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FINAL
BEST MANAGEMENT PRACTICES

DRY CLEANING AND LAUNDRY SERVICES:

NONYLPHENOL AND ITS ETHOXYLATES, CADMIUM, AND MERCURY

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EXECUTIVE SUMMARY

This Best Management Practices (BMPs) document for the Dry Cleaning and Laundry Services Sector is one in a series of documents to identify BMPs to eliminate or reduce specific harmful pollutants potentially found in wastewater effluents of six industrial sectors in Ontario. These documents provide qualitative and quantitative estimates of the potential reductions achievable through pollution prevention and treatment measures for specific pollutants of concern. This BMP document is a guide only; site-specific analysis of each facility is required to identify the most effective pollution prevention and treatment measures.

This document identifies BMPs to eliminate or reduce nonylphenol and its ethoxylates (NPE), cadmium, and mercury in wastewater effluents of the dry cleaning and laundry services sector. The two primary audiences for this document are municipal representatives and industrial facility representatives. Specific sub-sectors within the Dry Cleaning and Laundry Services sector addressed include Dry Cleaning and Laundry Services (except Coin-Operated) (NAICS[1] 812320) and Linen and Uniform Supply (NAICS 812330). Within dry cleaning operations, BMPs in this document apply specifically to wet process services (i.e., shirt laundering).

Benefits of implementing BMPs, specifically pollution prevention measures, include but are not limited to, the following:

- Increased cost-effectiveness and lower long-term costs;
- Increased customer satisfaction;
- Social benefits, such as good community relations;
- Reductions in energy, water and materials used; and
- Reduced risk and liability.

In the laundry and dry cleaning sector, NPE largely originate from detergents, cleaning intensifiers, spot removers, and pre-brushing fluids used by dry-cleaners and launderers in wet processes to optimize cleaning. As well, NPE may be contained in textile items brought into laundries and dry cleaners for cleaning.

The main sources of cadmium and mercury in wastewater effluent of dry cleaning and laundry services is from rags and shop towels brought in for cleaning by customers, such as printing facilities, chemical manufacturing industries, hospitals, and automotive facilities. Cadmium and mercury may also be contained on textiles laundered. Possible sources include the ink/dye pigments and coatings used during manufacture of the textile items and cadmium-containing fertilizers that may remain on textile raw materials.

In developing the BMP guidance documents, three reference criteria were considered with respect to final effluent concentrations for harmful substances. The three reference criteria limits are identified in Table ES.1. Reference Criteria 1 are the most stringent and Reference

[1] North American Industry Classification System (NAICS) used by Statistics Canada.

Criteria 3 are the least stringent. Due to the methodology applied to develop the reference criteria, as elaborated within the main text, two of the three reference criteria are the same in some instances.

Table ES.1 Reference Criteria for Substances in the Dry Cleaning and Laundry Services Sector

Substance	Reference Criteria 1 (mg/L)	Reference Criteria 2 (mg/L)	Reference Criteria 3 (mg/L)
Nonylphenol	0.001	0.001	0.0025
Nonylphenol Ethoxylates	0.001	0.01	0.025
Cadmium	0.0006	0.02	1
Mercury	0.0001	0.001	0.1

BMPs are described in this document in four categories: elimination and reduction; operating and housekeeping; education and training; and treatment. The first three categories are considered pollution prevention (P2) measures; treatment is not. P2 is defined as "the use of processes, practices, materials, products, substances or energy that avoids or minimizes the creation of pollutants and waste, and reduces the overall risk to the environment or human health."[2] P2 measures are more effective than treatment in reducing releases of hazardous substances and should, therefore, be implemented in preference to treatment to meet release reference criteria. Multiple P2 measures can be implemented concurrently.

Table ES.2 identifies the pollution prevention BMPs described in this document.

Table ES.2 Summary of P2 BMPs

Substance Addressed	BMP Name	Sub-Sector/ BMP Number
Elimination/ Reduction		All Sub-Sectors
NPE	NPE Surfactant Substitution	BMP #1
NPE	Cleaning Product Supplier Policy	BMP #2
Cadmium, Mercury	Customer Material Acceptance Policy	BMP #3
Operating Procedures and Housekeeping		All Sub-Sectors
NPE	Knowing the Sources and Pathways of NPE	BMP #4
Cadmium, Mercury	Customer Material Processing	BMP #5
Cadmium, Mercury	Inventory Control System	BMP #6
Education and Training		All Sub-Sectors
Cadmium, Mercury	Pricing Structure for Services	BMP #7
NPE, Cadmium, Mercury	Management and Staff Training	BMP #8
NPE	Supply Chain Education and Commitment	BMP #9

[2] Definition from *Guidelines for the Implementation of the Pollution Prevention Planning Provisions of Part 4 of the Canadian Environmental Protection Act, 1999 (CEPA 1999)*, National Office of Pollution Prevention, Environment Canada, 2001

To achieve the three reference criteria (Table ES.1), the most effective and appropriate combinations of P2 BMPs and treatment processes were identified. These combinations were selected on the basis of ability to achieve the reference criteria, costs, and feasibility for implementation, using estimates and engineering judgment. Table ES.3 provides an overview of the estimated effectiveness of the select P2 BMPs identified. Refer to the Tables in Section 5 for details of combinations of P2 and treatment BMPs identified.

Table ES.3 Summary of Effectiveness of P2 BMPs

Substance Addressed	BMP Name	BMP Number
Elimination/ Reduction Effectiveness: 30-70%		
NPE	NPE Surfactant Substitution	BMP #1
NPE	Cleaning Product Supplier Policy	BMP #2
Cadmium, Mercury	Customer Material Acceptance Policy	BMP #3
Operating Procedures and Housekeeping Effectiveness: 20% of the remaining substance after substitution		
NPE	Knowing the Sources and Pathways of NPE	BMP #4
Cadmium, Mercury	Customer Material Processing	BMP #5
Cadmium, Mercury	Inventory Control System	BMP #6
Education and Training Effectiveness: 2% - 20% of the remaining substance after substitution		
Cadmium, Mercury	Pricing Structure for Services	BMP #7
NPE, Cadmium, Mercury	Management and Staff Training	BMP #8
NPE	Supply Chain Education and Commitment	BMP #9

Based on the estimated initial concentrations and percent removal resulting from implementation of P2 measures, treatment is required for the removal of NPE to meet all three reference criteria. Both biological treatment and granular activated carbon (GAC) are required to remove these substances unless more aggressive P2 measures are implemented to eliminate NPE sources. Assuming more aggressive P2 measures and assuming low BOD_5 concentration in the wastewater, GAC alone may be able to reduce the levels of NPE to the required reference criteria concentrations. For cadmium, treatment is required to meet Reference Criteria 1 and 2; P2 measures can achieve Reference Criteria 3. For mercury, treatment is required to meet Reference Criteria 1; P2 measures can achieve Reference Criteria 2 and 3.

Cost ranges for capital and operating costs are also estimated. Cost estimates for implementation of pollution prevention measures are based on the number of persons employed at the facility as a proxy for operating budget levels. Cost estimates for treatment systems were based on a range of wastewater flow rates assumed for the sector. Capital and operational and maintenance (O&M) cost curves were developed for each reference criteria after the implementation of P2 measures. Table ES.4 provides a summary of estimated costs

for selected P2 BMPs and Table ES.5 provides a summary of estimated costs for selected treatment BMPs.

Note that estimates are dependent on the incoming concentrations of NPE, cadmium, and mercury prior to P2 measures, and concentrations achieved after P2 measures. Thus, site-specific wastewater testing is necessary at all facilities to determine compliance with regulations and to implement appropriate measures.

Table ES.4 Estimated Pollution Prevention Costs

Type of P2 Measure	Estimated Pollution Prevention Costs		
	Small Facilities (25 staff)	**Medium Facilities (175 staff)**	**Large Facilities (300 staff)**
Pollution Elimination or Reduction	negligible	Not applicable for the sector	
Operating/ Housekeeping	$20,000 annually		
Education and Training	$8,000 annually		
Total Estimate	$28,000 annually		

Note:

* Estimated annual costs for each P2 measure are approximations only; facility specific wastewater quality and operating practices must be assessed prior to selection of P2 practices.

Cadmium and mercury treatment technologies include deionization (DI) and/or reverse osmosis (RO). There will also be some removal of these metals with GAC. Cadmium and mercury levels in the wastewater after P2 measures are sufficiently low such that chemical precipitation is not required as the first treatment step for reduction of these metals.

Based on the estimated wastewater concentrations of cadmium, mercury and NPE after P2 measures and an assumption that the BOD_5 is less than 100 mg/L[3], the overall full treatment systems for each target reference criteria are as follows:

- Reference Criteria 1: biological treatment, sand/mixed media filtration, GAC, microfiltration, RO, and DI;
- Reference Criteria 2: biological treatment, sand/mixed media filtration, GAC, microfiltration, and DI; and
- Reference Criteria 3: biological treatment, sand/mixed media filtration and GAC.

Capital and annual O&M costs were developed for full treatment for the three reference criteria using a wastewater flow range of 1 m^3/h to 50 m^3/h. Costs were also developed for a treatment scenario where metals are substantially reduced or eliminated through more aggressive P2 measures, whereby DI may not be required for Reference Criteria 1 and 2.

[3] Regardless of BOD5 concentration in the wastewater, a combination of both biological treatment and GAC is required to achieve the removals of NPE for all three reference criteria, unless more aggressive P2 measures can be implemented to eliminate the sources of NPE. With more aggressive P2 implementation, biological treatment will, nevertheless, be required for wastewater BOD_5 concentrations greater than 100 mg/L.

Costing is also provided for the scenario where metals and NPE are substantially reduced or eliminated, whereby GAC only would be required. This eliminates the need for biological treatment assuming a low BOD5 concentration in the wastewater. Table ES.5 presents a summary of the capital and O&M cost data for the wastewater treatment alternatives after P2.

Table ES.5 Estimated Capital and Annual O&M Costs

Reference Criteria	Approximate Costs as Function of Flow Range of 1 to 50 m^3/h					
	Capital Cost Range			Annual O&M Cost Range		
	1m^3/h	25 m^3/h	50 m^3/h	1m^3/h	25 m^3/h	50 m^3/h
Full Treatment						
Criteria 1	$546,000	$3,025,000	$4,809,000	$82,000	$363,000	$481,000
Criteria 2	$502,000	$1,713,000	$2,850,000	$75,000	$206,000	$285,000
Criteria 3	$314,000	$978,000	$1,497,000	$47,000	$117,000	$150,000
Treatment Assuming Low Metals (i.e., No DI)						
Criteria 1	$371,000	$2,312,000	$3,526,000	$56,000	$277,000	$353,000
Criteria 2	$314,000	$978,000	$1,497,000	$47,000	$117,000	$150,000
Criteria 3	$70,000	$438,000	$748,000	$10,000	$53,000	$75,000
Treatment Assuming Low Metals and Low NPE (i.e., GAC treatment; No DI)						
Criteria 1	$70,000	$438,000	$748,000	$10,000	$53,000	$75,000
Criteria 2	$70,000	$438,000	$748,000	$10,000	$53,000	$75,000
Criteria 3	$0	$0	$0	$0	$0	$0

Note:
Costs exclude chemical precipitation (metals removal), which is assumed to be installed. If required, the following estimated capital costs should be added: 1 m^3/hr = $67,200; 25 m^3/hr = $371,000; 50 m^3/hr = $658,000.

Note that estimates are dependent on the incoming concentrations of NPE, cadmium, and mercury prior to P2 measures, and concentrations achieved after P2 measures. Thus, site-specific wastewater testing is necessary at all facilities to determine compliance with regulations and to implement appropriate measures.

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1. OVERVIEW OF THIS DOCUMENT

1.1 Objective and Audience

This document identifies best management practices (BMPs) to eliminate or reduce nonylphenol and its ethoxylates (NPE), cadmium, and mercury in wastewater effluents of the dry cleaning and laundry services sector. The benefits of undertaking BMPs are also described. Since this document addresses wastewater effluents, the BMPs described herein apply to laundering services within the sector (e.g., shirt cleaning services through dry cleaning service providers and laundry services at other sector operations). This BMP document is a guide only; site-specific analysis of each facility is required to identify the most effective pollution prevention and treatment measures.

This document is one in a series of documents to identify BMPs to eliminate or reduce specific harmful pollutants potentially found in wastewater effluents of six key industrial sectors in Ontario. Appendix A identifies the other industrial sectors and substances for which similar best management practice documents have been developed.

The two primary audiences for this document are:

- **Municipal representatives** interested in assisting industrial facilities with sewer discharges to eliminate or reduce harmful pollutants.
- **Industrial facility representatives** interested in implementing BMPs to eliminate or reduce harmful pollutants, and to increase company reputation for implementing 'green policies', specifically dry cleaning and laundry services operations and management staff.

Appendix B identifies assessment form templates for use by municipal representatives and self-assessment templates for use by industrial sector representatives.

Specific sub-sectors within the dry cleaning and laundry services sector addressed within this document include:

- Dry Cleaning and Laundry Services (except Coin-Operated) (NAICS[4] 812320); and
- Linen and Uniform Supply (NAICS 812330).

[4] North American Industry Classification System (NAICS) used by Statistics Canada. The NAICS is an industry classification system developed by the statistical agencies of Canada, Mexico and the United States. Created against the background of the North American Free Trade Agreement, it is designed to provide common definitions of the industrial structure of the three countries and a common statistical framework to facilitate the analysis of the three economies. http://www.statcan.ca/english/Subjects/Standard/naics/2002/naics02-intro.htm

Definitions for these sub-sectors are provided in Appendix C.

The harmful pollutants addressed in this series of BMP documents have been identified at both the federal and provincial government levels, as part of on-going initiatives to limit the effect of wastewater discharges on receiving waters. Appendix D provides a list of agreements and programs, as well as substances identified by the Ontario MOE to be of particular concern under these or other initiatives.

1.2 Benefits of Implementing Pollution Prevention

In addition to reductions in pollutants released to water, air, and soil, implementation of pollution prevention best management practices and high quality environmental performance have numerous benefits, including the following:

- Increased cost-effectiveness and lower long-term costs through implementation of pollution prevention measures in a planned, holistic manner;
- Increased customer satisfaction through meeting expectations for goods and services to be produced in an environmentally responsible manner;
- Social benefits, such as good community relations and potential endorsement of facility efforts and activities;
- Reductions in energy, water, and materials used, with associated operating cost savings;
- Compliance with federal and municipal regulations;
- Reduced risk and liability resulting from regulatory non-compliance, spills, and environmental emergencies;
- Increased innovation through process and materials improvements and supply chain communication;
- Better return on investment for shareholders;
- Health and safety benefits through reduced worker exposure; and
- Higher public approval ratings and improved corporate reputation.

A study of the relationship between environmental performance and financial performance,[5] using the Standard & Poor's 500 Index (S&P 500), compared the financial performance of "low polluter" portfolios to industry-matched "high

[5] Environmental and Financial Performance: Are They Related? M. A. Cohen, S. A. Fenn, S. Konar, Vanderbilt University, Nashville, TN, 1997 (URL http://sitemason.vanderbilt.edu/files/d/dLwFkQ/Environmental%20and%20Financial%20Performance.pdf, accessed January 2006)

polluter" portfolios. The study found that the "low polluter" portfolio performed as well as - and often better than - the "high polluter" group. Investors who chose the environmental leaders in an industry-balanced portfolio were found to do as well (or better) than those choosing the environmental laggards in each industry. According to the study, a portfolio that tracked the S&P 500 and included only the environmental leaders in each industry category would be expected to meet or exceed the market returns of the S&P 500. The study concluded that greener firms are performing as well as or better than their more polluting counterparts.

Literature references on pollution prevention do not generally quantify benefits and cost savings resulting from implementation of P2 measures. Individual case studies, however, often do identify cost savings and benefits. Refer to Appendix E, Case Study Examples Demonstrating Benefits of P2 Measures for case studies of facilities that have documented the benefits of implementing P2 measures while, at the same time, reducing releases of hazardous substances.

1.3 Methodology

This BMP document was developed by a consultant team with the advice of a Steering Committee of provincial and municipal representatives. A detailed review of literature was conducted by the consultant team to identify available information on specific substance–sector combinations. Sector specialists and other representatives identified through the literature review were contacted for additional information and to obtain recent data, where available. Engineering estimates and consultant team expertise also supported the analysis and development of the BMP documents.

A number of estimating procedures and assumptions were made to support the development of options and costs for both the pollution prevention and the treatment measures. These estimating procedures were developed through available data and consultant team expertise. Refer to Sections 3 and 4 for brief outlines of the estimating procedures made for pollution prevention and treatment effectiveness and costs.

1.4 How to Use This Document

In addition to this introductory section, this BMP document consists of the following sections:

- **Section 2, Background**, provides information on the use of substances of interest in the sector, reference criteria targets used to analyze and develop the BMPs and reporting requirements for the substances.
- **Section 3, Pollution Prevention**, identifies pollution prevention (P2) options, including operating, housekeeping, training and education opportunities and suggestions. Identifies specific combinations of P2 practices, including estimates of implementation costs.

- **Section 4, Treatment**, identifies the specific combinations of treatment (assuming the combinations of P2 measures identified in Section 3 are implemented) to achieve the three reference criteria levels, including underlying assumptions for the reduction analyses.

- **Section 5, Options for Reduction of Substance concentrations in Effluents,** summary tables of the P2 and treatment measures identified in Sections 3 and 4.

- **Section 6, References**, identifies key reference documents used in the development of this BMP document.

- **Section 7, Glossary**, defines terminology and acronyms used in the document.

- **Appendices** provide information on other documents in this series, templates for assessment of facilities, sector definitions, a list of harmful substances of particular interest, and case studies.

Once having read this document, practitioners are encouraged to:

- Assess the concentration of identified substances in the effluent of their facility versus the three reference criteria analyzed (Section 2.2).

- Identify potential sources of these substances in their effluent and assess pollution prevention and treatment options, as well as broader management practices (Sections 3 and 4).

- Review the estimating procedures and assumptions stated in Sections 3 and 4 and information presented in the Tables of Section 5 for an indication of measures that could potentially be implemented to meet the target reference criteria.

- Refer to municipal sewer use by-laws or other requirements applicable to the facility with respect to control requirements for the substances.

- Refer to the companion template documents that provide guidance on assessment (for municipal representatives) and self-assessment (for industrial representatives) of facilities.

2. BACKGROUND

2.1 Use of the Substances of Interest in this Sector

This BMP specifically focuses on the following substances in the dry cleaning and laundry services sector:

- Nonylphenol and its ethoxylates (NPE);
- Cadmium; and
- Mercury.

All three of these substances are listed as toxic on the *Canadian Environmental Protection Act* (CEPA) Toxic Substances List.[6] These substances are of interest where they may be discharged through wet processes.

Other toxic substances of concern are also released from the dry cleaning and laundry services sector, in particular, solvents used during the dry cleaning process. The four main solvents of concern are perchloroethylene, petroleum solvents, chlorofuorocarbons, and trichloroethane.

Perchlorotheylene, chlorofluorocarbons, and trichloroethane have also been declared as toxic on the CEPA Toxic Substances List.[7] Readers are referred to the CEPA website for the latest information on preventive actions or control requirements in place for these substances. These solvents, which are volatile and generally released with air emissions, are not addressed by this document since the BMPs focus on releases to wastewater.

For the purposes of assessing the effectiveness of pollution prevention measures and treatment technologies, representative raw wastewater concentrations of the substances addressed in this document have been estimated as summarized in Table 2.1. The raw wastewater concentrations in Table 2.1 were determined from an extensive review of available data for the dry cleaning and laundry services sector. In the data reviewed, concentrations of pollutants in wastewaters for this sector varied greatly. Each facility should assess its wastewater components, as the compounds listed in Table 2.1 may be found at higher, lower or negligible concentrations, depending on operating conditions and existing pollution prevention and treatment practices.

[6] http://www.ec.gc.ca/CEPARegistry/subs_list/ToxicList.cfm. (Accessed January 17, 2006)
[7] http://www.ec.gc.ca/CEPARegistry/subs_list/ToxicList.cfm. (Accessed January 17, 2006)

Table 2.1 Wastewater Concentrations in the Dry Cleaning and Laundry Services Sector

Substance	Representative Concentration in Wastewater (prior to pollution prevention or treatment) (mg/L)
Nonylphenol	5
Nonylphenol Ethoxylates	50
Cadmium	0.06
Mercury	0.001

This BMP document addresses specifically the compounds listed in Table 2.1. Other compounds that may be present in the wastewater should be identified as they may be reduced by practices identified herein or by other practices. A companion document in this series, *Best Management Practices. 1,4-Dichlorobenzene, 3,3-Dichlorobenzidine, Hexachlorobenzene, and Pentachlorophenol: Non-Sector Specific Practices*, discusses other substances of potential interest to the dry cleaning and laundry sector.

2.1.1 Nonylphenol and its Ethoxylates (NPE)

Nonylphenol ethoxylates are a class of the broader group of compounds known as alkylphenol ethoxylates (APE). They are chemicals used in detergents, surface cleaners, emulsifiers, wetting agents, and dispersing agents.[8] In the dry cleaning and laundry sector, NPE largely originate from detergents, cleaning intensifiers, spot removers, and pre-brushing fluids used to optimize cleaning.[9] As well, NPE may be contained in textile items brought into laundries and dry cleaners for cleaning. NPE have been declared toxic substances under section 64 of the *Canadian Environmental Protection Act* (CEPA) 1999, and added to the List of Toxic Substances in Schedule 1 of CEPA 1999.

Table 2.2 illustrates where NPE can be found in the dry cleaning and laundry service sector.

[8] Environment Canada. Assessment Report - Nonylphenol and its Ethoxylates. Accessed September 29, 2005 from http://www.ec.gc.ca/substances/ese/eng/psap/final/npe.cfm
[9] Danish Environmental Protection Agency News Release (2004). Accessed September 29, 2005 from http://www.mst.dk/news/09320000.htm

Table 2.2 NPE in the Dry Cleaning and Laundry Service Sector

Sub-Sector	Where NPE May be Found in Process
Dry cleaning and laundry services	Industrial laundry detergents, both powder and liquid products Cleaning intensifiers, spot removers, and pre-brushing fluids used in the laundering process Residues from textiles
Linen and uniform supply	Industrial laundry detergents, both powder and liquid products Residues from textiles

In many European Union (EU) Member States, use of NPE in domestic cleaning products has been phased out. The European Federation of Trade Associations reports that voluntary measures have resulted in the phase-out of NPE in domestic cleaning products.[10]

As of January 2005, under the 26th amendment to the EU Directive 76/796/EC, which applies to EU countries, NPE may not be placed on the market or used as a substance or constituent of preparations in concentrations equal to or higher than 0.1% weight to weight in a number of applications, including textiles and leather processing. The exceptions to this list of applications are processes with no release into wastewater, including those with special treatment where washing liquid is recycled or incinerated.

Canada has also taken steps to reduce the use of NPE in the Canadian marketplace. On December 4, 2004, Environment Canada published a Notice in Part I of the *Canada Gazette*, pursuant to the CEPA 1999, outlining the requirements for manufacturers and importers of soap and cleaning products containing NPE to prepare and implement pollution prevention (P2) plans for NPE. Soap and cleaning products are defined by Environment Canada to be "all products (powder, liquid, tablet, or other form) containing nonylphenol or nonylphenol ethoxylates as an ingredient that are used for industrial and institutional, household, or other cleaning." Examples include, but are not limited to, "laundry detergents, dish detergents, dishwasher detergents, hard surface cleaners, disinfectants, polishes, general purpose cleaners, toilet bowl cleaners, deodorizers, air fresheners, rug and carpet cleaners, metal cleaners, vehicle cleaners, etc." Facilities that have purchased or otherwise acquired a total of 2000 kilograms or more of nonylphenol and nonylphenol ethoxylates during one calendar year are subject to the Notice (i.e., the requirement to prepare P2 plans). Note that the threshold amount includes raw NPE, NPE in

[10] Department of the Environment, Transport and the Regions. (2000) Nonylphenol Risk Reduction Strategy. Accessed September 29, 2005 from http://europa.eu.int/comm/enterprise/chemicals/legislation/markrestr/studies/nonylphenol.pdf

formulations, and NPE in final products. Refer to the Environment Canada website[11] for further details.

2.1.2 Cadmium

Cadmium is a heavy metal that is present in the Canadian environment from both natural (e.g., forest fires, weathering of soil and rock) and anthropogenic (i.e., human activities) sources. Cadmium and its compounds are used in industries including metal plating and batteries, electronics, production of polyvinyl chloride products, automotive, ceramics, textile dyeing, printing, and electroplating.[12] Cadmium and its compounds have been declared toxic substances under Section 64 of the *Canadian Environmental Protection Act, 1999* (CEPA 1999), and added to the List of Toxic Substances in Schedule 1 of CEPA 1999.

The main source of cadmium in wastewater effluent of dry cleaning and laundry services is from rags, printer towels, and shop towels brought in for cleaning by customers such as printing facilities, chemical manufacturing industries, hospitals, and automotive facilities. Industrial laundries also clean a variety of other items that may carry cadmium, including uniforms, dust mops and cloths, mats, and gloves. Some of these items may contain several hazardous substances if they are used to clean up spills of hazardous waste, or if the container in which they are stored contains hazardous waste. Cadmium may also be contained on textiles laundered. Possible sources include the ink/dye pigments and coatings used during manufacture of the textile items and trace amounts from cadmium-containing fertilizers that may remain on textile raw materials.[13]

Low levels of cadmium may also be found in impurities in salt, sodium hydroxide (caustic soda), or sodium carbonate (soda ash) used by laundry services.

Table 2.3 summarizes where cadmium can be found in the dry cleaning and laundry service sector.

[11] http://www.ec.gc.ca/NOPP/DOCS/P2Plans/NPE/en/insert.cfm
[12] Scorecard Website: http://www.scorecard.org/chemical-profiles/html/cadmium.html
[13] *Water Quality Guidelines and Pollutant Fact Sheets*. Business for Social Responsibility. Spring 2002.

Table 2.3 Cadmium in the Dry Cleaning and Laundry Service Sector

Sub-Sector	Where Cadmium May be Found in Process
Dry cleaning and laundry services	Shop towels, rags and other items brought in by customers for cleaning including, but not limited to, materials from automotive facilities, chemical manufacturing sites, printing facilities and hospitals. Residues from textiles brought in for cleaning Impurities in salt, sodium hydroxide (caustic soda), or sodium carbonate (soda ash) used in laundry services (minute amounts)
Linen and uniform supply	Linens and uniforms brought in by customers for cleaning including, but not limited to, items from automotive facilities, chemical manufacturing facilities, printing facilities and hospitals. Residues from textiles brought in for cleaning. Impurities in salt, sodium hydroxide (caustic soda), or sodium carbonate (soda ash) used in laundry services (minute amounts)

In an Environmental Protection Agency (EPA) study conducted on industrial laundry effluent, cadmium was detected in untreated industrial laundry wastewater over 90% of the time, with a mean average of 0.1 mg/L, and a range of 0.01 to 0.7 mg/L.[14]

2.1.3 Mercury

Mercury is a heavy metal that is a liquid at room temperature. It is odourless and sinks in water. Mercury has a high surface tension and, when spilled, it breaks up into tiny beads. Mercury has the highest volatility of any metal and vapourizes to become a colourless, odourless gas.[15] It should only be handled in well-ventilated areas. Mercury can exist as elemental mercury, and organic and inorganic mercury, and can also combine with other substances to form compounds. Mercury and its components have been declared under Section 64 of the *Canadian Environmental Protection Act, 1999* (CEPA 1999), and added to the List of Toxic Substances in Schedule 1 of CEPA 1999.

The main source of mercury from the dry cleaning and laundry services sector is from rags and shop towels brought in for cleaning by customers, such as, but not limited to, printing industries, chemical manufacturing facilities, hospitals, and automotive facilities. Some mercury residues may also be contained on textile items from the ink/dye pigments and coatings used on the textiles at the time of manufacture. Low levels of mercury may also be found in some types of bleach and soap.

[14] Based on samples collected between 1993 and 1996 from seven industrial laundries facilities.
[15] Environment Canada website: http://www.ec.gc.ca/MERCURY/EH/EN/eh-p.cfm?SELECT=EH

Table 2.4 summarizes the main sources of mercury in the dry cleaning and laundry service sector.

Table 2.4 Mercury in the Dry Cleaning and Laundry Service Sector

Sub-Sector	Where Mercury May be Found in Process
Dry cleaning and laundry services	Shop towels and rags brought in by customers for cleaning, including, but not limited to, automotive facilities such as auto recyclers and mechanics, printing facilities, chemical manufacturing facilities, and hospitals. Residues from textiles brought in for cleaning Chemicals used in the cleaning process, such as soaps and bleach (minute amounts).
Linen and uniform supply	Linens and uniforms brought in by customers for cleaning, including, but not limited to, automotive facilities, chemical manufacturing facilities, printing facilities, and hospitals. Residues from textiles brought in for cleaning Chemicals used in the cleaning process, such as soaps and bleach. (minute amounts)

Research from Western Lake Superior Sanitary District (WLSSD) and the Detroit Water and Sewerage District suggest that the mercury contribution from industrial laundries can be significant.[16] In an EPA study conducted on industrial laundry effluent, mercury was detected in untreated industrial laundry wastewater 60% of the time, with a mean average of 0.001 mg/L, and a range of 0.001 to 0.01 mg/L.[17]

2.2 Reference Criteria for Concentrations of Substances of Interest in Discharges to Sewers

This sub-section identifies the reference criteria for substances of concern. In developing the BMP guidance documents, three reference criteria were considered with respect to final effluent concentrations for harmful substances. In Table 2.5, Reference Criteria 1 are the most stringent; that is, Reference Criteria 1 are the lowest reference criteria, whereas Reference Criteria 3 are the least stringent reference criteria. Due to the methodology applied to develop the reference criteria, as elaborated below, two reference criteria for certain substances are the same in several instances.

[16] Western Lake Superior Sanitary District: http://www.wlssd.duluth.mn.us/publications/Blueprint for mercury/Revised Blueprint for Mercu.pdf (Accessed January 17, 2006)
[17] Based on samples collected between 1993 and 1996 from seven industrial laundries facilities.

Table 2.5 Reference Criteria for Substances in the Dry Cleaning and Laundry Services Sector

Substance	Designation	Reference Criteria 1 (mg/L)	Reference Criteria 2 (mg/L)	Reference Criteria 3 (mg/L)
Nonylphenol	CEPA** Toxic	0.001	0.001	0.0025
Nonylphenol Ethoxylates	CEPA Toxic	0.001	0.01	0.025
Cadmium	COA* Tier II	0.0006	0.02	1
Mercury	COA Tier I	0.0001	0.001	0.1

Notes:
**CEPA: Canadian Environmental Protection Act
*COA: Canada-Ontario Agreement respecting the Great Lakes Basic Ecosystem

The *Canadian Environmental Protection Act, 1999* (CEPA) is the cornerstone of the Government of Canada's environmental legislation aimed at preventing pollution and protecting the environment and human health. CEPA recognizes the contribution of pollution prevention and the management and control of toxic substances and hazardous waste to reducing threats to Canada's ecosystems and biological diversity. CEPA acknowledges the need to virtually eliminate the most persistent toxic substances that remain in the environment for extended periods of time before breaking down, and bioaccumulative toxic substances that accumulate within living organisms.

From a regulatory perspective, pollution prevention planning becomes one of the tools Environment Canada risk managers can use to address Schedule 1 CEPA toxic substances. Facilities that use Schedule 1 CEPA toxic substances should be aware of the impact that CEPA may have on them.

Reference Criteria 1

Substances identified in Canada-Ontario Agreement respecting the Great Lakes Basin Ecosystem (COA) are either Tier I substances, subject to virtual elimination, or Tier II substances, targeted for reduction. Column 2 of Table 2.5 identifies substances subject to the COA. For substances identified in the COA, Reference Criteria 1 are the more stringent of the Recommended Method Detection Limit (RMDL) or the Provincial Water Quality Objective (PWQO).

For other substances not subject to COA, Reference Criteria 1 are the more stringent of 20 times the PWQO or 20 times the RMDL except for NPE, where Reference Criteria 1 are the threshold identified in the Canadian Environmental Quality Guidelines, Canadian Council of Ministers of the Environment (CCME), 2002.

Reference Criteria 2

Reference Criteria 2 were established by the minimum values identified in municipal sewer use by-laws in Ontario for the identified substances. In cases where the sewer use by-law limit was the same as the PWQO or RMDL, Reference Criteria 2 are the same as Reference Criteria 1.

Reference Criteria 3

Reference Criteria 3 were established by the median values identified in municipal sewer use by-laws in Ontario for the identified substances. In cases where only one by-law identified a limit for the substance, or where the same limit was identified in all by-laws, Reference Criteria 3 are the same as Reference Criteria 2.

2.3 Select Regulatory Requirements for the Substances Addressed

Toxic and hazardous substances may be subject to several regulations at the federal, provincial, and municipal levels, in addition to international agreements and protocols. It is incumbent on owners and operators of industrial facilities to be knowledgeable of all management and reporting requirements for specific substances used in, produced by, transported to and from, or otherwise used at, or released from, their facilities and operations.

The following section is intended as a guide only regarding specific regulations. Proponents are advised to consult these regulations directly to ensure they have all information they require. Requirements discussed in this section include municipal sewer use by-laws, the National Pollutant Release Inventory (NPRI) and the federal Environmental Emergency requirements.

Municipal Sewer Use By-laws

The majority of municipalities in the province of Ontario have municipal sewer use by-laws. A wide range of materials, chemicals, and conditions for discharge are identified in the sewer use by-laws with corresponding objectives that may include the following:[18]

- Protection of the environment;
- Protection of municipal staff and infrastructure;
- Efficient use of the system;
- Prevention of stormwater and 'clear' water from entering the system;
- Protection of sludge or biosolids quality; and
- Protection of public health and safety and protection of public property.

Some municipal sewer use by-laws include an option for entering into over-strength agreements with industrial dischargers, although these agreements are typically limited to substances intended for treatment by the community wastewater treatment facility and do not include the toxic substances addressed in this document. Some municipal sewer use by-laws also require pollution prevention planning and

[18] Review of Existing Municipal Wastewater Effluent (MWWE) Regulatory Structures in Canada, Marbek Resource Consultants for the Canadian Council of Ministers of the Environment (CCME), 2005

reporting by industrial facilities. Proponents are encouraged to access the municipal sewer use by-law pertaining to the community sewer system into which they discharge to ensure they are in compliance with all discharge and reporting requirements of the by-law.

Canada's National Pollutant Release Inventory

The NPRI has several reporting thresholds, including number of employee hours, quantities, and concentrations of reportable substances manufactured, processed or otherwise used, with requirements pertaining to specific cases where substances are produced as by-products. Practitioners are encouraged to reference the NPRI website[19] directly for the most recent reporting requirements, including reportable substances and reporting thresholds, as these may change over time. There are over 330 substances and substance groups reportable under NPRI; Table 2.6 identifies the substances of interest for this BMP document.

Table 2.6 NPRI Reporting Requirements (2003) for Substances in the Dry Cleaning and Laundry Services Sector

Substance	NPRI Reportable Substances	NPRI Part Designation	Reporting Threshold
Nonylphenol and Ethoxylates	Specific substances	Group 1A	10 tonnes (total in 2003)
Cadmium	Cadmium and its compounds	Part 1B	5 kg
Mercury	Mercury and its compounds	Part 1B	5 kg

As of 2003, one dry cleaning and laundry service company met the reporting thresholds for NPE. This company reported that it discharges to the municipal wastewater treatment plant. No dry cleaning and laundry services companies reported releases to the NPRI for cadmium or mercury.

Pollution Prevention Plans for NPE

As indicated in Section 2.1.1, Environment Canada, under CEPA 1999, has set out pollution prevention planning requirements for manufacturers and importers of soap and cleaning products containing NPE. Laundry and dry cleaning facilities that have purchased or otherwise acquired a total of 2,000 kilograms or more of NPE during one calendar year are required to prepare P2 plans and meet all related requirements of the Notice published in the *Canada Gazette* on this topic. Refer to the Environment Canada website[20] for further details.

Federal Environmental Emergency (EE) Regulation

Environmental Emergency (EE) Regulations under Part 8 of CEPA 1999 promote prevention and planning for preparedness, response, and recovery. One of the three substances discussed in this document is identified in the federal emergency

[19] NPRI website: http://www.ec.gc.ca/pdb/npri/npri_home_e.cfm
[20] http://www.ec.gc.ca/NOPP/DOCS/P2Plans/NPE/en/insert.cfm

regulation at this time. Practitioners are encouraged to reference the regulatory requirements at Environment Canada's website.[21] Table 2.7 provides information on substances of specific interest in this document.

Table 2.7 Environmental Emergency Substances and Thresholds

Substance Name	CAS number	Concentration	Threshold Quantity (tonnes)	Comment
Mercury	7439-97-6	Not specified	1.00	Part 2 - Other Hazardous Substances

MOE Spills Action Centre

When a spill occurs, it is the responsibility of the owner and the person who had control of the pollutant at the time it was spilled to clean up and dispose of the pollutants and ameliorate any adverse effects in a timely manner. It is the Ministry's role to ensure that those responsible tale preventative measures and use proper clean up, disposal, and amelioration practices. Under the Environment Protection Act, the Ministry can order those responsible for the spill to clean up the site.

The MOE should be contacted (Spill Action Centre 1-800-268-6060) if the spill is discharged to a storm water system and into the natural environment, migrates off-site, or where the spill occurs off-site. In such a situation, the MOE, the municipality and the controller, and/or owner of the pollutant, if different, are to be notified.

[21] Environment Canada EE Regulatory Requirements website: http://www.ec.gc.ca/ee-ue/default.asp?lang=En&n=8A6C8F31-1

3. POLLUTION PREVENTION

Pollution prevention (P2) is defined as "the use of processes, practices, materials, products, substances or energy that avoids or minimizes the creation of pollutants and waste, and reduces the overall risk to the environment or human health."[22] P2 practices therefore include elimination of hazardous substances through materials substitutions (Section 3.2); reduction of hazardous substances through process or equipment modifications (Section 3.2); operating procedures and housekeeping practices (Section 3.3); and education and training of staff, suppliers, customers and the public (Section 3.4). P2 measures can be undertaken concurrently. The most effective actions are those that eliminate hazardous substances, through substitution, for example.

Treatment (Section 4) is not a pollution prevention activity. For many substances, treatment moves pollutants from one media to another (e.g., removal of a metal from the water effluent to a solids residue) and does not avoid or minimize the creation of the pollutant or waste.

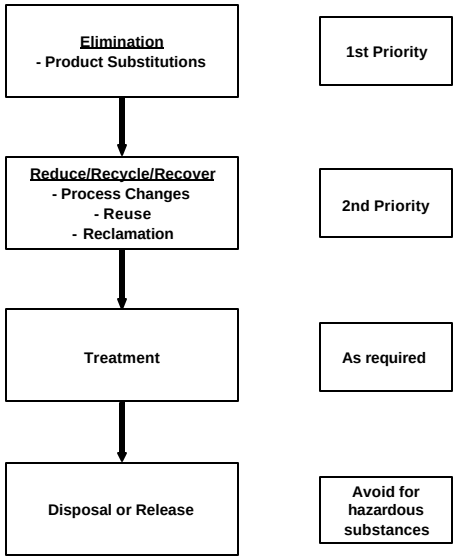
Pollution prevention and treatment BMPs must be assessed and implemented based on specific site and process conditions and characteristics; however, some overall observations can be made about effective ways to proceed with assessment and implementation of BMPs. Specific options for the dry cleaning and laundry services sector for P2 are outlined in the sub-sections following.

The best way to improve environmental management issues is to use a systematic approach. One key first step is to develop an environmental policy and strategy that is formally supported through senior management's commitment to the strategy. An Environmental Management System (EMS) is a tool that organizations in a variety of sectors have implemented to systematically identify, prioritize, and take action to address the environmental impacts of their operations and services. In addition, an EMS can establish the record-keeping and reporting required to ensure facility management has the necessary information for continuous improvements. It is recommended that all facilities consider developing, adopting, and implementing an EMS. One example of such a system is the ISO 14001 standard. Pollution prevention, product stewardship, and social responsibility are important aspects of a comprehensive, integrated environmental approach. Employee engagement and training, communication throughout the supply chain, and customer education may be appropriate elements for a successful, integrated approach to long-term sustainability.

The following sequence of steps (Figure 3.1) presents a hierarchy of techniques for undertaking pollution prevention and waste minimization:

[22] Definition from: *Guidelines for the Implementation of the Pollution Prevention Planning Provisions of Part 4 of the Canadian Environmental Protection Act, 1999 (CEPA 1999)*, National Office of Pollution Prevention, Environment Canada, 2001

Figure 3.1 Environmental Management Options Hierarchy



- Eliminate generation of waste streams through process development and design;
- Reduce waste streams at source through process-integrated changes to raw materials, equipment, and operating procedures;
- Recycle waste streams by direct re-use or reclamation and re-use;
- Recover any resource value from waste streams; and
- Treat and dispose of waste streams using end-of-pipe techniques.

The sequence of general techniques to prevent and minimize release of water pollutants includes the following steps:

- Identify all wastewater streams and characterize their quality, quantity, and variability;
- Minimize quantity of water used in the process;
- Minimize contamination of process water and washwater contamination with hazardous raw materials, product, or wastes;
- Maximize wastewater re-use; and
- Maximize the recovery and retention of substances from streams unfit for re-use.

3.1 Overview of P2 Measures for NPE, Cadmium, and Mercury in the Dry Cleaning and Laundry Services Sector

This sub-section provides an overview of the P2 measures discussed in the following three sub-sections: 3.2 Pollution Elimination or Reduction; 3.3 Operating Procedures and Housekeeping; and, 3.4 Education and Training.

Table 3.1 P2 Measures for NPE, Cadmium, and Mercury in the Dry Cleaning and Laundry Services Sector

Substance Addressed	BMP Name	Sub-Sector/ BMP Number
Elimination/ Reduction		All Sub-Sectors
NPE	NPE Surfactant Substitution	BMP #1
NPE	Cleaning Product Supplier Policy	BMP #2
Cadmium, Mercury	Customer Material Acceptance Policy	BMP #3
Operating Procedures and Housekeeping		All Sub-Sectors
NPE	Knowing the Sources and Pathways of NPE	BMP #4
Cadmium, Mercury	Customer Material Processing	BMP #5
Cadmium, Mercury	Inventory Control System	BMP #6
Education and Training		All Sub-Sectors
Cadmium, Mercury	Pricing Structure for Services	BMP #7
NPE, Cadmium, Mercury	Management and Staff Training	BMP #8
NPE	Supply Chain Education and Commitment	BMP #9

3.2 Pollution Elimination or Reduction

P2 opportunities to eliminate or reduce hazardous substances include material substitutions and process alterations. Changes in operating costs will depend on the cost differential of the substitute in comparison with the hazardous material. Where the cost of the substitute is higher, operating costs will increase; however, where the cost of the substitute is lower, operating costs will decrease. Some capital investment in equipment modifications or replacements to accommodate any differences in properties of the substitute substances may also be required. Alterations to processes to reduce use of hazardous substances may entail changes in operating budget, including possible reductions in costs due to more efficient operations. Capital investment for equipment modification or replacement may also be required.

3.2.1 Reduction Measures for Nonylphenol and its Ethoxylates

BMP #1: NPE Surfactant Substitution:

The sources of NPE in the dry cleaning and laundry services sector are primarily cleaning intensifiers, spot removers, and pre-brushing fluids used in the laundering process, and powder and liquid industrial laundry products. Since NPE is introduced through products, owners or operators can address substitution requirements through suppliers. (As noted in Section 2.1.1 above, the federal government has taken steps to control NPE in soap and cleaning products.) For the benefit to the owner or operator, some information on NPE surfactant substitution options is provided following.

NPE surfactant substitution is the replacement of NPE surfactants with suitable non-NPE surfactants. More specifically, linear alcohol ethoxylates (LAE) are the preferred substitute for NPE in most instances.[23] LAE appear to be substantially removed from water during biological sewage treatment. In general, the toxicity values for LAE substitutes are (on the whole) lower than for than for NPE, although there are certain LAE that are of similar toxicity to NPE.[24] Caution is therefore required in choosing substitute surfactants to ensure the replacement is less toxic.

For applications where LAE is not an appropriate substitute, other non-NPE surfactants with similar characteristics (readily degradable to non-toxic degradation products) should be selected.

As with all proposed substitutions, care must be taken to ensure that the substituted compound is not more toxic than the compound it is replacing. Octylphenols (OP) and octylphenol ethoxylates (OPE) are known substitutes for NPE; however, OP and OPE have similar toxicological properties and possibly greater estrogenic properties than NPE, and are therefore not appropriate alternatives to NPE.

BMP #2: Cleaning Product Supplier Policy

The sources of NPE in the dry cleaning and laundry services sector are primarily cleaning intensifiers, spot removers, and pre-brushing fluids used in the laundering process, and powder and liquid industrial laundry products. Therefore, a Cleaning Product Supplier Policy is a prudent step in pollution prevention for laundry facilities.

The Cleaning Product Supplier Policy should include a corporate policy regarding purchase of NPE-containing products. Refer, for example, to the Marks & Spencer policy that disallows the use of NPE in the manufacture or processing of Marks & Spencer goods.[25] Although this example applies to the textiles sector, a similar approach to the supply chain for laundry facilities can be adopted.

3.2.2 Reduction Measures for Cadmium and Mercury

BMP #3: Customer Material Acceptance Policy

The sources of cadmium and mercury in the dry cleaning and laundry services sector are primarily products delivered by customers for cleaning. Therefore, a Customer Material Acceptance Policy is a prudent step in pollution prevention for dry cleaning and laundry facilities. In a survey of 190 industrial laundries completed by the United States Environmental Protection Agency (USEPA), the most common pre-process pollution prevention activities were 1) refusal of items with free liquids

[23] Marbek et al., 2002
[24] http://www.defra.gov.uk/environment//chemicals/pdf/nonylphenol_rrs.pdf (accessed January 17, 2006)
[25] (Marks & Spencer, 2004)

(28% of facilities surveyed) and 2) refusal of certain items, such as shop towels, printer towels/rags, and industrial garments (22% of facilities surveyed).[26]

The following elements are recommended for the Customer Material Acceptance Policy:

- Refuse items with free liquids and suspect items. Items most often refused by the industrial laundries include shop and printer towels/rags. Where appropriate, require that customers centrifuge items to remove free liquids prior to drop-off.[27] Alternatively, require that customers allow items with free liquids to drain (in appropriate areas) prior to drop-off of the items.

- Require that customer-contaminated wipes with hazardous waste residues be delivered in closed containers to prevent the evaporation of any contaminants into the air, with clear labelling as to the contents and Material Safety Data Sheets (MSDS) affixed to the outside of the containers. (Note that MSDS are suitable for screening level information only since constituents present in materials in amounts less than 1% may not be identified.[28])

- Refuse storage containers with accumulated free liquids at the bottom of the container.

- Pre-sort items to remove trash/objects (e.g., thermometers containing mercury from hospitals, debris from industrial facilities).

- Segregate non-hazardous and hazardous waste streams, to allow for separate cleaning procedures.

- Require MSDS from all customers for all products used at customers' facilities, to identify sources of hazardous/toxic substances and to determine whether items should be refused.

- Initiate customer awareness programs to identify and limit cadmium and mercury in soiled items.

3.3 Operating Procedures and Housekeeping

Operating procedures and housekeeping BMPs are P2 measures that can be implemented concurrently with elimination/reduction BMPs and education/training BMPs. Some operating costs may be incurred to initiate improved operating and housekeeping practices, for example, to establish an inventory control system. Once

[26] U.S. EPA. *Technical Development Document for the Final Action Regarding Pretreatment Standards for the Industrial Laundries Point Source Category*. March 2000.
[27] The free liquid removed may require hazardous waste handling procedures and may also require explosion proof centrifuges. The customers' facility, rather than the laundry facility, is best equipped to do this, as facility staff are more knowledgeable of the substances contained on the items and the laundry receives a wide range of items from its customer base. In some cases, customers can reuse or recycle collected free liquids in their processes.
[28] Hazardous Products Act

implemented, however, these costs can be expected to be offset by optimized performance, reduced losses of time and materials, reduced liability, better-informed staff and management, and, potentially, improved customer satisfaction. Reliable record-keeping systems are needed to realize the full benefits of operating procedures and housekeeping BMPs. Minimal capital investment to implement operating and housekeeping BMPs can be expected.

A comprehensive management approach is important for effective reduction of releases of hazardous substances.

BMP #4: Knowing the Sources and Pathways of NPE

The following steps should be undertaken to understand sources and pathways of NPE in dry cleaning and laundry facilities:

1. Identify chemicals containing NPE and quantify concentrations;

2. Identify processes using NPE;

3. Establish a chemical use inventory to monitor usage and discharges through both inventory control and direct measurement; and

4. Substitute substances containing NPE with less-toxic alternatives, where substitutes exist.

BMP #5: Customer Material Processing

Dry cleaning and laundry facilities should sort products delivered by customers into clearly identified and properly contained separate non-hazardous and hazardous soiled items. This BMP complements BMP #3: Customer Material Acceptance Policy.

BMP #6: Inventory Control System

The following steps should be undertaken to manage incoming items that may be contaminated with metals:

- Identify customers who potentially provide laundry items containing cadmium or mercury. These customers may include automotive service facilities, printing facilities, laboratories, and hospitals.

- MSDS should be requested from these customers to identify the products used at their sites and that may be carried on items brought in to be dry cleaned and/or laundered. (Note that MSDS are suitable for screening level information only since constituents present in materials in amounts less than 1% may not be identified.[29])

[29] Hazardous Products Act

- Establish an inventory control system that tracks items from these customers. Use this system to assist in sorting potentially hazardous from non-hazardous items.

- Use hazardous/toxic waste exchange programs for items found in the laundry that contain or are suspected to contain cadmium/mercury, for example, thermometers and electronic goods.

3.4 Education and Training

Education and training are P2 measures that can be implemented concurrently with elimination/reduction BMPs and operating/housekeeping BMPs. Investments in education and training for management and staff can return significant benefits, including improved staff motivation, an improved health and safety record, reduced material losses, improved productivity, and, potentially, improved customer satisfaction. Communication and education of the supply chain, including material and equipment suppliers, can result in improved working relationships, as well as environmental benefits resulting from reduced pollution release.

It is important to keep education and training current and to ensure a management system is in place to maintain the relevance of education and training delivered. As mentioned above, a comprehensive management approach is important for effective reduction of releases of hazardous substances, including reductions through education and training.

Some operating costs may be incurred to initiate education and training practices, for example, time required to discuss improved materials specifications with suppliers. Once implemented, however, these costs can be expected to be offset by the benefits of education and training. Capital investment is not typically required for implementation of education and training practices.

BMP #7: Pricing Structure for Services

Implement different pricing structures for customers who provide articles that contain targeted substances to be reduced (e.g., mercury, cadmium). Articles that contain unwanted residues would command a higher price, to reflect the actual treatment costs involved in handling the contaminated items. Customers with articles that contain relatively benign substances would be charged a lower price. A differentiated pricing structure would provide incentive to customers to investigate alternatives to eliminate or reduce toxics, and also require customers to be knowledgeable on substances on their articles.

BMP #8: Management and Staff Training

The following components are part of a proactive training program to reduce exposure risks and release rates of hazardous substances:

- Ensure every employee is fully trained regarding the Customer Material Acceptance Policy before beginning his or her first employment shift.

- MSDS should be available for all compounds used in the dry cleaning and laundry facility. In addition, MSDS should be required from customers' hazardous/toxic substances that may be contained on items brought in for dry cleaning/laundering. (Note that MSDS are suitable for screening level information only since constituents present in materials in amounts less than 1% may not be identified.[30])

- Ensure employees are familiar with the site layout and catch basin locations. Ensure they employ good housekeeping practices and understand proper reporting procedures.

- Ensure all employees are aware of the spill response plan and are properly trained to carry it out.

- Document all employees' training and retain the records for a minimum of two years after the employee ceases employment. Information should include, for example, the date and location of training, subject(s) covered, test results if applicable, and trainer's name.

BMP #9: Supply Chain Education and Commitment

To gain a clear commitment from the whole supply base that NPE will not be deliberately introduced into any chemical formulations for production, laundry service providers may need to educate suppliers on the hazards and importance of reducing NPE discharges. Environment Canada and other Internet sources have useful material regarding the assessment and requirements for NPE management in Canada.

3.5 P2 Options and Costs

The rationale for selection of BMPs and associated cost estimates is outlined in this section. In general, information on the effectiveness and cost of P2 measures is not well documented in literature. Therefore, a number of estimating procedures were made with respect to the effectiveness and costs of implementing BMPs to eliminate or reduce the substances of concern. In the absence of specific information, rules of thumb were developed for each type of P2 measure, as summarized below.

Data in literature with respect to substance removal effectiveness of P2 measures is very sparse. Where data is provided, there is wide variability in results. Further, costs and cost savings information are not provided with sufficient context to be useful for this analysis. In the absence of directly relevant data, several rules of thumb were developed for P2 effectiveness and cost estimations were based on available literature information. Case study information from a range of literature sources for the six sectors of interest was researched to identify P2 effectiveness experience for any substance. These case study results were grouped by type of P2 measure and the

[30] Hazardous Products Act

data was assessed to derive a reasonable range of substance removal effectiveness. The following Table provides a summary of the rules of thumb for P2 effectiveness.

Table 3.2 Rules of Thumb for P2 Effectiveness

Type of P2 Measure	Estimated Percent Reductions in Releases			
	Material Substitution	**Process Modification**	**Operating/ Housekeeping**	**Education and Training**
Sub-Section title in BMP Document	Pollution Elimination or Reduction	Pollution Elimination or Reduction	Operating Procedures and Housekeeping	Education and Training
Rule of Thumb to Apply (in absence of specific information)	50% to 75%	10% to 40%	10% to 30%	1% to 30%

In the absence of directly relevant data for P2 costs, it was assumed that P2 costs primarily impact operating budgets, except in the case of process modifications where capital investments were also assumed to be required. Extrapolations of operating costs were derived from Statistics Canada data on annual average earnings by company size for manufacturing and service sector groups.

Table 3.3 Rules of Thumb for P2 Costs

P2 Rules of Thumb	Range of Costs			
Type of P2 Measure	**Material Substitution**	**Process Modification**	**Operating/ Housekeeping**	**Education and Training**
Rule of Thumb to Apply (in absence of specific information)	Materials budget implications of –2% to 4%; negligible for typical materials	¼ person year to 5 person year per modification, plus capital investment (annualized $5,000 per year for manufacturing sectors; $1,000 per year for service)	½% to 5% increase in operating budget staff time (off-set over time as a result of reduced liability, materials losses, etc.)	¼% to 2% increase in staff time (based on 240 workdays per year).

3.5.1 P2 Removal Effectiveness

For the Dry Cleaning and Laundry Services Sector, it was assumed that the most effective Elimination/Reduction P2 measure would be implemented for each substance of concern. In addition, all applicable measures in the Operating Procedures and Housekeeping group of BMPs and all applicable measures in the Education and Training group of BMPs are suitable for implementation in all facilities and there therefore included in the implementation scenario.

The most effective Elimination/Reduction P2 BMPs for NPE, cadmium, and mercury are as follows:

- NPE: NPE Surfactant Substitution - BMP #1.
- NPE: Cleaning Product Supplier Policy - BMP #2.
- Cadmium, Mercury: Customer Material Acceptance Policy - BMP #3.

Effectiveness of materials substitution for NPE removal is estimated to be 70%, based on substitution of NPE containing detergents. This reduction estimate includes the supplier policy to assist in the implementation of the materials substitution. The estimate is not higher due to two factors: 1) a current absence of alternatives for spot removal; and, 2) residual NPEs from previous washes are assumed to reduce the effectiveness of detergent substitutions.

Effectiveness for materials reduction for cadmium and mercury is estimated to be 30% removal, based on rules of thumb developed for application where no specific industry data was available. A materials acceptance policy is a process modification since it alters the materials entering the process (in this case, the cleaning process).

This estimate is at the upper mid-point of the assumed effectiveness of process modifications. The estimate acknowledges that customer compliance with the materials policy may vary and that some level of metals will continue to come into the process on materials that do meet the Materials Acceptance policy requirements.

The Operating Procedures and Housekeeping BMPs identified are as follows:

- NPE: Knowing the Sources and Pathways of NPE - BMP #4.
- Cadmium, Mercury: Customer Material Processing - BMP #5.
- Cadmium, Mercury: Inventory Control System - BMP #6.

The effectiveness of Operating Procedures and Housekeeping is estimated to be 20% removal of the remaining contaminants after materials substitution (i.e., the mid-range of assumed effectiveness of this group of BMPs).

In the case of NPE, Operating Procedures and Housekeeping are estimated to remove 20% of the remaining 30% of contaminants, for an additional 6% net reduction in NPE prior to treatment.

For cadmium and mercury, Operating Procedures and Housekeeping are estimated to remove 20% of the remaining 70% of contaminants, for an additional 14% net reduction in cadmium and mercury concentration in the wastewater effluent from dry cleaning and laundry facilities, prior to treatment (if necessary).

Applicable Education and Training BMPs for NPE, cadmium, and mercury are as follows:

- Cadmium, Mercury: Pricing Structure for Services - BMP #7.
- NPE, Cadmium, Mercury: Management and Staff Training - BMP #8

- NPE: Supply Chain Education and Commitment – BMP#9.

The effectiveness of Education and Training practices in removing NPE is assumed to be 2% removal of the remaining contaminants after materials substitution. This effectiveness rate is relatively low due to the fact that the Dry Cleaning and Laundry Services Sector staff and supply chain should be already familiar with issues associated with NPE since it is a high-profile contaminant. Nevertheless, Education and Training is an integral component of a comprehensive pollution prevention program and is needed to ensure the success of recommended BMPs.

For cadmium and mercury, Education and Training practices are estimated to remove 20% of the remaining 70% present in wastewater effluent, for an additional 14% removal.

In summary, for NPE, the combination of Substance Substitution, Operating Procedures and Housekeeping and Education/Training in the wastewater effluent from dry cleaning and laundry facilities is estimated to result in a cumulative removal of 77%. For cadmium and mercury, the combination of Substance Substitution, Operating Procedures and Housekeeping, and Education/Training in the wastewater effluent from dry cleaning and laundry facilities is estimated to result in a cumulative removal of 58%.

Table 3.4 provides a summary of the estimated effectiveness discussed in this section. Refer to Tables 5.1 to 5.4 (Section 5) for a summary of P2 BMP effectiveness and treatment measures to achieve the reference criteria.

Table 3.4 Summary of Effectiveness of P2 BMPs

Substance Addressed	BMP Name	BMP Number
Elimination/ Reduction Effectiveness: 30-70%		
NPE	NPE Surfactant Substitution	BMP #1
NPE	Cleaning Product Supplier Policy	BMP #2
Cadmium, Mercury	Customer Material Acceptance Policy	BMP #3
Operating Procedures and Housekeeping Effectiveness: 20% of the remaining substance after substitution		
NPE	Knowing the Sources and Pathways of NPE	BMP #4
Cadmium, Mercury	Customer Material Processing	BMP #5
Cadmium, Mercury	Inventory Control System	BMP #6
Education and Training Effectiveness: 2%[31] - 20% of the remaining substance after substitution		
Cadmium, Mercury	Pricing Structure for Services	BMP #7
NPE, Cadmium, Mercury	Management and Staff Training	BMP #8
NPE	Supply Chain Education and Commitment	BMP #9

3.5.2 P2 Costs

Costs for elimination/reduction measures (i.e., NPE cleaning agents material substitution and rejection of customer items containing cadmium and mercury) are assumed to be negligible for all sizes of facility. Some business may be lost from the Customer Material Acceptance Policy; however, these are expected to balance against the positive indirect benefits, such as reduced hazardous materials handling costs and reduced costs from worker health and safety claims due to cadmium and mercury (as well as other heavy metals) exposure.

Costs associated with implementation of Operating Procedures and Housekeeping BMPs are assumed to be proportional to staff complement and to cost between 0.5% and 5% of the staff budget. The upper end of this range would be applicable to facilities without well-established operating procedures and record-keeping practices. The cost estimates adopt the mid-range of the estimated percent of staff budget.

Costs associated with implementation of Education and Training BMPs are assumed to be proportional to staff complement and to cost between 0.25% and 2% of the staff budget. The upper end of this range would be applicable to facilities without

[31] Note that, in the case of NPE, the estimated effectiveness of education and training is at the lower end of the potential range because it is reasonable to assume that staff and the supply chain are already familiar with NPE due to their high profile in Canada (i.e., actions by the federal government under the Canadian Environmental Protection Act 1999). Therefore, while education and training continues to be important, additional estimated removals of the substances resulting from education and training are low.

well-established training programs or contact with supply chain representatives. The cost estimates adopt the mid-range of the rule of thumb range.

Estimated costs for implementation of the P2 BMPs are summarized in Table 3.5. Clearly, these estimates constitute a first-cut high-level estimate in the absence of facility-specific data and circumstances.

Table 3.5 Estimated Pollution Prevention Costs

Type of P2 Measure	Estimated Pollution Prevention Costs		
	Small Facilities (25 staff)	**Medium Facilities (175 staff)**	**Large Facilities (300 staff)**
Pollution Elimination or Reduction	negligible	Not applicable for the sector	
Operating/ Housekeeping	$20,000 annually		
Education and Training	$8,000 annually		
Total Estimate	$28,000 annually		

Note:

* Estimated annual costs for each P2 measure are approximations only; facility specific wastewater quality and operating practices must be assessed prior to selection of P2 practices.

4. TREATMENT

Treatment is not a P2 measure and it is not as effective as P2 in preventing the release of hazardous substances since it occurs after the hazardous substance has been used or created and subsequently becomes part of the facility's wastewater. With some treatment, the hazardous substance may be simply transferred from the water to the air or the sludge. Operating and capital costs of treatment can be significant. As a result, treatment should only be considered after P2 measures have been implemented and after all efforts have been taken to reduce or eliminate the substance first through P2 practices.

4.1 Treatment Measures

Treatment measures and BMPs must be assessed and implemented based on specific site and process conditions and characteristics. The following subsections present treatment processes to be considered where P2 alone does not meet the reference criteria.

The reference criteria outlined in Section 2.2 are provided for the purpose of assessing the potential for application of select treatment technologies for the select substances identified in this BMP document.

The following subsections provide a brief overview of typical treatment systems for the removal of individual pollutants. The processes described were based on estimated wastewater constituents for the dry cleaning and laundry services sector. The treatment review was based on representative wastewater data available for this sector.[32] Other treatment processes may be more applicable at facilities that have a wastewater stream significantly different from that used in this assessment.

4.1.1 Treatment Measures for NPE

Two types of treatment processes are potentially applicable to meet the reference criteria for NPE outlined in Section 2.2. The treatment processes provided are presented in sequential order of treatment requirements, with the process required to achieve the lowest concentration presented last. These treatment processes can be used alone or in combination, depending on specific wastewater properties.

- **Aerobic biological treatment:** Biological treatment involves contacting wastewater with a microbial reactor to remove biodegradable organic pollutants. The microorganisms convert the organic material into new microbial cells, which results in a sludge that requires disposal. Aerobic biological treatment involves adding air to the process to facilitate aerobic biodegradation, which is the process required for the contaminants of concern. Treatment can be either a suspended biomass system (such as activated sludge) or an attached growth system (e.g., trickling filters, rotating

[32] Refer to Section 2.1.

biological contactors). Both types of systems require a clarification process after the bioreactor. This process requires specific environmental control to operate effectively, e.g., sufficient aeration and a limited pH range. There are limited data available on the degradation of NPE in the biological treatment process; therefore, pilot testing is recommended for this process.

- **Granular activated carbon (GAC) or powdered activated carbon (PAC):** The GAC process involves pumping wastewater through a fixed-bed column containing GAC granules. The GAC adsorbs pollutants from the wastewater. A two-stage system may be required to reduce the concentration to below the concentrations required to meet the reference criteria. The spent GAC is regenerated off-site. The type of pollutants adsorbed and the extent of adsorption are a function of the source material for the GAC and the preparation procedure for the GAC granules. Typically, a sand or mixed media filter is required to remove suspended solids as a pre-treatment stage for a GAC filter. As an alternative to GAC, PAC can be added to the reactor of a suspended biomass biological treatment system. PAC cannot be regenerated and is disposed of as a waste with the biological treatment sludge. There are limited data on the removal efficiency of GAC or PAC for NPE; therefore, pilot testing is recommended for these processes.

Biological treatment will typically be required as a preliminary treatment stage before GAC treatment when the concentration of organic compounds in the wastewater [measured as 5-day biochemical oxygen demand (BOD_5)] is greater than 100 mg/L. For wastewater streams that have a relatively low BOD_5, GAC will be the most cost-effective treatment option, provided that GAC alone is sufficient to meet the reference criteria for NPE.

4.1.2 Treatment Measures for Cadmium

Three types of treatment processes are potentially applicable to meet the reference criteria for cadmium outlined in Section 2.2. The treatment processes provided are presented in sequential order of treatment requirements, with the process required to achieve the lowest concentration presented last. These treatment processes can be used alone or in combination, depending on specific wastewater properties.

- **Chemical precipitation:** Cadmium can be precipitated as insoluble cadmium hydroxide by pH adjustment. The precipitated metal is removed from the wastewater stream by flocculation followed by settlement. Filtration using a sand or mixed media filter may be used after settlement to further reduce the concentration. It is assumed that chemical precipitation and settlement is in place for facilities with raw wastewater cadmium concentrations in excess of the sewer use by-law limit. Therefore, this treatment stage was not included in the cost assessment for cadmium removal. It is important to note that some cadmium may accumulate in the sludge of a biological treatment system, which could be released during sludge treatment. Therefore, facilities using a

biological treatment system should chemically precipitate cadmium before biological treatment to minimize cadmium accumulation in biological sludge.

- **Granular activated carbon (GAC):** GAC is not a conventional treatment option for cadmium, as the removal efficiency is relatively low (around 30%). However, if a GAC process is used to remove organic pollutants, such as NPE, there will also be some reduction in the cadmium concentration. The GAC process involves pumping wastewater through a fixed-bed column containing GAC granules. The GAC adsorbs pollutants from the wastewater. The spent GAC is regenerated off-site. The type of pollutants adsorbed and the extent of adsorption are a function of the source material for the GAC and the preparation procedure for the GAC granules. Typically, a sand or mixed media filter is required to remove suspended solids as a pre-treatment stage for a GAC filter.

- **Reverse osmosis (RO) or Deionization (DI)**: RO or DI processes can be used as a polishing stage to further reduce the concentration of cadmium. Filtration using a sand or mixed media filter followed by microfiltration is typically used as a pre-treatment stage. The RO process separates water from dissolved materials in solution by filtering through a semipermeable membrane under pressure. The basic components of an RO system are the membrane, a membrane support structure, a containing vessel, and a high-pressure pump. The permeability of the membrane used, level of wastewater pre-treatment, and membrane cleaning are the key criteria for the performance of this process. RO results in a waste stream, or reject, that must be disposed of. For the DI process, specific ions are displaced from an insoluble exchange material (or resin) by different ions in solution. The spent resin is regenerated and reused. The waste stream from regeneration must be disposed of. The type of resin, level of wastewater pre-treatment, and frequency of regeneration are the key criteria for effectiveness of treatment for DI.

4.1.3 Treatment Measures for Mercury

Three types of treatment processes are potentially applicable to meet the reference criteria for mercury outlined in Section 2.2. The treatment processes provided are presented in sequential order of treatment requirements, with the process required to achieve the lowest concentration presented last. These treatment processes can be used alone or in combination, depending on specific wastewater properties.

- **Chemical precipitation:** Mercury can be precipitated as insoluble mercury sulfide by adding a sulfide salt (e.g., sodium sulfide) to the wastewater. The precipitated metal is removed from the wastewater stream by flocculation followed by settlement. Filtration using a sand or mixed media filter may be used after settlement to further reduce the concentration. It is assumed that chemical precipitation and settlement is in place for facilities with raw wastewater mercury concentrations in excess of the sewer use by-law limit.

Therefore, this treatment stage was not included in the cost assessment for mercury removal. It is important to note that some mercury may accumulate in the sludge of a biological treatment system, which could be released during sludge treatment. Therefore, facilities using a biological treatment system should chemically precipitate mercury before biological treatment to minimize mercury accumulation in biological sludge.

- **Granular activated carbon (GAC):** GAC is not a conventional treatment option for mercury as the removal efficiency is relatively low (around 30%). However, if a GAC process is used to remove organic pollutants, such as NPE, there will also be some reduction in the mercury concentration. The GAC process involves pumping wastewater through a fixed-bed column containing GAC granules. The GAC adsorbs pollutants from the wastewater. The spent GAC is regenerated off-site. The type of pollutants adsorbed and the extent of adsorption are a function of the source material for the GAC and the preparation procedure for the GAC granules. Typically, a sand or mixed media filter is required to remove suspended solids as a pre-treatment stage for a GAC filter.

- **Reverse osmosis (RO) or Deionization (DI):** RO or DI treatment can be used as a polishing stage to further reduce the concentration of mercury. Filtration using a sand or mixed media filter followed by microfiltration is typically used as a pre-treatment stage. The RO process separates water from dissolved materials in solution by filtering through a semipermeable membrane under pressure. The basic components of an RO system are the membrane, a membrane support structure, a containing vessel, and a high-pressure pump. The permeability of the membrane used, level of wastewater pre-treatment and membrane cleaning are the key criteria for the performance of this process. RO results in a waste stream, or reject, that must be disposed of. For the DI process, specific ions are displaced from an insoluble exchange material (or resin) by different ions in solution. The spent resin is regenerated and reused. The waste stream from regeneration must be disposed of. The type of resin, level of wastewater pre-treatment and frequency of regeneration are the key criteria for effectiveness of treatment for DI.

4.2 Treatment Options and Costs

Treatability information is provided for the individual pollutants specified in Tables 5.1 to 5.4 as a guide (Section 5). Based on the estimated wastewater concentrations of NPE, cadmium, and mercury after P2 measures, an assumption that BOD_5 is less than 100 mg/L[33], and assuming the combined reduction or removal of NPE,

[33] Regardless of BOD5 concentration in the wastewater, a combination of both biological treatment and GAC is required to achieve the removals of NPE for all three reference criteria, unless more aggressive P2 measures can be implemented to eliminate the sources of NPE. With more aggressive P2 implementation, biological treatment will, nevertheless, be required for wastewater BOD_5 concentrations greater than 100 mg/L.

cadmium, and mercury, the overall full treatment systems in terms of sequential process steps for each target reference criteria are as follows:

- Reference Criteria 1: biological treatment, sand/mixed media filtration, GAC, microfiltration, RO, and DI;
- Reference Criteria 2: biological treatment, sand/mixed media filtration, GAC, microfiltration, and DI; and
- Reference Criteria 3: biological treatment, sand/mixed media filtration, and GAC.

DI is required to remove cadmium and mercury. For Reference Criteria 1, both RO and DI are required for metals removal. Biological treatment and GAC are required to remove NPE to meet all three reference criteria. GAC will also reduce the concentration of cadmium and mercury in wastewater.

The proposed treatment strategies identified above serve as preliminary guidelines for the full level of treatment likely to be required. Different treatment options may be required, depending on the wastewater constituents and strength. Assuming more aggressive P2 measures for the substantial reduction or elimination of NPE, and assuming low BOD_5 concentration in the wastewater, GAC alone may be able to reduce the levels of NPE to the required reference criteria concentrations. For cadmium, treatment is required to meet Reference Criteria 1 and 2; P2 measures can achieve Reference Criteria 3. For mercury, treatment is required to meet Reference Criteria 1; P2 measures can achieve Reference Criteria 2 and 3.

Cadmium and mercury treatment technologies include deionization (DI) and/or reverse osmosis (RO). There will also be some removal of these metals with GAC. Cadmium and mercury levels in the wastewater after P2 measures are sufficiently low such that chemical precipitation is not required as the first treatment step for reduction of these metals. Through more aggressive P2 practices to remove metals, it may be possible to eliminate the DI component required to meet Reference Criteria 1 and 2. There may also be site-specific cases where RO is a better option than DI for metals removal.

Site and facility specific information is needed to determine what treatment trains and components are required to achieve the reference criteria. A typical total treatment process for dry cleaning and laundry services wastewater after P2 measures will provide treatment for all pollutants identified in the wastewater. A comprehensive analysis of the wastewater stream is required and bench-scale and/or pilot testing of treatment may be needed to verify the optimum treatment system for a specific facility.

Capital and annual operational and maintenance (O&M) costs were developed for full treatment for the three reference criteria using a wastewater flow range of 1 m^3/h to 50 m^3/h. The estimated costs are presented in Table 4.1. Costs are also provided for two other treatment scenarios, namely the substantial reduction or elimination of

metals by more aggressive P2 measures (i.e., no DI required), and the substantial reduction or elimination of both metals and NPE through more aggressive P2 measures (i.e., GAC treatment, no DI).

The costs provided in Table 4.1 are conceptual level only, normally considered to be accurate to a range of –35% to + 50%.

Table 4.1 Estimated Capital and Annual O&M Costs

Reference Criteria	Approximate Costs as Function of Flow Range of 1 to 50 m^3/h*					
	Capital Cost Range			Annual O&M Cost Range		
	1m^3/h	25 m^3/h	50 m^3/h	1m^3/h	25 m^3/h	50 m^3/h
Full Treatment						
Criteria 1	$546,000	$3,025,000	$4,809,000	$82,000	$363,000	$481,000
Criteria 2	$502,000	$1,713,000	$2,850,000	$75,000	$206,000	$285,000
Criteria 3	$314,000	$978,000	$1,497,000	$47,000	$117,000	$150,000
Treatment Assuming Low Metals (i.e., no DI)						
Criteria 1	$371,000	$2,312,000	$3,526,000	$56,000	$277,000	$353,000
Criteria 2	$314,000	$978,000	$1,497,000	$47,000	$117,000	$150,000
Criteria 3	$70,000	$438,000	$748,000	$10,000	$53,000	$75,000
Treatment Assuming Low Metals and Low NPE (i.e., GAC treatment, No DI)						
Criteria 1	$70,000	$438,000	$748,000	$10,000	$53,000	$75,000
Criteria 2	$70,000	$438,000	$748,000	$10,000	$53,000	$75,000
Criteria 3	$0	$0	$0	$0	$0	$0

Note:

* Refer to Figures 4.1 to 4.3 for capital and O&M costing curves to estimate full treatment costs for a specific flow rate. Costs exclude chemical precipitation (metals removal), which is assumed to be installed. If required, the following estimated capital costs should be added: 1 m^3/hr = $67,200; 25 m^3/hr = $371,000; 50 m^3/hr = $658,000.

The capital costs presented in Table 4.1 do not include chemical precipitation for metals pre-treatment and removal, as it is assumed that this would be a treatment process already installed and operating. Should a particular plant or facility not have a chemical precipitation system installed, then the capital costs should be increased accordingly, as shown in Table 4.1. Costing includes engineering, equipment, piping and instrumentation, electrical and controls, installation, and construction costs.

The annual O&M costs were determined as a function of percentage of capital costs, assuming 15% for the 1 m^3/h flow condition, 12% for the intermediate 25 m^3/h flow condition, and 10% for the 50 m^3/h flow condition. Annual O&M costs include a consideration of the following:

- Increased power and energy costs to operate the additional treatment processes;
- Chemical costs for treatment chemicals, where required;
- Additional labour costs for operation;
- Sampling and monitoring costs for the specific substances requiring treatment; and
- Disposal costs for residues and waste streams generated from treatment.

Figures 4.1 to 4.3 show capital and annual O&M costing curves for the estimated full treatment cost ranges presented in Table 4.1 for each set of reference criteria.

Figure 4.1 Dry Cleaning and Laundry Sector Capital and O&M Costs for Reference Criteria 1

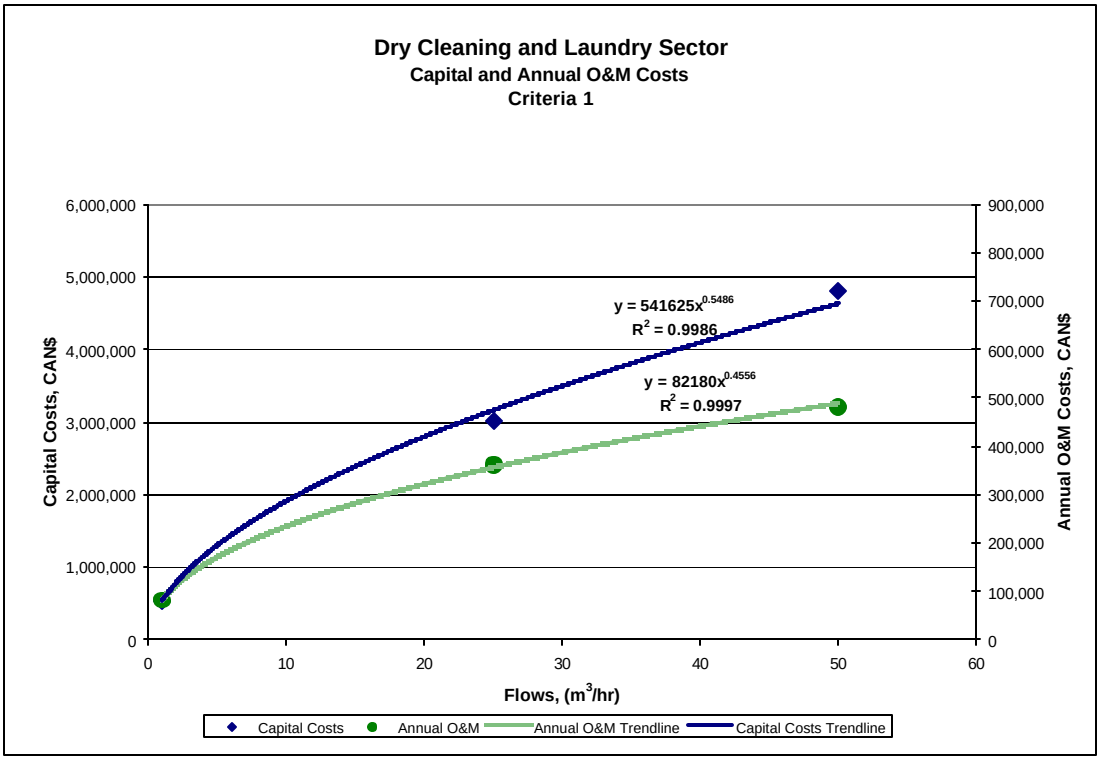


Figure 4.2 Dry Cleaning and Laundry Sector Capital and O&M Costs for Reference Criteria 2

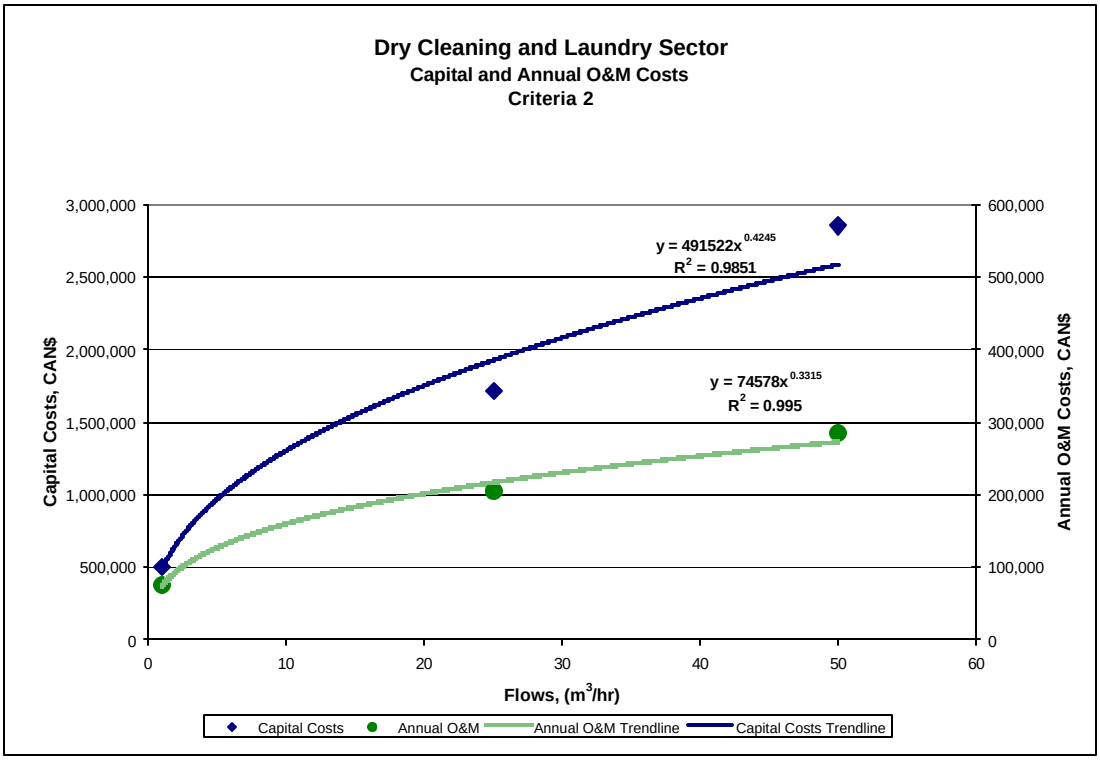


Figure 4.3 Dry Cleaning and Laundry Sector Capital and O&M Costs for Reference Criteria 3

5. OPTIONS FOR REDUCTION OF SUBSTANCE CONCENTRATIONS IN EFFLUENTS

The following tables outline the combination of P2 measures and treatment evaluated for substance removal effectiveness. These measures were chosen on the basis of ability to achieve the reference criteria, costs, and feasibility for implementation.

Based on the estimating procedures used to determine initial concentrations and percent removal resulting from implementation of P2 measures, some reference criteria may be met with P2 alone (i.e., no additional treatment required):

- Reference Criteria 1: No substances.
- Reference Criteria 2: Mercury.
- Reference Criteria 3: Cadmium and mercury.

In the case of NPE, treatment is required to meet all three reference criteria, unless aggressive elimination of all NPE sources is undertaken. Site and facility specific analysis of the wastewater stream is required to determine which pollutants can be reduced to the reference criteria by implementation of P2 measures.

Information provided in the tables is based on assumptions for the concentration of each substance in wastewater before and after P2 measures. Treatability information is also based on estimated removal rates for treatment processes. A detailed analysis of the waste streams and the wastewater would be required for each facility to determine the optimum treatment system should this be required after P2 implementation.

Table 5.1 Summary: Nonylphenol

Table 5.2 Summary: Nonylphenol Ethoxylates

Table 5.3 Summary: Cadmium

Table 5.4 Summary: Mercury

6. REFERENCES

The following documents were key in preparing this summary of BAT for this sector/substance combination:

1. APE Research Council. *Top Ten Treatment Tips for NPE*. Undated. Available at URL: http://www.aperc.org/toptentreatment.pdf

2. Business for Social Responsibility. *Water Quality Guidelines and Pollutant Fact Sheets.* Spring 2002. Available at URL: http://www.bsr.org/CSRResources/Environment/WQG_Pollutant_FactSheet.pdf

3. Danish Environmental Protection Agency. *Mapping of chemicals in dry-cleaned textiles from Rynex and hydrocarbon dry-cleaning shops*, 2003. Available at URL: http://www.mst.dk/chemi/01081501.htm

4. Marks & Spencer. *Environmental Code of Practice Dyeing, Printing and Finishing, Issue No. 5*, September 2004. Available at URL: http://www2.marksandspencer.com/thecompany/ourcommitmenttosociety/environment/reports/

5. OSPAR Commission. *Hazardous Substances Series: Nonylphenol/Nonylphenolethoxylates*, 2001 (2004 Update). Available at URL: http://www.ospar.org/documents/dbase/publications/p00136_BD%20on%20nonylphenol.pdf

6. U.S. Environmental Protection Agency. *Technical Development Document for the Final Action Regarding Pre-treatment Standards for the Industrial Laundries Point Source Category*. Revised March 2000. Available at URL: http://www.epa.gov/waterscience/guide/laundry/techdevfinal.html

7. U.S. Environmental Protection Agency. *Occurrence and Treatability of Priority Pollutants in Industrial Laundry Wastewaters (Draft Final Report).* Available at URL: http://www.p2pays.org/ref/15/14141.pdf

8. Western Lake Superior Sanitary District. *Blueprint for Mercury Elimination: Mercury Reduction Project Guidance for Wastewater Treatment Plants.* Revised January 2002. Available at URL: http://www.wlssd.duluth.mn.us/publications/Blueprint for mercury/Revised Blueprint for Mercu.pdf

7. GLOSSARY OF TERMS

Best Management Practices (BMPs) to reduce or eliminate pollutants encompass a wide range of activities including changes to materials or processes, operating procedures, housekeeping activities, and treatment techniques. BMPs may also include management activities, such as education and training, record-keeping and reporting, information systems, and communication with stakeholders, customers, and supply chain partners. BMPs can also include management approaches such as loss control programs and environmental management systems.

Canadian Environmental Protection Act 1999 (CEPA 1999) is federal legislation that was first created in 1988 and consolidated various pieces of 1970s environmental legislation.[34] In addition, CEPA 1999 added many new Ministerial authorities and obligations, including new requirements for risk assessment and risk management of toxic substances and a strengthened pollution prevention approach.

Criteria are the reference criteria identified for analysis. There are three reference criteria, with Reference Criteria 1 being the most stringent and Reference Criteria 3 the least stringent.

Environmental Management System (EMS)[35] refers to management systems focussed on the minimization of harmful effects on the environment caused by corporate activities. Management systems in general are part of an organization's structure for managing its processes or activities that transform inputs of resources into a product or service, which meet the organization's objectives, such as satisfying the customer's quality requirements, complying with regulations, or meeting environmental objectives. Environmental management is what the organization does to minimize harmful effects and to achieve continual improvement of its environmental performance.

Hazardous Substances refers to substances that are potentially harmful to the environment or human health and safety. Hazardous substances include substances considered toxic under the Canadian Environmental Protection Act 1999, as well as other substances of interest subject to international agreement and reporting requirements. Refer to the Appendices for a list of substances of particular interest in this series of BMP documents.

Industrial Facility Representatives may include any industrial employee or contractor of an industrial sector with responsibility, for example, for facility operations, facility design, public relations, compliance.

National Pollution Release Inventory (NPRI) is a database of information on annual releases to air, water, land, and disposal or recycling from all sectors -

[34] Refer to the CEPA 1999 Environmental Registry for more information at URL: http://www.ec.gc.ca/CEPARegistry/default.cfm

[35] Definition adapted from definitions by the International Organization for Standardization, URL: http://www.iso.org/iso/en/iso9000-14000/understand/inbrief.html

industrial, government, commercial, and others.[36] The NPRI is a national reporting system legislated under the Canadian Environmental Protection Act 1999.

Municipal Representatives may include any municipal employee or contractor with responsibility, for example, wastewater quality, wastewater infrastructure management, industrial sewer use programs, industrial relations, public outreach, and/or by-law enforcement.

NAICS Code is the North American Industry Classification System (NAICS), which assigns numerical codes to industrial sectors and sub-sectors in North America. This system has replaced an older system of classification, known as the U.S. Standard Industrial Classification (SIC) system. Statistics Canada uses the NAICS classification system in its analysis of industrial activities in Canada.

Pollution Prevention (P2) is "the use of processes, practices, materials, products, substances or energy that avoids or minimizes the creation of pollutants and waste, and reduces the overall risk to the environment or human health."[37]

Reference Criteria are the maximum desired final effluent concentrations for the harmful substances identified. Three reference criteria were identified for analysis in terms of pollution prevention measures and treatment measures required to achieve the reference criteria.

Rules of Thumb are sets of engineering estimates based on similar or related datasets, professional judgement, and stated assumptions. Rules of Thumb are applied where specific information is not available. In the absence of specific information, Rules of Thumb can be used to develop reasonable ranges of potential outcomes or effects resulting from actions taken (such as implementation of certain P2 or treatment measures, for example).

Substances of Interest are the potentially hazardous substances or toxic substances examined within this series of best management practices. Refer to the Appendices for a list of substances of particular interest in this series of BMP documents.

Supply Chain refers to the network of organizations that provide materials, products, and services to industrial sectors in order that the industry can produce, market, and sell its products. The supply chain can include organizations selling raw materials, organizations selling semi-finished and finished goods, retail outlets, customers, etc.

Treatment in this document refers to wastewater treatment processes used to remove or transform pollutants in the wastewater stream. Treatment is not

[36] See the NPRI website at URL: http://www.ec.gc.ca/pdb/npri/npri_home_e.cfm
[37] Definition in Guidelines for the Implementation of the Pollution Prevention Planning Provisions of Part 4 of the *Canadian Environmental Protection Act*, 1999 (CEPA 1999), National Office of Pollution Prevention, Environment Canada, 2001

considered a pollution prevention measure since it occurs after pollutants have been introduced or used in a process; pollutants that are present in a wastewater stream indicate that opportunities to prevent pollution have passed and treatment must therefore be used to reduce release of the pollutants to the environment.

APPENDIX A

BEST MANAGEMENT PRACTICES DOCUMENTS

APPENDIX A: BEST MANAGEMENT PRACTICES DOCUMENTS

Table A.1 identifies the available Best Management Practices Documents in this series, and the industrial sectors and harmful pollutants which are addressed in each.

Table A.1 Industrial Sectors and Substances Addressed in BMP Documents

Document Name	Sector and Sub-Sector Titles and NAICS Codes	Harmful Pollutants
Best Management Practices. Textiles Sector: Nonylphenol and its Ethoxylates and Chromium	Textiles Sector (313) Fibre, Yarn, Thread Mills Fabric Mills Textile and Fabric Finishing and Fabric coating	Nonylphenol and its ethoxylates Chromium
Best Management Practices. Fabricated Metal Product Manufacturing: Cadmium, Lead and Copper	Fabricated Metal Product Manufacturing (332) Forging and Stamping Architectural and Structural Metals Manufacturing Boiler, Tank and Shipping Container Manufacturing Spring and Wire Product Manufacturing Coating, Engraving, Heat Treating and Allied Activities Other Fabricated Metal Product Manufacturing	Cadmium Lead Copper
Best Management Practices. Motor Vehicle Parts Manufacturing: Cadmium and Nonylphenol and its Ethoxylates	Motor Vehicle Parts Manufacturing (3363) Motor Vehicle Gasoline Engine and Engine Parts Manufacturing Motor Vehicle Electrical and Electronic Equipment Manufacturing Motor Vehicle Metal Stamping Motor Vehicle Steering and Suspension Components (except Spring)Manufacturing Motor Vehicle Brake System Manufacturing Motor Vehicle Transmission and Power Train Parts Manufacturing	Cadmium Nonylphenol and its ethoxylates

Document Name	Sector and Sub-Sector Titles and NAICS Codes	Harmful Pollutants
Best Management Practices. Automotive Repair and Maintenance: Cadmium and PAHs	Automotive Repair and Maintenance (8111) Automotive Repair and Maintenance Automotive Body, Paint and Interior Repair and Maintenance Car Washes	Cadmium PAHs
Best Management Practices. Dry Cleaning and Laundry Services: Nonylphenol and its Ethoxylates, Cadmium, and Mercury	Dry Cleaning and Laundry Services (8123) Dry Cleaning and Laundry Services (except Coin-Operated) Linen and Uniform Supply	Nonylphenol and its ethoxylates Cadmium Mercury
Best Management Practices. Chemical Manufacturing Sector: Cadmium, Chromium, Copper, Mercury, Zinc, Nonylphenol and its Ethoxylates, and Vinyl Chloride	Chemical Manufacturing Sector (325) Basic Chemical Manufacturing (NAICS 3251); Pharmaceutical and Medicine Manufacturing (NAICS 3254); Soap, Cleaning Compound and Toilet Preparation Manufacturing (NAICS 3256) Other Chemical Product Manufacturing (NAICS 3257)	Cadmium Chromium Copper Mercury Zinc Nonylphenol and its ethoxylates Vinyl chloride
Best Management Practices. Chemical Manufacturing Sector: Resin, Synthetic Rubber, and Artificial and Synthetic Fibres and Filaments Manufacturing: Cadmium, Chromium, Copper, Mercury, Zinc, Nonylphenol and its Ethoxylates, and Vinyl Chloride	Chemical Manufacturing Sector (325) Resin, Synthetic Rubber, and Artificial and Synthetic Fibres and Filaments Manufacturing (NAICS 3252)	Cadmium Chromium Copper Mercury Zinc Nonylphenol and its ethoxylates Vinyl chloride

Document Name	Sector and Sub-Sector Titles and NAICS Codes	Harmful Pollutants
Best Management Practices. Chemical Manufacturing Sector: Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing: Cadmium, Chromium, Copper, Mercury, Zinc, and Nonylphenol and its Ethoxylates	Chemical Manufacturing Sector (325) Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing (NAICS 3253)	Cadmium Chromium Copper Mercury Zinc Nonylphenol and its ethoxylates
Best Management Practices. Chemical Manufacturing Sector: Paint, Coating, and Adhesive Manufacturing: Cadmium, Chromium, Copper, Mercury, Zinc, and Nonylphenol and its Ethoxylates	Chemical Manufacturing Sector (325) Paint, Coating, and Adhesive Manufacturing (NAICS 3255)	Cadmium Chromium Copper Mercury Zinc Nonylphenol and its ethoxylates
Best Management Practices. 1,4-Dichlorobenzene, 3,3-Dichlorobenzidine, Hexachlorobenzene, and Pentachlorophenol: Non-Sector Specific Practices	Not applicable.	1,4-Dichlorobenzene 3,3-Dichlorobenzidine Hexachlorobenzene Pentachlorophenol

APPENDIX B

TEMPLATES

APPENDIX B – TEMPLATES (TASK 5)

To be provided upon completion of Task 5.

APPENDIX C

SUB-SECTOR DEFINITIONS

APPENDIX C – SUB-SECTOR DEFINITIONS

Definitions for this NAICS[38] sector are provided below:[39]

Dry Cleaning and Laundry Services (NAICS 8123).

This industry group comprises establishments primarily engaged in providing self-service laundry and dry-cleaning facilities for public use; providing dry cleaning and laundering services; laundering and supplying laundered uniforms, linens, and other fabric items; and providing other laundry services.

The following sub-sectors in the Dry Cleaning and Laundry Services Sector are the focus of this document:

- Dry Cleaning and Laundry Services (except Coin-Operated) (NAICS 812320)

  This Canadian industry comprises establishments primarily engaged in laundering, dry cleaning, and pressing apparel and linens of all types, including leather. These establishments may also provide clothing repair and alteration services. Laundry pick-up and delivery stations, operated independently from power laundries, and dry-cleaning plants, and establishments primarily engaged in cleaning, repairing, and storing fur garments are also included.

- Linen and Uniform Supply (NAICS 812330)

  This Canadian industry comprises establishments primarily engaged in supplying and laundering towels, napkins, table cloths, sheets, gowns, aprons, diapers, and other linen items, for household or commercial use, typically on a contract basis. Establishments engaged in supplying and laundering commercial and industrial uniforms, laboratory coats, safety gloves, and flame and heat resistant clothing are also included.

[38] North American Industry Classification System (NAICS) used by Statistics Canada. The NAICS is an industry classification system developed by the statistical agencies of Canada, Mexico and the United States. Created against the background of the North American Free Trade Agreement, it is designed to provide common definitions of the industrial structure of the three countries and a common statistical framework to facilitate the analysis of the three economies.
http://www.statcan.ca/english/Subjects/Standard/naics/2002/naics02-intro.htm (accessed December 20, 2005

[39] http://stds.statcan.ca/english/naics/2002/naics02-class-search.asp?criteria=8123 (accessed December 20, 2005)

APPENDIX D

AGREEMENTS FOR TOXIC REDUCTION AND SUBSTANCES OF CONCERN

APPENDIX D – AGREEMENTS FOR TOXIC REDUCTION AND SUBSTANCES OF CONCERN

Following is the list of agreements and programs identified by the Ontario MOE to be of particular concern. These agreements and programs were the impetus behind the development of this series of BMP documents.

- The 2002 Canada-Ontario Agreement respecting the Great Lakes Basin Ecosystem (COA), which identifies the goal of virtual elimination Tier I substances, reductions of Tier II substances and virtual elimination of 17 PAHs.
- The *Canadian Environmental Protection Act*, 1999 (CEPA).
- The 1997 Bi-National Toxics Strategy (BNTS), signed by Environment Canada and the USEPA.
- The Ontario government's commitment to implement recommendation #32 of Commissioner O'Connor's Report on the Walkerton Inquiry Part 2 to support major wastewater plant operators to identify practical methods to reduce or remove heavy metals and priority organics that are not removed by conventional treatment.

The following hazardous substances are subject of the agreements identified above and/ or subject of potential concern due to environmental and human health effects. (Note that not all of these substances have been addressed in the series of BMP documents for the six sectors.)

Table D.1 Substances of Concern Subject to Agreements

Substance	COA	CEPA	BNTS
1,4-dichlorobenzene	Tier II	n/a	Level II
3,3-dichlorobenzidine	Tier II	Schedule 1	Level II
alkyl-lead	Tier I	n/a	Level I
cadmium	Tier II	n/a	Level II
chromium	n/a	n/a	n/a
copper	n/a	n/a	n/a
dioxins and furans	Tier I	n/a	Level I
hexachlorobenzene	Tier I	Schedule 1	Level I
hexachlorobutadiene/hexachloro-1,3-butadiene	n/a	Schedule 1	Level II
hexachlorocyclohexane	Tier II	n/a	Level II
lead	n/a	Schedule 1	n/a
mercury	Tier I	Schedule 1	Level I
nonylphenol and ethoxylates	n/a	Schedule 1	n/a
octachlorostyrene	Tier I	n/a	Level I
polynuclear aromatic hydrocarbons (PAHs)	Tier II	Schedule 1	Level II
pentachlorophenol	Tier II	n/a	Level II
vinyl chloride	n/a	Schedule 1	n/a
zinc	n/a	n/a	n/a

APPENDIX E

CASE STUDY EXAMPLES DEMONSTRATING BENEFITS OF P2 MEASURES

APPENDIX E: CASE STUDY EXAMPLES DEMONSTRATING BENEFITS OF P2 MEASURES

The following case studies pertain to facilities among the six industrial sectors of interest for this BMP series. The case studies demonstrate the reduction effectiveness of P2 measures for specific applications while, at the same time, demonstrating the benefits of undertaking P2 measures. Reference information is provided for further investigation of the case study experience.

Proponents are encouraged to document their experience with P2 measures for publication as case studies. Several organizations recognize leadership in Canada in the area of P2 implementation, including the Canadian Council of Ministers of the Environment (CCME).

Case Study for P2 Measure: Material Substitution

Hafner Inc., with four facilities in Granby, Quebec, is the largest Canadian manufacturer of furniture fabric and stretch knitted fabric. Material substitution enabled the company to reduce its nonylphenol and nonylphenol ethoxylated derivatives load from 6,800 kilograms in 2001 to 68 kilograms in 2003. The chemical oxygen demand (COD) of the wastewater was reduced from 210,000 kilograms per year to 110,000 kilograms per year. The reduction in COD reduced the annual effluent disposal costs by $15,000. For further information, see the following:

Environment Canada's Pollution Prevention Success Stories website: Hafner Inc.
http://www.ec.gc.ca/pp/en/storyoutput.cfm?storyid=111

Case Study for P2 Measure: Process Modification

Monsanto Company, Muscatine, Iowa Plant, is a large agricultural herbicide manufacturing facility. Through internal recycling and process modifications, the facility reduced wastewater biochemical oxygen demand (BOD) loading by 97 %. For further information, see the following:

U.S. Environmental Protection Agency's National Environmental Performance Track website: Performance Track Case Study Monsanto Company – Muscatine, Iowa Plant
http://www.epa.gov/performancetrack/tools/casestudies/MonsantoCaseStudy.pdf

Case Study for P2 Measure: Operating Procedures and Housekeeping

Hendersons Automotive Group, a major supplier of seating components, has implemented several good housekeeping measures which have helped raise pollution prevention consciousness among the 180 employees at the company's Melrose Park plant in South Australia. Cleaner production measures introduced have resulted in annual savings of $270,000. The measures cost a total of $309,000 and paid for themselves in only 18 months after implementation. For more information, see the following:

Australian Department of the Environment and Heritage's Eco-Efficiency and Cleaner Production website: Hendersons Automotive Group Cleaner Production – Continuous Improvement Programs
http://www.deh. gov.au/settlements/industry/corporate/eecp/case-studies/hendersons.html

Case Study for P2 Measure: Process Modification

Monroe Australia is a leading Adelaide-based manufacturer of shock absorbers and strut suspension units for the automotive industry. The company has implemented a major waste minimization strategy that has enabled it to process liquid waste, reduce water usage, reduce chemical and waste disposal costs, and eliminate pollution. It installed new equipment which treats wastewater to remove emulsified fats and oils, grease, heavy metals and all forms of suspended, colloidal and some dissolved solids. Monroe's mains water usage has been reduced by over 10 ML per year; wastewater discharge to sewer has been reduced by 50 percent. The new technology has produced a savings of $250,000 per year with total outlay of $530,000 for a payback period of approximately two years. For more information, see the following:

Australian Department of the Environment and Heritage's Eco-Efficiency and Cleaner Production website: Monroe Australia Pty Ltd Cleaner Production – Waste Minimisation Strategy
http://www.deh.gov.au/settlements/industry/corporate/eecp/case-studies/monroe.html

Case Study for P2 Measure: Process Modification and Operating Procedures

Specific Plating is a small metal finishing company where parts are plated with metals such as copper, nickel, zinc, silver, and gold. Specific Planting has dramatically reduced its sewer discharges of copper and nickel through pollution prevention efforts including both modifications of industrial processes and improved waste handling and treatment techniques. After the completion of the P2 projects, a reduction of approximately 88% for copper discharges and 85% for nickel discharges was achieved. Wastewater discharge flow has been reduced 27% and off-site sludge disposal has been reduced 53%.

Installation of equipment or changes in operating procedures required an investment of $63,000. Annual savings of $30,000 was realized with the payback period ranging from 1.5 years to just under 3 years. For more information, see the following:

City of Palo Alto's website: Pollution Prevention at Specific Plating Company
http://www.city.palo-alto.ca.us/public-works/documents/cb-specific.pdf