	Petro-Canada M	Petro-Canada O	Petro-Canada D	Shell M	Shell O	Shell D
Oil and Grease	0	0	0	0	0	1	0	0	0
Phenols	0	0	0	0	0	0	0	0	0
Sulfide	0	0	0	0	0	0	0	0	0
Ammonia Nitrogen	0	0	0	0	0	0	0	0	0
Total Suspended Matter	0	0	0	0	0	3	0	0	1
pH			0			0			0
Toxicity			0			0			0
Total	0	0	0	0	0	4	0	0	1
Percentage by Region	0	0	0	0	0	80.0	0	0	20.0
Percentage of time in compliance	100	100	100	100	100	99.7	100	100	99.9

b) Number of Monthly Amounts exceeding the limits by:	Esso M	Petro-Canada M	Shell M
0 to 24%	0	0	0
25 to 49%	0	0	0
50 to 99%	0	0	0
100 to 199%	0	0	0
Over 200%	0	0	0

M: Monthly Amount; O: One-day Amount; D: Maximum Daily Amount

	Esso Sarnia	Petro-Canada Mississauga	Shell Corunna
Actual Crude Rate (1000 m³/day)	16.3	6.1	10.4
Reference Crude Rate (1000 m³/day)	19.1	5.7	11.3
Status	Existing	Existing	Existing
Number of months in operation	12	12	12
Number of tests reported	1163	1157	1163

Petro-Canada Oakville			Suncor Sarnia			Esso Nanticoke			Novacor Corunna			Region		
Guideline Deposits	Actual Deposits		Guideline Deposits	Actual Deposits		Regulated Deposits Esso, Novacor	Actual Deposits			Actual Deposits		Average Authorized Deposits	Average Actual Deposits	
15.1	0.80		15.3	1.2		8.6	0.83			0.08		14.3	0.90	
1.6	0.01		1.5	0.01		0.9	0.00			0.00		1.4	0.01	
0.6	0.06		0.5	0.02		0.3	0.02			0.09		0.5	0.03	
13.3	1.8		12.7	0.94		10.3	0.06			0.84		12.9	0.66	
36.1	7.6		36.6	7.2		20.5	1.7			1.3		34.3	8.1	
M	O	D	M	O	D	M	O	D	M	O	D	M	O	D
0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
		0			0			0			0			0
		0			0			0			0			0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
0	0	0	0	0	0	0	0	0	0	0	0			
100	100	100	100	100	100	100	100	100	100	100	100	100	100	99.9
0			0			0			0			0		
0			0			0			0			0		
0			0			0			0			0		
0			0			0			0			0		
0			0			0			0			0		
	7.2			11.5			13.3			7.1				71.9
	8.8			9.0			12.5			7.9				74.3
	Existing 6.7 + Expanded 2.1			Existing 6.9 + Expanded 2.1			New			New			Existing 49.7 + Expanded 4.2 + New 20.4	
	12			12			12			12				
	1163			1163			1160			1145				8114

Table A-4 Deposits and Compliance Assessment - Prairie and Northern Region

	Refinery								
	Co-op Regina			Esso Norman Wells			Petro-Canada Edmonton		
A. DEPOSITS (All guidelines and regulated deposits are for monthly averages.)									
Yearly average of daily deposits (kg/1000 m^3 of crude oil)	Guideline Deposits	Actual Deposits		Guideline Deposits	Actual Deposits		Guideline Deposits	Actual Deposits	
Oil and Grease	13.2	21.4		16.0	6.8		13.6	0.14	
Phenols	1.3	0.05		1.6	0.02		1.4	0.00	
Sulfide	0.5	0.15		0.6	0.03		0.5	0.01	
Ammonia Nitrogen	12.5	5.4		13.8	0.48		12.7	0.06	
Total Suspended Matter	31.6	31.0		38.3	NR		32.6	1.8	
B. COMPLIANCE ASSESSMENT									
a) Number of deposits in excess of limits set in Guidelines/Regulations	M	O	D	M	O	D	M	O	D
Oil and Grease	4	NR	NR	1	0	1	0	0	0
Phenols	0	NR	NR	0	0	0	0	0	0
Sulfide	1	NR	NR	0	0	0	0	0	0
Ammonia Nitrogen	0	NR	NR	0	0	0	0	0	0
Total Suspended Matter	3	NR	NR	NR	NR	NR	0	0	0
pH			2			0			0
Toxicity			NR			NR			0
Total	8	NR	2	1	0	1	0	0	0
Percentage by Region	88.9	NR	66.7	11.1	100	33.3	0	0	0
Percentage of time in compliance	86.7	NR	91.7	97.9	100	99.9	100	100	100
b) Number of Monthly Amounts exceeding the limits by:									
0 to 24%	2			1			0		
25 to 49%	1			0			0		
50 to 99%	1			0			0		
100 to 199%	3			0			0		
Over 200%	1			0			0		
M: Monthly Amount; O: One-day Amount; D: Maximum Daily Amount									
Actual Crude Rate (1000 m^3/day)		7.9			NR			15.2	
Reference Crude Rate (1000 m^3/day)		7.9			0.6			20.8	
Status		Existing 2.1 + Expanded 5.8			Existing 0.5 + Expanded 0.1			Existing 15.2 + Expanded 5.6	
Number of months in operation		12			12			12	
Number of tests reported		84			785			1160	

Esso Strathcona			Shell Scotford			Region		
Regulated Deposits Esso, Shell	**Actual Deposits**		**Actual Deposits**			**Average Authorized Deposits**	**Average Actual Deposits**	
8.6	1.1		1.1			11.1	3.9	
0.9	0.01		0.01			1.1	0.01	
0.3	0.07		0.01			0.4	0.05	
10.3	0.34		0.50			11.5	1.1	
20.5	4.9		0.00			26.4	6.9	
M	**O**	**D**	**M**	**O**	**D**	**M**	**O**	**D**
0	0	0	0	0	0	5	0	1
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	1	0	0
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	3	0	0
		0			0			2
		0			0			0
0	0	0	0	0	0	9	0	3
0	0	0	0	0	0			
100	100	100	100	100	100	96.9	100	99.9
0			0			3		
0			0			1		
0			0			1		
0			0			3		
0			0			1		
	17.4			11.1			51.6	
	18.7			11.1			59.2	
	New			New			Existing 17.8 + Expanded 11.5 + New 29.8	
	12			12				
	1142			342			3513	

Table A-5 Deposits and Compliance Assessment - Pacific and Yukon Region

		Refinery		
		Esso Ioco	Husky Prince George	Petro-Canada Port Moody
A. DEPOSITS	(All guidelines and regulated deposits are for monthly averages.)			
Yearly average of daily deposits (kg/1000 m^3 of crude oil)	Guideline Deposits Esso, Husky, Petro-Canada, Shell	Actual Deposits	Actual Deposits	Actual Deposits
Oil and Grease	17.1	0.72	2.0	5.7
Phenols	1.7	0.01	0.04	0.85
Sulfide	0.6	0.04	0.05	0.56
Ammonia Nitrogen	14.3	0.51	3.1	2.1
Total Suspended Matter	41.1	5.4	16.3	14.1

B. COMPLIANCE ASSESSMENT

	Esso Ioco M	Esso Ioco O	Esso Ioco D	Husky Prince George M	Husky Prince George O	Husky Prince George D	Petro-Canada Port Moody M	Petro-Canada Port Moody O	Petro-Canada Port Moody D
a) Number of deposits in excess of limits set in Guidelines/Regulations	M	O	D	M	O	D	M	O	D
Oil and Grease	0	0	0	0	0	0	0	0	0
Phenols	0	0	0	0	0	0	1	0	1
Sulfide	0	0	0	1	0	0	3	0	3
Ammonia Nitrogen	0	0	0	1	0	1	0	0	0
Total Suspended Matter	0	0	0	1	0	1	0	0	0
pH			0			2			3
Toxicity			0			0			NR
Total	0	0	0	3	0	4	4	0	7
Percentage by Region	0	0	0	10.7	0	6.7	14.3	0	11.7
Percentage of time in compliance	100	100	100	95.0	100	98.5	93.3	100	97.8
b) Number of Monthly Amounts exceeding the limits by:									
0 to 24%	0			1			0		
25 to 49%	0			1			0		
50 to 99%	0			0			1		
100 to 199%	0			0			1		
Over 200%	0			1			2		

* M: Monthly Amount; O: One-day Amount; D: Maximum Daily Amount

	Esso Ioco	Husky Prince George	Petro-Canada Port Moody
Actual Crude Rate (1000 m^3/day)	6.5	1.5	4.6
Reference Crude Rate (1000 m^3/day)	6.2	1.7	4.7
Status	Existing	Existing	Existing
Number of months in operation	12	12	12
Number of tests reported	307	271	312

	Shell Burnaby			Chevron Burnaby			Region	
	Actual Deposits		Guideline Deposits	Actual Deposits		Average Authorized Deposits	Average Actual Deposits	
	5.9		14.6	16.3		16.4	7.1	
	0.12		1.5	1.2		1.6	0.55	
	0.19		0.5	0.69		0.57	0.36	
	4.8		13.1	1.1		13.9	1.8	
	18.2		35	54.9		39.3	24	
M	O	D	M	O	D	M	O	D
0	0	0	5	2	8	5	2	8
0	0	0	4	2	8	5	2	9
0	0	0	7	0	5	11	0	8
0	0	0	0	0	2	1	0	3
0	0	0	5	3	9	6	3	10
		0			17			22
		0			0			0
0	0	0	21	7	49	28	7	60
0	0	0	75	100	81.7			
100	100	100	65	99.1	83.8	90.7	99.8	95.9
0			7			8		
0			3			4		
0			1			2		
0			3			4		
0			7			10		
	3.4			6.6			22.6	
	3.3			6.7			22.6	
	Existing			Existing 3.8 + Expanded 2.9			Existing 19.7 + Expanded 2.9	
	12			12				
	265			303			1458	

Table A-6 Deposits and Compliance Assessment - National

	Region								
	Atlantic			Quebec			Ontario		
A. DEPOSITS (All guidelines and regulated deposits are for monthly averages.)									
Yearly average of daily deposits (kg/1000 m³ of crude oil)	Average Authorized Deposits	Average Actual Deposits		Average Authorized Deposits	Average Actual Deposits		Average Authorized Deposits	Average Actual Deposits	
Oil and Grease	14.0	8.4		17.1	3.1		14.3	3.1	
Phenols	1.4	0.20		1.7	0.08		1.4	0.08	
Sulfide	0.5	0.05		0.6	0.02		0.5	0.02	
Ammonia Nitrogen	12.8	3.2		14.3	1.3		12.9	1.3	
Total Suspended Matter	33.6	14.9		41.1	14.5		34.3	14.5	
B. COMPLIANCE ASSESSMENT									
a) Number of deposits in excess of limits set in Guidelines/Regulations	M	O	D	M	O	D	M	O	D
Oil and Grease	1	1	3	0	0	1	0	0	1
Phenols	1	1	1	0	0	0	0	0	0
Sulfide	0	0	0	0	0	0	0	0	0
Ammonia Nitrogen	0	1	1	0	0	0	0	0	0
Total Suspended Matter	0	1	3	0	0	0	0	0	4
pH			1			0			0
Toxicity			1			0			0
Total	2	4	10	0	0	1	0	0	5
Percentage of National	5.1	36.4	12.7	0	0	1.3	0	0	6.3
Percentage of time in compliance	99.2	99.9	99.8	100	100	99.9	100	100	99.9
b) Number of Monthly Amounts exceeding the limits by:									
0 to 24%	2			0			0		
25 to 49%	0			0			0		
50 to 99%	0			0			0		
100 to 199%	0			0			0		
Over 200%	0			0			0		

M: Monthly Amount; O: One-day Amount; D: Maximum Daily Amount

	Atlantic	Quebec	Ontario
Actual Crude Rate (1000 m³/day)	47.7	44.5	71.9
Reference Crude Rate (1000 m³/day)	54.4	48.8	74.3
Number of tests reported	4335	3464	8114

Prairie and Northern			Pacific and Yukon			National		
Average Authorized Deposits	Average Actual Deposits		Average Authorized Deposits	Average Actual Deposits		Average Authorized Deposits	Average Actual Deposits	
11.1	3.9		16.4	7.1		14.1	4.1	
1.1	0.01		1.6	0.55		1.4	0.11	
0.4	0.05		0.6	0.36		0.5	0.07	
11.5	1.1		13.9	1.8		12.8	1.5	
26.4	6.9		39.3	24.0		33.9	11.9	

M	O	D	M	O	D	M	O	D
5	0	1	5	2	8	11	3	14
0	0	0	5	2	9	6	3	10
1	0	0	11	0	8	12	0	8
0	0	0	1	0	3	1	1	4
3	0	0	6	3	10	9	4	17
		2			22			25
		0			0			1
9	0	3	28	7	60	39	11	79
23.1	0	3.8	71.8	63.6	75.9			
96.9	100	99.9	90.7	99.8	95.9	97.3	99.9	99.6
3			8			13		
1			4			5		
1			2			3		
3			4			7		
1			10			11		

Prairie and Northern	Pacific and Yukon	National
516	22.6	238.2
59.2	22.6	260.8
3513	1458	20884