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FINAL
BEST MANAGEMENT PRACTICES
TEXTILES SECTOR:
NONYLPHENOL AND ITS ETHOXYLATES
AND CHROMIUM

Prepared for:

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EXECUTIVE SUMMARY

This Best Management Practices (BMPs) document for the Textiles 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) and chromium in wastewater effluents of the textiles sector. The two primary audiences for this document are municipal representatives and industrial facility representatives. Specific sub-sectors within the textiles sector addressed include Fibre, Yarn, Thread Mills (NAICS¹ 3131); Fabric Mills (NAICS 3132); and Textile and Fabric Finishing and Fabric Coating (NAICS 3133).

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.

NPE can be used in surfactants, cleaning agents, or wetting and de-wetting agents; however, their use has decreased significantly in Canadian textile mills since they were declared toxic under the *Canadian Environmental Protection Act* (CEPA). The majority of textile mills have reached the Pollution Prevention - Phase Two 95% reduction target established by Environment Canada. Some NPE are still used in textile mills, primarily in oils for knitting and hosiery production equipment.² Textile mills releasing NPE may operate within any of the NAICS sub-sectors of interest.

Chromium in textile mill effluents can be introduced in two primary ways: 1) dyes and dye processes; and 2) on-site laboratory operations. Heavy metals are typically used in textiles dyes to achieve brilliance in colours. Other minor sources of metals include impurities in materials other than dyes, including fibres, salts, caustic, and soda ash.

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

² Personal communication. Fintex Mechanical and Process Inc. January 2006. Based on the Environment Canada website, a 95% reduction of the total mass of nonylphenol and/or nonylphenol ethoxylates used and/or imported annually, from base year levels, is required for persons/facilities as defined by Environment Canada (refer to website).

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

Substance	Reference Criteria 1 (mg/L)	Reference Criteria 2 (mg/L)	Reference Criteria 3 (mg/L)
Chromium	0.2	1	5
Nonylphenol	0.001	0.001	0.0025
Nonylphenol Ethoxylates	0.001	0.01	0.025

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. Pollution prevention (P2) is defined as “the use of processes, practices, materials, products, substances or energy that avoid or minimize the creation of pollutants and waste, and reduce the overall risk to the environment or human health.”³ P2 measures are more effective than treatment in reducing releases of hazardous substances and should, therefore, be implemented in preference to treatment to meet 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 & Chromium	Automated Chemical Dosing Systems	BMP #1
NPE & Chromium	Low Liquor Ratio Dyeing Machines	BMP #2
NPE & Chromium	Cold Pad Batch Dyeing	BMP #3
NPE	NPE Surfactant Substitution	BMP #4
Chromium	Metal Dye Substitution	BMP #5
Chromium	Dye Auxiliary Techniques	BMP #6
Chromium	Low-Chrome Techniques	BMP #7
Operating Procedures and Housekeeping		All Sub-Sectors
NPE & Chromium	Quality Control for Raw Materials	BMP #8
NPE & Chromium	Chemical Use Inventory	BMP #9
NPE	Knowing the Sources and Pathways of NPE	BMP #10

³ 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

Table ES.2 (cont'd) Summary of P2 BMPs

Substance Addressed	BMP Name	Sub-Sector/ BMP Number
Chromium	“Smart” scheduling of machine cleaning	BMP #12
Chromium	Knowing the metal-content of dyes and other materials	BMP #13
Chromium	Improved Laboratory Procedures	BMP #14
Education and Training		All Sub-Sectors
NPE & Chromium	Management and Staff Training	BMP #15
NPE & Chromium	Supply Chain Education and Commitment	BMP #16
NPE	Industry Standards for NPE	BMP #17
Chromium	Industry Standards for Chromium Dyestuff	BMP #18

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 Selected P2 BMPs

Substance Addressed	BMP Name	BMP Number
Elimination/ Reduction Effectiveness: 70 – 95%		
NPE	NPE Surfactant Substitution	BMP #4
Chromium	Metal Dye Substitution	BMP #5
Operating Procedures and Housekeeping Effectiveness: 20% of the remaining substance after substitution		
NPE & Chromium	Quality Control for Raw Materials	BMP #8
NPE & Chromium	Chemical Use Inventory	BMP #9
NPE	Knowing the Sources and Pathways of NPE	BMP #10
Chromium	Operational procedures for chrome wool dyeing	BMP #11
Chromium	“Smart” scheduling of machine cleaning	BMP #12
Chromium	Knowing the metal-content of dyes and other materials	BMP #13
Chromium	Improved Laboratory Procedures	BMP #14
Education and Training Effectiveness: 2% of the remaining substance after substitution		
NPE & Chromium	Management and Staff Training	BMP #15
NPE & Chromium	Supply Chain Education and Commitment	BMP #16
NPE	Industry Standards for NPE	BMP #17
Chromium	Industry Standards for Chromium Dyestuff	BMP #18

In the case of nonylphenol and nonylphenol ethoxylates, treatment is required after implementation of P2 practices to meet all three reference criteria (unless aggressive elimination of all NPE sources is undertaken). In the case of chromium, treatment is required

after implementation of P2 practices to meet Reference Criteria 1 and 2; however, P2 measures can achieve Reference Criteria 3 concentrations.

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. Table ES.4 provides a summary of costs for selected P2 BMPs and Table ES.5 provides a summary of costs for selected treatment BMPs.

Note that estimates are dependent on the incoming concentrations of NPE and chromium 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 P2 Costs (for selected BMPs)

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	negligible	negligible
Operating/ Housekeeping	\$28,000 annually	\$220,000 annually	\$440,000 annually
Education and Training	\$12,000 annually	\$90,000 annually	\$180,000 annually
Total Estimate	\$40,000 annually	\$310,000 annually	\$620,000 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.			

Based on the estimated wastewater concentrations of NPE and chromium after P2 measures and an assumption that the BOD₅ is greater than 100 mg/L⁴, the overall full treatment systems for each target reference criteria are as follows:

- Reference Criteria 1: chemical precipitation, biological treatment, filtration, granular activated carbon (GAC), microfiltration, and reverse osmosis (RO);
- Reference Criteria 2: chemical precipitation, biological treatment, filtration, and GAC; and
- Reference Criteria 3: biological treatment.

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 m³/h to 50 m³/h. Costs for a facility that has lowered chromium concentrations through aggressive P2 measures (where RO is not required for Reference Criteria 1) are also provided. Costs were also developed for an influent wastewater with a low BOD₅ concentration where GAC can be

⁴ Should BOD₅ concentrations after P2 measures but before treatment be lower than 100 mg/L, then biological treatment may not be required and NPE treatment and removal may be sufficient using granular activated carbon (GAC).

used in place of biological treatment for NPE removal. Table ES.5 presents a summary of the capital and O&M cost data for wastewater treatment after P2.

Chemical precipitation is the first process step for the reduction and removal of chromium. In the costing information provided in Table ES.5, it is assumed that a chemical precipitation system for the removal of metals is already in place. Chemical precipitation is not required for chromium to meet Reference Criteria 3.

Table ES.5 Estimated Capital and Annual O&M Treatment 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 Assuming High BOD₅						
Criteria 1	\$371,000	\$2,312,000	\$3,526,000	\$56,000	\$277,000	\$353,000
Criteria 2	\$275,000	\$619,000	\$884,000	\$41,000	\$74,000	\$88,000
Criteria 3	\$275,000	\$619,000	\$884,000	\$41,000	\$74,000	\$88,000
Treatment Assuming Low Chromium (i.e., no RO for Reference Criteria 1)						
Criteria 1	\$314,000	\$978,000	\$1,497,000	\$47,000	\$117,000	\$150,000
Criteria 2	\$275,000	\$619,000	\$884,000	\$41,000	\$74,000	\$88,000
Criteria 3	\$275,000	\$619,000	\$884,000	\$41,000	\$74,000	\$88,000
Treatment Assuming Low BOD₅ (i.e., GAC in place of biological treatment)						
Criteria 1	\$127,000	\$1,772,000	\$2,777,000	\$19,000	\$213,000	\$278,000
Criteria 2	\$70,000	\$438,000	\$748,000	\$10,000	\$53,000	\$75,000
Criteria 3	\$70,000	\$438,000	\$748,000	\$10,000	\$53,000	\$75,000
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 the pollutants identified 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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APPENDICES

Appendix A	Best Management Practices Documents
Appendix B	Templates (Task 5)
Appendix C	Sub-Sector Definitions
Appendix D	Agreements for Toxic Reduction and Substances of Concern
Appendix E	Case Study Examples Demonstrating Benefits of P2 Measures

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) and chromium in wastewater effluents of the textiles sector. The benefits of undertaking the best management practices are also described. 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 BMP 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, specifically:
 - Textile Mill Operations Staff; and
 - Textile Mill Management Staff interested in implementing BMPs to eliminate or reduce harmful pollutants and to increase company reputation for implementing ‘green policies’.

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 textiles sector addressed within this document include:

- Fibre, Yarn, Thread Mills (NAICS⁵ 3131);
- Fabric Mills (NAICS 3132); and
- Textile and Fabric Finishing and Fabric Coating (NAICS 3133).

⁵ 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)

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 Ministry of the Environment (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:

- 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,⁶ using the Standard & Poor's 500 Index (S&P 500), compared the financial performance of "low polluter" portfolios to industry-matched "high

⁶ 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

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 textiles 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.

Table 2.1 Wastewater Concentrations in the Textiles Sector

Substance	Representative Concentration in Wastewater (prior to pollution prevention or treatment) (mg/L)
Chromium	4.6
Nonylphenol	0.15
Nonylphenol Ethoxylates	4.1

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 textile sector.

2.1.1 Nonylphenol and its Ethoxylates (NPE)

Textile mills releasing NPE may operate within any of the NAICS sub-sectors of interest (i.e., 3131, 3132, or 3133). Table 2.2 illustrates where NPE can be found in the textile sub-sectors profiled in this document.

Table 2.2 NPE in the Textiles Sector

Sub-sector	Where NPE may be found in process ⁷
Fibre, Yarn, Thread Mills (NAICS 3131)	Mercerizing, Bleaching, Dyeing
Fabric Mills (NAICS 3132)	<p>Woven Mills – De-sizing, Scour and Wash, Mercerize and Wash, Bleach and Wash, Printing, Dyeing and Washing, Finishing and Drying (in the same establishment)</p> <p>Non-woven Mills – Dyeing, Chemical Finishing (in the same establishment)</p> <p>Knit Mills – Scour, Bleach, Dyeing, Printing, Wet Finishing (in the same establishment)</p> <p>Wool Mills – Bleach and Rinse, Light Scour, Dye, Carbonize, Piece Dyeing, Chemical Finishing (in the same establishment)</p>
Textile and Fabric Finishing and Fabric Coating (NAICS 3133)	<p>Woven Mills - Finishing and Drying</p> <p>Nonwoven Mills –Chemical Finishing</p> <p>Knit Mills – Wet Finishing</p> <p>Wool Mills – Chemical Finishing</p>

Nonylphenol ethoxylates are a class of the broader group of compounds known as alkylphenol ethoxylates (APEs). They can be used in surfactants, cleaning agents, or wetting and de-wetting agents; however, their use has decreased significantly in Canadian textile mills since they were listed on Schedule 1 of the *Canadian Environmental Protection Act 1999* (CEPA 1999).

Due to the concern for NPE, governments are taking action to reduce the use of NPE in the marketplace. In Canada, owners or operators of facilities that manufacture soap and cleaning products, processing aids used in textile wet processing, or pulp and paper processing aids, as well as importers and bulk purchasers of NPE, are required to prepare and implement a pollution prevention plan. The P2 plan must reduce by 50% the mass of NPE used or imported annually by the year 2007 and reduce the mass used or imported annually by 95% by the year 2010. The majority of textile mills have reached the Pollution Prevention - Phase Two 95% reduction target set by Environment Canada as a result of pollution prevention plan requirements implemented through CEPA 1999 by the federal government as part of the federal risk management measures for NPE. Refer to Section 2.3 for a short description of pollution prevention plan requirements for NPE in wet textile mill processing. See Environment Canada's Canada Gazette Notice⁸ for precise

⁷ Based on Crechem Technologies Inc. *Background Study on Textile Mill Effluents* (undated).

⁸ website: http://www.ec.gc.ca/Ceparegistry/documents/notices/g1-13849_n4.pdf

requirements. Some NPE are still used in textile mill processes, primarily in oils for knitting and hosiery production equipment.⁹

Canada's steps are similar to those of the European Union (EU), which as of January 2005, under the 26th amendment to Directive 76/796/EC, requires that 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.

Nonylphenol is used in the production of nonylphenol ethoxylates. The water solubility of nonylphenol is approximately 10 mg/L, but may be pH dependent. Having an adsorption coefficient $\log K_{oc}$ of 4.4-5.7, nonylphenol is expected to adsorb strongly to organic matter. Specific gravity, viscosity and aqueous solubility increase with nonylphenol ethoxylate chain length.¹⁰ Nonylphenol ethoxylates with a chain length greater than six are readily soluble in water. The vapour pressures of nonylphenol and nonylphenol ethoxylates are low; therefore, partitioning to air is extremely limited. Since nonylphenol is not very volatile, residues in textile materials are expected to remain during use or until they are washed out.¹¹

2.1.2 Chromium

Chromium (a heavy metal) in textile mill effluents can be introduced in two primary ways: 1) dyes and dye processes; and 2) on-site laboratory operations.¹² Heavy metals are typically used in textiles dyes to achieve brilliance in colours. Other minor sources of metals include impurities in materials other than dyes, including fibres, salts, caustic, and soda ash.¹³

The most common use of chrome dyes and chrome-based dyeing processes is for dark colours on wool fibres.

Table 2.3 illustrates where chromium can be found in the textiles sector.

⁹ Personal communication, Fintex Mechanical and Process Inc. January 2006. Based on the Environment Canada website, a 95% reduction of the total mass of nonylphenol and/or nonylphenol ethoxylates used and/or imported annually, from base year levels, is required for persons/facilities as defined by Environment Canada (refer to websites, for example, the Notice requiring P2 Plans for NPE from wet textile mill processes <http://canadagazette.gc.ca/part1/2004/20041204/html/notice-e.html#i4>.)

¹⁰ Environment Canada, Health Canada, 2001

¹¹ Source: <http://www.mst.dk/chemi/01081812.htm#7.6.2>

¹² United States Environmental Protection Agency (USEPA), 1996; European Union (EU), 2003

¹³ USEPA, 1996

Table 2.3 Chromium in Textiles Sector

Sub-Sector	Where Chromium may be found in process
Fibre, Yarn, Thread Mills (NAICS 3131)	Dyeing After-chrome processes for wool Clearing or discharge printing Laboratory testing
Fabric Mills (NAICS 3132)	Dyeing Laboratory testing
Textile and Fabric Finishing and Fabric Coating (NAICS 3133)	Dyeing Laboratory testing

There is abundant literature on best practices for dye processes and operations, but it does not necessarily identify specific pollutants, such as chromium resulting from dyes. The following best practice recommendations draw on literature specifically identifying chromium reductions. Textile practitioners are encouraged to reference sector literature on textile processes as a whole for multi-pollutant reduction. Refer to Section 6 for key literature sources for the sector.

Chromium may be present as an intentional component of dye formulation or it may be present as an impurity in dyestuff. Metals used in dye formulation may be “bound” or “unbound”.¹⁴ Bound metals are those in which the metal forms an integral structural element. An unbound metal is one that is not structurally bound to the dye molecule, but that simply exists in some quantity in the dye formulation.¹⁵ Not all dye wastes come from the dye bath; dye wastes also result from handling, weighing, small-scale routine working losses, implement and drum cleaning, and spills.¹⁶

Chromium concentrations in dyes with chrome as a formulation component vary from 3 to 83 parts per million (ppm).¹⁷ Chrome can be found in several dye classes or types, including acid dyes, pre-metallized dyes, and mordant dyes.¹⁸ According to the European Union (EU) (2003), metal-complex dyes do not represent a specific application dye class, but belong to many classes of dyes, including acid, direct, and reactive dyes. Pre-metallized dyes may be 3% to 4% metal.¹⁹ Most natural dyes are mordant dyes, the most important of which are the synthetic mordant dyes (chrome dyes) used for wool.²⁰ Metal complex dyes are also suitable for polyamide fibres.²¹ Mordant dyes comprise some 30% of dyes used for wool, and are especially useful for black and navy shades.²² New reactive dyestuffs that are non-chrome containing

¹⁴ USEPA, 1996

¹⁵ USEPA, 1996

¹⁶ USEPA, 1996

¹⁷ Barclay et al., 2000

¹⁸ USEPA, 1996

¹⁹ Barclay et al., 2000

²⁰ USEPA, 1996

²¹ EU, 2003

²² USEPA, 1996

have recently been introduced to the market and these can provide good levels of fastness, equivalent with those achievable with chrome dyes used for dark shades.²³

Chromium can be present as a dyestuff impurity, for example, where metals are used as catalysts during the manufacturing of chrome dyes.²⁴ An analysis of 1,298 dyes not containing bound metal as an integral part of the dye molecule by x-ray fluorescence²⁵ found casual chromium concentrations as shown in Table 2.4. The United States Environmental Protection Agency (USEPA) (1996) does note that these data are somewhat dated, but represent the only detailed analysis of the metal content of dyes to 1996.

Several European initiatives discourage the use of chrome mordant dyes, such as, the Protection of the Marine Environment of the North-East Atlantic (OSPAR), EU-Ecolabel, and the Association of Environmentally Friendly Carpets (GuT).²⁶ The Ecological and Toxicological Association of Dyes and Organic Pigments Manufacturers (ETAD) has established limits in the content of heavy metal in dyestuffs to meet known wastewater requirements,²⁷ and some best practice documents, such as the Marks and Spenser Environmental Code of Practice for Dyeing, Printing and Finishing (2004), refer to a requirement to purchase dyestuffs from ETAD member companies.

Table 2.4 Average Metal Concentration of Selected Dyes with Casual Chromium Content (USEPA, 1996)

Dye Type	Acid	Basic	Direct	Disperse	Fibre Reactive	Vat
Number of Dyes Tested	404	137	303	117	46	58
Average Chromium Concentration (mg/L) ²⁸	9	2.5	3	3	24	83

Certain dye classes (particularly vats and sulfur dyes), were formerly oxidized with dichromate, but are now almost universally oxidized with other materials, such as iodate, bromate, and peroxide.²⁹ Several sources of metals in dyeing are not directly related to the dyestuffs themselves, including after chrome processes for wool and clearing or discharge printing.³⁰ In the after chrome process, the dye is applied first

²³ EU, 2003

²⁴ EU, 2003

²⁵ ADMI in USEPA, 1996

²⁶ EU, 2003

²⁷ EU, 2003

²⁸ Concentration units are not noted in the USEPA source document however other figures provide concentrations in mg/L and therefore it is assumed this is the concentration unit for this concentration data.

²⁹ Dr B. Smith, Identification and Reduction of Pollutant Sources in Wet Textile Processing (1987)

³⁰ USEPA, 1996

and the fibre is then chromed in a separate step, utilizing the exhausted dye bath, and conserving water.³¹

Textile mills often have on-site laboratories where effluent characteristics are evaluated for compliance with permits and/or discharge limits. In textile mills where chrome dyes are not used, the most significant source of chromium in effluent is most likely from laboratory operations for Chemical Oxygen Demand (COD) testing.³² The COD test entails assessment of the amount of oxidizer consumed during oxidation of an effluent sample by dichromate in a standard test, usually expressed in ppm.³³ Chromium oxidizers may also be present in laboratories as chromic acid cleaning solution.³⁴

Incoming materials, which may include fibres, salts, caustic, and soda ash,³⁵ may have trace amounts of chromium from impurities in upstream processes. In the case of wool fibres, wool scouring removes natural impurities and the effluent is therefore oily, alkaline, high in solids, and high in Biochemical Oxygen Demand (BOD). Wool fibre accounts for only 40% of the mass processed; the remainder are impurities of various materials. Typical wastes for a mill that scours and finishes wool may contain chromium concentrations of 4 mg/L in wool processing wastes.³⁶

Hexavalent chromium 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.

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 of the three reference criteria are the same in several instances.

³¹ EU, 2003

³² B. Smith, pers. comm.

³³ Dr B. Smith, A Workbook for Pollution Prevention by Source Reduction in Textile Wet Processing (1988)

³⁴ Dr B. Smith, Identification and Reduction of Toxic Pollutants in Textile Mill Effluent (1990)

³⁵ USEPA, 1996

³⁶ Cooper, 1978 in Barclay et al., 2000

Table 2.5 Reference Criteria for Substances in the Textiles Sector

Substance	Designation	Reference Criteria 1 (mg/L)	Reference Criteria 2 (mg/L)	Reference Criteria 3 (mg/L)
Chromium	CEPA* Toxic**	0.2	1	5
Nonylphenol	CEPA* Toxic	0.001	0.001	0.0025
Nonylphenol Ethoxylates	CEPA Toxic	0.001	0.01	0.025
Notes:				
*CEPA: Canadian Environmental Protection Act				
** Hexavalent chromium and its compounds are CEPA Toxic				

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 the 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:³⁷

- 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

³⁷ Review of Existing Municipal Wastewater Effluent (MWW) 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 (NPRI)

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 website³⁸ 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 Textiles Sector

Substance	NPRI Reportable Substances	NPRI Part Designation	Reporting Threshold
Chromium	Chromium and its compounds and hexavalent chromium	Group 1A, except hexavalent chromium is Part 1B	10 tonnes except hexavalent chromium is 50 kg
NPE	Specific substances (identified by NPRI through individual Chemical Abstracts Service (CAS) number)	Group 1A	10 tonnes (total NPE ³⁹)

For the textiles sector, there were no companies reporting releases to the NPRI in 2003 for these substances, indicating that there were no companies meeting the reporting threshold identified in the above table (assuming all sector facilities complied with the regulation).

Pollution Prevention Plans for NPE in Wet Textile Processing

As indicated in Section 2.1.1, Environment Canada, under CEPA 1999, has set out pollution prevention planning requirements for wet textile mill processes using NPE. The requirements apply to the persons or class of persons who own or operate a textile mill that is involved in wet processing activities and discharges all or part of its effluent to an off-site wastewater treatment facility, and has had an effluent flow greater than 30 m³/day, based on average annual discharge, in at least one year between 1999 and 2003. These owners or operators must prepare and implement a pollution prevention plan in respect of effluents from textile mills that use wet processing and NPE. Guidance on factors to consider in the plans, considerations

³⁸ NPRI website: http://www.ec.gc.ca/pdb/npri/npri_home_e.cfm

³⁹ NPRI requirement in 2003

when choosing alternatives to NPE, as well as monitoring requirements, declaration requirements, filing, and other details are outlined in the Notice published in the *Canada Gazette*, available on the Environment Canada website.⁴⁰ It is recommended that textile mill owners and operators refer to this website. Environment Canada also assessed textile mill effluents; textile mill effluents from wet processing facilities have been added to Schedule 1 of CEPA 1999.

Federal Environmental Emergency (EE) Regulation

Environmental Emergency (EE) Regulations under Part 8 of the CEPA 1999, promote prevention and planning for preparedness, response and recovery. Neither of the two substances discussed in this document are identified in the federal emergency regulation at this time. Practitioners are encouraged to reference the regulatory requirements at Environment Canada's website.⁴¹

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 take preventative measures and use proper clean up, disposal, and amelioration practices. Under the Environmental 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.

⁴⁰ <http://canadagazette.gc.ca/partI/2004/20041204/html/notice-e.html#i4>

⁴¹ 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 avoid or minimize the creation of pollutants and waste, and reduce the overall risk to the environment or human health.”⁴² 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.

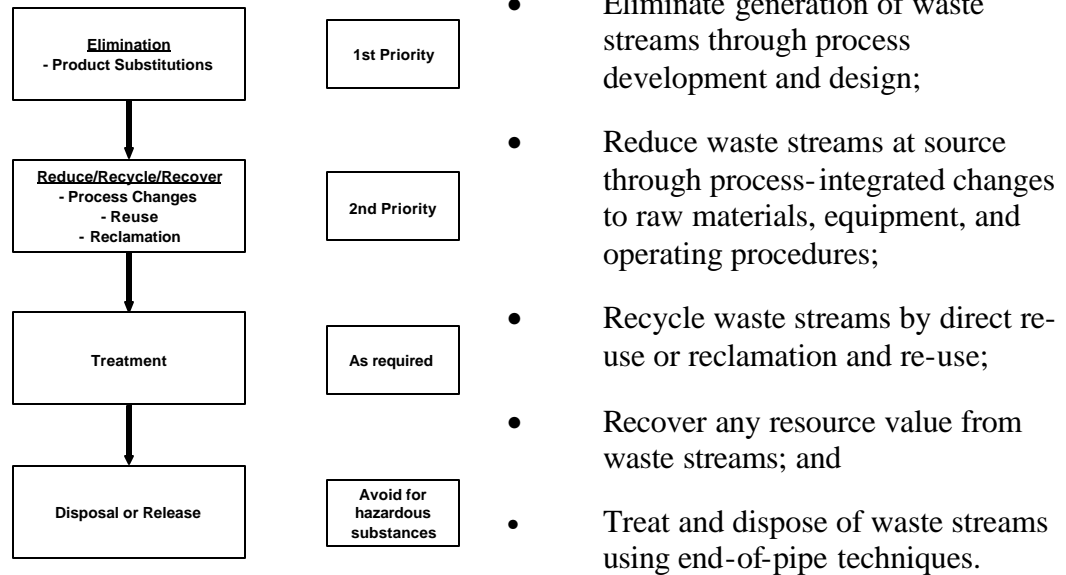
Pollution prevention and treatment BMPs must be assessed and implemented based on specific site and process conditions and characteristics; however, some overall observations can be made about effective ways to proceed with assessment and implementation of BMPs. Specific options for the textiles sector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

The following sequence of steps presents a hierarchy of techniques for undertaking pollution prevention and waste minimization.

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.

⁴² 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



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 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 and Chromium in the Textiles 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 Overview of P2 Measures for NPE and Chromium in the Textiles Sector

Substance Addressed	BMP Name	Sub-Sector/ BMP Number
Elimination/ Reduction		All Sub-Sectors
NPE & Chromium	Automated Chemical Dosing Systems	BMP #1
NPE & Chromium	Low Liquor Ratio Dyeing Machines	BMP #2
NPE & Chromium	Cold Pad Batch Dyeing	BMP #3
NPE	NPE Surfactant Substitution	BMP #4
Chromium	Metal Dye Substitution	BMP #5
Chromium	Dye Auxiliary Techniques	BMP #6
Chromium	Low-Chrome Techniques	BMP #7
Operating Procedures and Housekeeping		All Sub-Sectors
NPE & Chromium	Quality Control for Raw Materials	BMP #8
NPE & Chromium	Chemical Use Inventory	BMP #9
NPE	Knowing the Sources and Pathways of NPE	BMP #10
Chromium	Operational procedures for chrome wool dyeing	BMP #11
Chromium	“Smart” scheduling of machine cleaning	BMP #12
Chromium	Knowing the metal-content of dyes and other materials	BMP #13
Chromium	Improved Laboratory Procedures	BMP #14
Education and Training		All Sub-Sectors
NPE & Chromium	Management and Staff Training	BMP #15
NPE & Chromium	Supply Chain Education and Commitment	BMP #16
NPE	Industry Standards for NPE	BMP #17
Chromium	Industry Standards for Chromium Dyestuff	BMP #18

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 Elimination/ Reduction BMPs Common to All Substances of Interest

BMP #1: Automated Chemical Dosing Systems:⁴³ Automated chemical dosing systems can accurately and precisely deliver a given quantity of a specific chemical at a particular time interval,⁴⁴ particularly with respect to liquid chemicals used in dyeing and finishing. These systems reduce the tendency to overuse environmentally harmful chemicals and, therefore, reduce pollutant loads of discharged effluents. They also reduce handling loss and equipment clean-up. In addition, they improve the efficiency and reliability of chemical reactions in the dyebath, ensuring consistent and reproducible results.

A range of 3 to 8% reduction in NPE process water concentration can be achieved in knit, woven, yarn, and wool processing effluents through application of this BMP.⁴⁵ No estimate is available for chromium reductions.

BMP #2: Low Liquor Ratio Dyeing Machines:⁴⁶ Dyeing machines can be classified into two groups: rope and open width. Common machine types are jet and beck for rope dyeing, and beam, continuous, jig, and pad-batch for open-width. The latest jet machines employ low-liquor-ratio, and have a number of environmental advantages. The liquor ratio of conventional jet machines ranges from 8:1 to 12:1, while the latest machines are operated at liquor ratio of 5:1.⁴⁷ The low-liquor-ratio jet dyeing can achieve significant reduction of water and chemical use. According to a study conducted by Schramm and Jantschgi (1999), the low-liquor-ratio (5:1) jet equipment, on average, can reduce water use by 70% and chemical use by 60% in comparison with the conventional equipment (liquor ratio = 8:1). The water use includes both dyebath and rinse required for removal of unfixed dyes and absorbed chemicals.

A range of 2 to 8% reduction in NPE process water concentration can be achieved in knit, woven, yarn, and wool processing effluents through application of this BMP.⁴⁸ No estimate is available for chromium reductions.

BMP #3: Cold Pad Batch Dyeing:⁴⁹ Equipment for pad batch dyeing consists of 1) padding unit; 2) batcher or material handling system; 3) dye/alkali mixing device; 4) A-frames, storage racks or storage boxes; and 5) wash-off device (beam, beck, continuous, etc.). Chemical use is reduced greatly with pad batch dyeing. Only small amounts of detergent are used in washing-off. BOD and COD loadings associated with chemical use can be reduced up to 80 % compared to atmospheric becks. Other benefits associated with pad batch dyeing include savings on water and labour. Certain limitations can be experienced with pad batch dyeing. Although it is a cost-effective way for facilities to apply reactive dyes to cotton and rayon, this method

⁴³ Marbek et al., 2002

⁴⁴ USEPA, 1996

⁴⁵ Marbek et al., 2002

⁴⁶ Marbek et al., 2002

⁴⁷ Schramm and Jantschgi, 1999; and USEPA, 1996

⁴⁸ Marbek et al., 2002

⁴⁹ Marbek et al., 2002

may not achieve the desired final fabric properties for all cottons. Pad batch dyeing is also not appropriate for dyeing synthetic fabrics.

Cold patch dyeing is most applicable to woven fabrics, and an approximate 1% reduction in NPE process water concentration is achievable.⁵⁰ No estimate is available for chromium reductions.

3.2.2 Elimination/Reduction BMPs for Nonylphenol and its Ethoxylates

Measures to avoid or eliminate the use of hazardous substances are most desirable since these are the most effective means to ensure environmental protection from the substance release. Substitutions of process materials that contain NPE with materials that do not contain NPE should be considered wherever possible.

BMP #4: NPE Surfactant Substitution: NPE surfactant substitution has been defined as the replacement of NPE surfactants with suitable non-NPE surfactants. More specifically, linear alcohol ethoxylates (LAE) are the most preferable substitute for NPE in most instances,⁵¹ in view of the degradability of LAE and the non-toxic nature of its degradation products. For applications where LAE are not appropriate substitutes, other non-NPE surfactants with similar characteristics (readily degradable to non-toxic degradation products) should be selected.

This BMP should be implemented with regard for the supply chain and with specific requirements for suppliers. A corporate policy regarding purchase of NPE-containing products should be developed. Refer, for example, to the Marks & Spencer chain in the U.K., which disallows the use of NPE in the manufacture or processing of Marks & Spencer goods.⁵²

Up to a 100% reduction in NPE process water concentration is achievable in knit, woven, yarn, and wool processing effluents, provided that NPE-free products are available from suppliers.⁵³

3.2.3 Elimination/Reduction BMPs for Chromium

As mentioned above for NPE, measures to avoid or eliminate the use of hazardous substances are most desirable since these are the most effective means to ensure environmental protection from the substance release. Substitutions of process materials that contain chromium with materials that do not contain chromium should be considered wherever possible.

The first BMP for this substance therefore concerns substitution for chromium containing dyes, as follows.

⁵⁰ Marbek et al., 2002

⁵¹ Marbek et al., 2002

⁵² Marks & Spencer, 2004

⁵³ Marbek et al., 2002

BMP #5: Metal Dye Substitution: In general, Best Available Techniques (BATs) for substitution include a review of chemicals used in the mill and replacement of those that are hazardous to the environment with chemicals that have less impact; also to use dyes that have high exhaustion rates and require less salt.⁵⁴ New reactive dyestuffs that are non-chrome containing have recently been introduced to the market and can provide good levels of fastness, equivalent with those achievable with chrome dyes used for dark shades.⁵⁵

In Europe, the first edition of a standard called the “Oeko-Tex Standard 1000” was issued in 1995. This standard contains requirements for textile manufacturing sites to fulfill a strict set of concentration limits, addressing areas such as heavy metals. The label “Oeko-Tex Standard 1000” applies to finished textile products.⁵⁶ Textiles mills should require that the independent industry Oeko-Tex Standard 1000 for chemicals used in the production of clothing be referenced by all suppliers with a substantial relationship with the company. Oeko-Tex certified dyestuffs are reported to be cost-competitive to other dyes and do not require a change in process machinery.⁵⁷

In addition, any toxic azo dyes used should be substituted with non-toxic alternatives. The use of certain azo dyes is banned in Europe.⁵⁸ Wool dyes that do not require after-chroming⁵⁹ are also recommended for substituting chromium dyes.

The following measures indicate practices to reduce the use of chromium dyes where substitution is not possible.

BMP #6: Dye Auxiliary Techniques: For wool dyeing when chrome dyes are used, operators can enhance dye uptake through use of a special auxiliary⁶⁰ - a mixture of different fatty alcohol ethoxylates with high affinity for the fibre and dyestuff - and replace acetic acid with formic acid. This optimized process is known as the Lanaset TOP process, and was launched by a dyestuffs and textile auxiliary’s supplier in 1992.⁶¹ With the control of pH and the use of the auxiliary, dyeing times can be shortened with almost a 100% exhaustion rate.

BMP #7: Low-Chrome Techniques: For wool dyeing when chrome dyes are used, operators can employ low-chrome and ultra-low chrome stoichiometric dyeing techniques⁶² to minimize the amount of residual chromium in the final effluent.⁶³

⁵⁴ Barclay et al., 2000

⁵⁵ EU, 2003

⁵⁶ Website: <http://www.oeko-tex.com/en/start/start.html>

⁵⁷ Personnel communication with Fintex Mechanical and Process Inc., January 2006.

⁵⁸ Website: <http://www.tfl.com/pdfs/others/eubanazodyes.pdf>

⁵⁹ Barclay et al., 2000

⁶⁰ European Union, 2003

⁶¹ EU, 2003

⁶² European Union, 2003

⁶³ EU, 2003

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 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. The following practices outline measures to reduce NPE and chromium through operating and housekeeping practices.

BMP #8: Quality Control for Raw Materials:⁶⁴

Hazardous substances can be present in trace quantities that may become significant where sufficient materials are purchased or processed. Quality control for raw materials and incoming goods is an essential component to reduce chromium and other hazardous trace materials. Measures include the following:

1. Purchasing policies that require confirmation, in writing, from suppliers that none of the products they supply contain NPE or chromium. The purchasing policy should be applied to:
 - a. Raw materials and semi-finished materials coming into the facility for processing.
 - b. Incoming greige⁶⁵ goods.
 - c. Process materials and other purchased materials.
 - d. Maintenance chemicals.
2. A practice of regular testing of dyes and pigment batches before use to verify the supplier claims and for quality assurance/quality control purposes.

BMP #9: Chemical Use Inventory: A database of chemical use should be maintained to control and track the use of raw chemicals, in particular, NPE and chromium dyes. This database should record quantities of goods or materials used that contain these substances. The inventory can be used to assess losses due to spillage or other housekeeping measures, as well as tracking products used in processes and/or final products.

⁶⁴ Marbek et al., 2002

⁶⁵ Any woven fabric just off the loom that has not yet been dyed or finished

BMP #10: Knowing the Sources and Pathways of NPE:⁶⁶ The following steps should be undertaken to understand sources and pathways of NPE in textile facilities:

1. Identify chemicals containing NPE and quantify concentrations;
2. Identify processes using NPE and manage their usage;
3. Determine applicable discharge limitations based on regulations or ecological considerations;
4. Monitor usage and discharges through both inventory control and direct measurement; and
5. Implement control strategies to obtain compliance with established discharge limits.

BMP #11: - Operational procedures for chrome wool dyeing:⁶⁷ The following steps should be considered in establishing procedures where chrome dyes are applied:

- If the dyebath is not completely exhausted before chroming, the bath should be drained. This prevents mixing of dyeing and chroming solutions.?
- The optimum pH for maximizing dye chroming is in the range of 3.5 to 3.8. This can be attained using formic acid instead of acetic or other acids, which may inhibit exhaustion of the chromate ion.
- Only the minimum required amount of chrome should be added to the bath.
- The dyer should follow a time-temperature cycle that is optimum for chrome dyeing.
- Thiosulfate can be added after chroming to destroy residual dichromate.
- Raising the temperature to between 98°C and 100°C results in better chrome utilization and lower chrome residual. A 7.5% anhydrous sodium sulfate solution must be used to ensure even chrome treatment at these temperatures. An alternative is to add chrome, wait 10 minutes, and then lower pH to 3.5 to 3.8.

BMP #12: “Smart” scheduling of machine cleaning: Machine cleaners are generally among the most toxic and offensive chemicals used in textile wet processing. Two major pollution sources from continuous, as well as batch, operations are generated from dumping unused portions of mixes and machine cleaning, which may be necessary between shades. “Smart” scheduling systems should be used to schedule dyeing production in such a way that machine cleaning is

⁶⁶ Smith (undated)

⁶⁷ Duffield in USEPA, 1996

minimized, as well as mix dumps. To minimize dye machine cleaning requirements, colour dyeing should be grouped within chroma families (e.g., red, yellow, blue), and sequenced from light to dark and from brighter/brilliant to duller/greyish. The opportunity presented by this BMP is fairly straightforward and the technical barriers are minimal.⁶⁸

BMP #13: – Knowing the metal content of dyes and other materials: The metal content of dyes can easily be determined by consulting the Material Safety Data Sheets (MSDS) for the dye.⁶⁹ (Note that MSDS are suitable for screening level information only since constituents present in materials in amounts less than 1% may not be identified.⁷⁰) MSDS for all dyes used should be stored centrally and at the location where the chemical is used.⁷¹ Dyes should be purchased from reputable manufacturers who are members of responsible dyestuff industry associations. In developing procedures, reference can be made to existing best practices, for example, Marks and Spencer (2004) requires that dyes be purchased from manufacturers that are members of the Ecological and Toxicological Association of Dyes and Organic Pigment Manufacturers.⁷²

BMP #14: Improved Laboratory Procedures: With the substitution of chrome-containing dyes, laboratory testing materials can present the most likely source of chromium in textile facilities. Following are potential options to eliminate or reduce use of chromium in laboratory operations:

- Switch to non-dichromate solutions. These are readily available, very suitable, and produce non-toxic wastes, when properly treated.⁷³ With substitution to non-dichromate solutions, disposal of dichromate solutions to the sanitary sewer would be eliminated.
- A database of chemical use should be maintained to control and track the use of laboratory chemicals.

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.

⁶⁸ Dr B. Smith, *The Future of Pollution Prevention: An Alternative to Costly Waster Treatment* (1994)

⁶⁹ USEPA, 1996

⁷⁰ Hazardous Products Act

⁷¹ Marks and Spencer, 2004

⁷² ETAD, www.etad.com

⁷³ Dr B. Smith, *Identification and Reduction of Toxic Pollutants in Textile Mill Effluent* (1990)

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 #15: Management and Staff Training:

Management training is essential to ensure the commitment to eliminate or reduce toxic substance use and release is an integral part of doing business. Similarly, staff training in toxic substance elimination, use, handling, and other related issues are an important component of achieving consistent and successful results.

- Ensure every employee is fully trained before beginning his or her first employment shift and whenever new equipment is installed or new procedures implemented. Staff should be familiar with the hazards that accompany the material they are using and be aware of potential sources of contamination. MSDS should be available for all compounds used at the facility.
- 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; e.g., date and location of training, subject(s) covered, test results if applicable, trainer's name, etc.

BMP #16: Supply Chain Education and Commitment: Gain a clear commitment from the whole supply base that nonylphenols will not be deliberately introduced into any chemical formulations for production.⁷⁴ Textile owners or operators 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.

BMP #17: Industry Standards for NPE: Industry standards are important education tools since they establish performance targets that can trigger suppliers, operators, and others in the marketplace to investigate the underlying issues. In

⁷⁴ Such a requirement is in place in Marks & Spencer, 2004.

Europe, Marks & Spencer requires that the independent industry bluesign®⁷⁵ standard for chemicals used in the production of clothing be referenced by all suppliers with a substantial relationship with the company.⁷⁶ Canadian industry should support suppliers who follow these standards (in the absence of a similar Canadian-specific standard). The declared objective of the independent bluesign® standard is to “put a reliable and proactive tool at the disposal of the entire textile production chain – from raw material and component suppliers who manufacture e.g. dyes and additives, to textile producers and traders, to consumers.”

BMP #18: Industry Standards for Chromium Dyestuff: Industry standards are important education tools since they establish performance targets that can trigger suppliers, operators and others in the marketplace to investigate the underlying issues. (See BMP #17 above regarding the example of the European bluesign® standard.)

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 in the following overview.

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 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.

⁷⁵ <http://www.bluesign-tech.com/public/default.asp> The independent industry bluesign® standard is an ecosystem-based environmental code for the chemical and processing industry’s best practices (Marks and Spencer, 2004). Developed by industry representatives from academic, industrial, environmental protection, and consumers sectors, the brand and products licensed by bluesign® indicate that the manufacturing and products comply with the criteria set for ecosystem conservation and physical health.

⁷⁶ Marks & Spencer, 2004

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 Textiles 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 are therefore included in the implementation scenario.

The most effective Elimination/Reduction P2 measure for both NPE and chromium is materials substitution: BMP #4 NPE Surfactant Substitution and BMP #5 Metal Dye Substitution, respectively.

The effectiveness of materials substitution is assumed to be 95% for nonylphenol and nonylphenol ethoxylates removal, based on available data from the sector for this substance.⁷⁷

Effectiveness of material substitution is assumed to be 70% removal for chromium dye substitution, based on rules of thumb developed for application where no specific industry data was available.

Applicable Operating Procedures and Housekeeping BMPs for NPE include the following:

- BMP #8 Quality Control for Raw Materials;
- BMP #9 Chemical Use Inventory; and
- BMP #10 Know the Sources and Pathways of NPE.

Applicable Operating Procedures and Housekeeping BMPs for chromium include the following:

- BMP #8 Quality Control for Raw Materials;
- BMP #9 Chemical Use Inventory;
- BMP #12 “Smart” Scheduling of Machine Cleaning;
- BMP #13 Know the Metal Content of Dyes and Other Materials; and
- BMP #14 Laboratory Procedures.

BMP #11 Operational Procedures for Chrome Wool Dyeing is not included because it is superseded by BMP #5 Metal Dye Substitution.

The effectiveness of Operating Procedures and Housekeeping is assumed 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 assumed to remove 20% of the remaining 5% of contaminants, for an additional 1% net reduction in NPE prior to treatment.

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

⁷⁷ *Evaluation of NPE Reduction Efforts in Selected Wet Processing Textile Mills.* Marbek Resource Consultants. December 11, 2002 (prepared for Environment Canada); and Environment Canada Phase 2 Reduction Target (95%) for facilities using NPEs. Textile mills surveyed by Fintex Mechanical and Process Inc. to date have achieved the 95% target reduction. (personnel communication, January 2006)

Applicable Education and Training BMPs for NPE include the following:

- BMP #15 Management and Staff Training;
- BMP #16 Supply Chain Education and Commitment; and
- BMP #17 Industry Standards for NPE.

Applicable Education and Training BMPs for chromium include the following:

- BMP #15 Management and Staff Training;
- BMP #16 Supply Chain Education and Commitment; and
- BMP #18 Industry Standards for Chromium Dyestuff.

The effectiveness of Education and Training practices is assumed to be 2% removal of the remaining contaminants after materials substitution. This effectiveness rate is at the low end of the assumed range for this group of BMPs based on the assumption that the Textile Sector's staff and supply chain are already familiar with issues associated with these two high-profile contaminants.

In the case of NPE, Education and Training practices would therefore result in negligible net reductions in NPE prior to treatment (i.e., 2% of the remaining 5% of pollutant).

In the case of chromium, Education and Training practices would remove 2% of the remaining 30% of chromium contaminant, for an additional 1% net reduction in chromium prior to treatment.

In summary, the effectiveness of P2 BMPs in achieving reductions of the pollutants examined is estimated to be 96% removal of NPE prior to treatment and 77% removal of chromium prior to treatment. Table 3.4 provides a summary of the estimated effectiveness discussed in this section. Refer to Tables 5.1 to 5.3 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: 70 – 95%		
NPE	NPE Surfactant Substitution	BMP #4
Chromium	Metal Dye Substitution	BMP #5
Operating Procedures and Housekeeping Effectiveness: 20% of the remaining substance after substitution		
NPE & Chromium	Quality Control for Raw Materials	BMP #8
NPE & Chromium	Chemical Use Inventory	BMP #9
NPE	Knowing the Sources and Pathways of NPE	BMP #10
Chromium	Operational procedures for chrome wool dyeing	BMP #11
Chromium	“Smart” scheduling of machine cleaning	BMP #12
Chromium	Knowing the metal-content of dyes and other materials	BMP #13
Chromium	Improved Laboratory Procedures	BMP #14
Education and Training Effectiveness: 2% ⁷⁸ of the remaining substance after substitution		
NPE & Chromium	Management and Staff Training	BMP #15
NPE & Chromium	Supply Chain Education and Commitment	BMP #16
NPE	Industry Standards for NPE	BMP #17
Chromium	Industry Standards for Chromium Dyestuff	BMP #18

3.5.2 P2 Costs

Costs for materials substitutions are assumed to be negligible for all sizes of facility, given relatively small materials cost impacts, and positive indirect benefits, such as reduced hazardous materials handling.

Costs associated with implementation of Operating Procedures and Housekeeping BMPs are assumed to be proportional to staff complement and to cost between 1/2% 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 ¼% and 2% of the staff budget. The upper end of this range would be applicable to facilities without well-

⁷⁸ Note that, in the case of the textile sector, 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 these substances and potential reduction techniques due to the high profile of the substances and textile mill effluents 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.

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 (for selected P2 BMPs)

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	negligible	negligible
Operating/ Housekeeping	\$28,000 annually	\$220,000 annually	\$440,000 annually
Education and Training	\$12,000 annually	\$90,000 annually	\$180,000 annually
Total Estimate	\$40,000 annually	\$310,000 annually	\$620,000 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 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 textiles sector. The treatment review was based on representative wastewater data available for this sector.⁷⁹ 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

⁷⁹ 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 (i.e., two GAC columns operated in series) 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 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 bioreactor of an activated sludge 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 (BOD₅)] is greater than 100 mg/L. For wastewater streams that have a relatively low BOD₅, GAC will be the most cost-effective treatment option. Typically, a sand filter or mixed media filter is required to remove suspended solids as a pre-treatment stage for a GAC filter.

4.1.2 Treatment Measures for Chromium

Three types of treatment processes are potentially applicable to meet the reference criteria for chromium 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:** Unlike most heavy metals that are precipitated readily as insoluble hydroxides by pH adjustment, hexavalent chromium (Cr⁺⁶) must first be reduced to the trivalent state because it forms the chromate complex that behaves as an anion and cannot form an insoluble hydroxide. Conventional chromium reduction is achieved by reaction of Cr⁺⁶ with a reducing agent. The most commonly used reducing agents are sulphur dioxide gas and sodium metabisulphite. The precipitated metal is removed from the wastewater stream by settlement. Filtration using a sand or mixed media filter can be used after chemical precipitation and settlement to further reduce the chromium concentration. It is assumed that chemical precipitation and settlement is in place for facilities with raw wastewater chromium

concentrations in excess of the sewer use by-law limit (typically 5 mg/L). Therefore, this pre-treatment stage was not included in the cost assessment for chromium reduction. It is important to note that some chromium 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 chromium before biological treatment to minimize chromium accumulation in biological sludge.

- **Granular activated carbon (GAC):** GAC is not a conventional treatment option for chromium as the removal efficiency is relatively low (around 50%). However, if a GAC process is used to remove organic pollutants, such as NPE, there will also be some reduction in the chromium 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 chromium. 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 5.3 as a guide (Section 5). Based on the estimated wastewater concentrations of NPE and chromium after P2 measures that are provided in the tables and an assumption that the BOD₅ is greater than 100 mg/L⁸⁰, and assuming the reduction or removal of NPE and chromium, the overall treatment systems in terms of sequential process steps for each target reference criteria are as follows:

⁸⁰ Should BOD₅ concentrations after P2 measures but before treatment be lower than 100 mg/L, then biological treatment may not be required and NPE treatment and removal may be sufficient using granular activated carbon (GAC).

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

Chemical precipitation and RO are required for the removal of chromium in order to meet Reference Criteria 1 and 2, and biological treatment and GAC for the removal of NPE for all reference criteria. GAC will also reduce the concentration of chromium in wastewater.

Chemical precipitation is the first process step for the reduction and removal of chromium. Due to chromium removal through P2 practices, chemical precipitation is not required for chromium to meet Reference Criteria 3.

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. For example, for a facility with an influent wastewater that has a low BOD₅ concentration, GAC can be used in place of biological treatment for NPE removal. RO may not be required for Reference Criteria 1 where aggressive P2 measures were implemented to lower initial chromium concentrations. In addition, DI may be a more suitable process than RO for chromium removal at some facilities.

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 textile 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 m³/h to 50 m³/h. The estimated costs are presented in Table 4.1. Costs are also provided for facilities that have sufficiently lowered chromium concentrations, where RO would not be required for Reference Criteria 1. Should it be determined for a specific facility that influent wastewater is sufficiently low in BOD₅ concentration that GAC can be used in place of biological treatment for NPE removal, then the range of capital costs can be reduced significantly, as shown in Table 4.1.

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

Table 4.1 Estimated Capital and Annual Operation and Maintenance 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		
	1 m ³ /h	25 m ³ /h	50 m ³ /h	1 m ³ /h	25 m ³ /h	50 m ³ /h
Full Treatment Assuming High BOD₅						
Criteria 1	\$371,000	\$2,312,000	\$3,526,000	\$56,000	\$277,000	\$353,000
Criteria 2	\$275,000	\$619,000	\$884,000	\$41,000	\$74,000	\$88,000
Criteria 3	\$275,000	\$619,000	\$884,000	\$41,000	\$74,000	\$88,000
Treatment Assuming Low Chromium (i.e., no RO for Reference Criteria 1)						
Criteria 1	\$314,000	\$978,000	\$1,497,000	\$47,000	\$117,000	\$150,000
Criteria 2	\$275,000	\$619,000	\$884,000	\$41,000	\$74,000	\$88,000
Criteria 3	\$275,000	\$619,000	\$884,000	\$41,000	\$74,000	\$88,000
Treatment Assuming Low BOD₅ (i.e., GAC in place of biological treatment)						
Criteria 1	\$127,000	\$1,772,000	\$2,777,000	\$19,000	\$213,000	\$278,000
Criteria 2	\$70,000	\$438,000	\$748,000	\$10,000	\$53,000	\$75,000
Criteria 3	\$70,000	\$438,000	\$748,000	\$10,000	\$53,000	\$75,000
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. Full treatment costs assume the combined reduction or removal of NPE and chromium.

The annual O&M costs were determined as a function of percentage of capital costs, assuming 15 % for the 1 m³/h flow condition, 12 % for the intermediate 25 m³/h flow condition and 10 % for the 50 m³/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 range presented in Table 4.1 for each set of reference criteria.

Figure 4.1 Textiles Sector Capital and O&M Costs for Reference Criteria 1

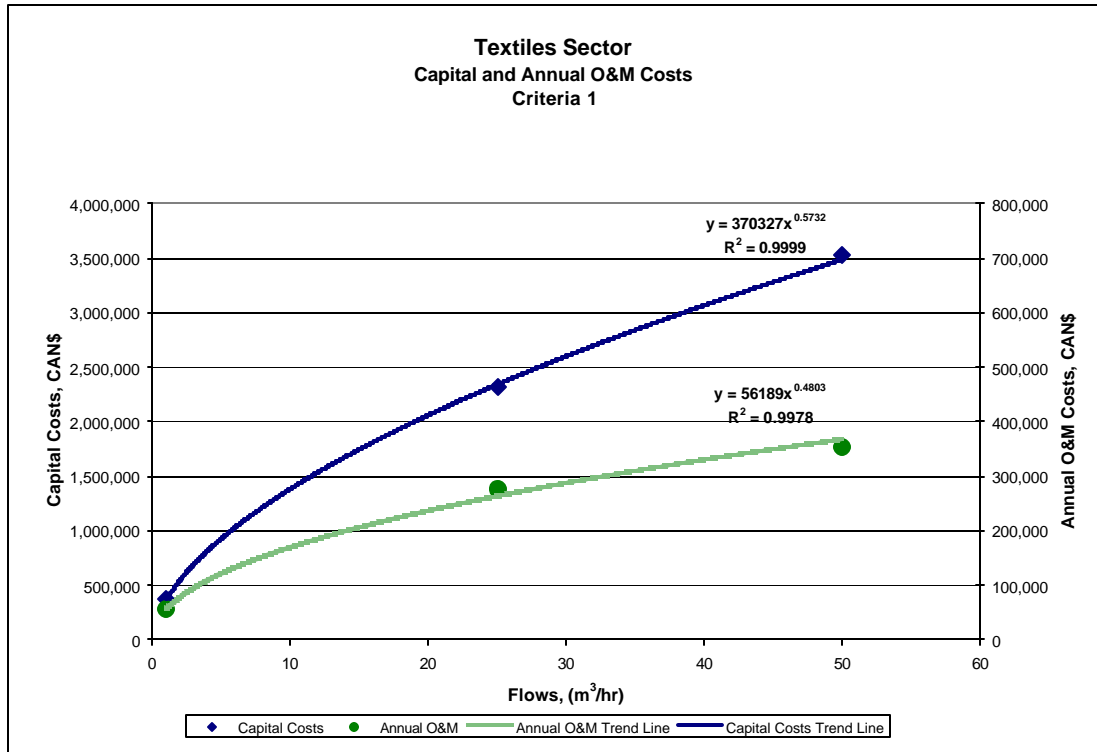


Figure 4.2 Textiles Sector Capital and O&M Costs for Reference Criteria 2

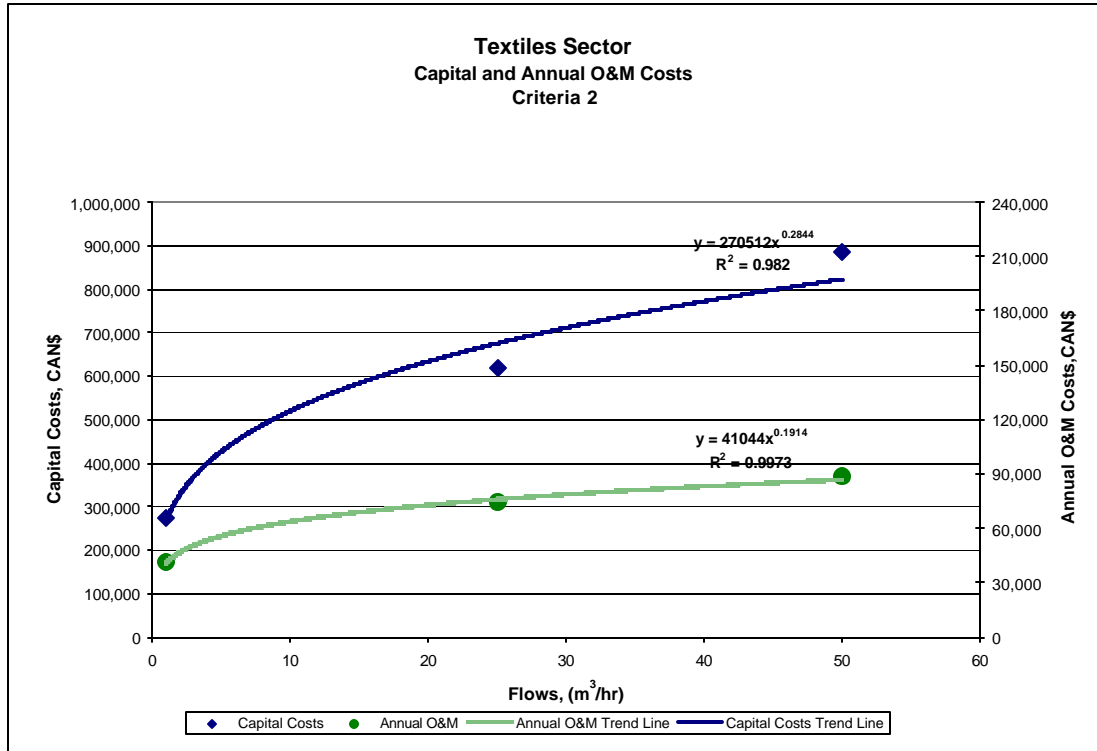
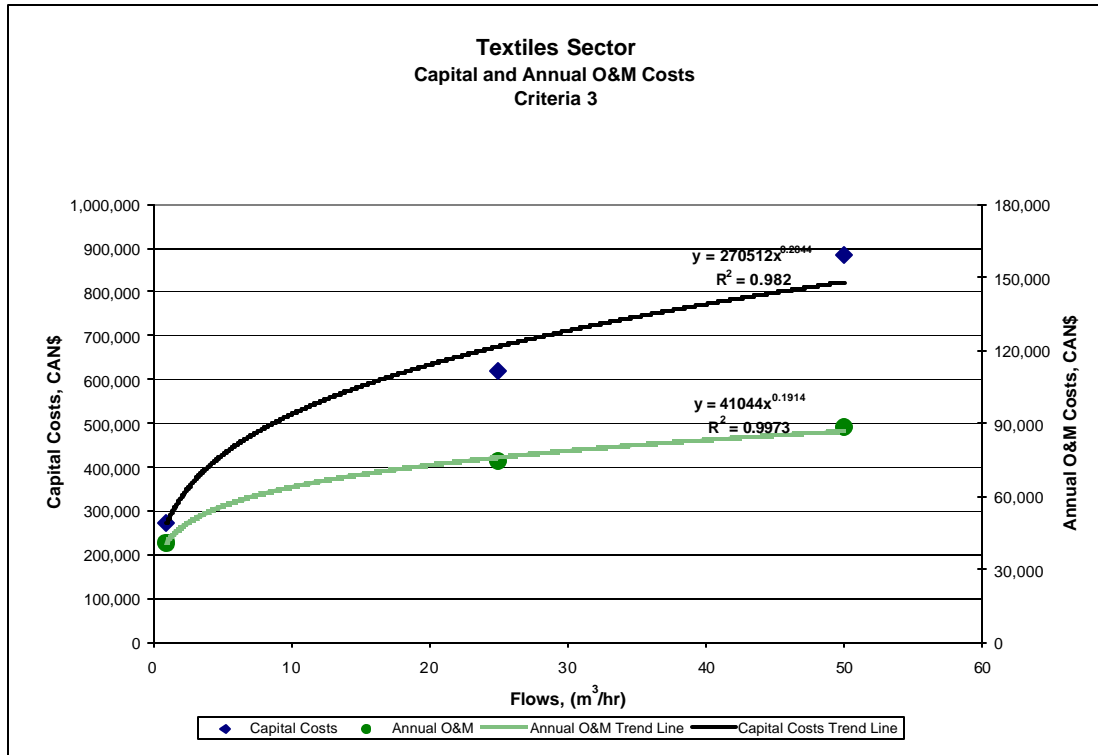


Figure 4.3 Textiles Sector Capital and O&M Costs for Reference Criteria 3



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 use to define 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: No substances.
- Reference Criteria 3: Chromium.

In the case of nonylphenol and nonylphenol ethoxylates, 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.

BMP Textiles Sector (NAICS 313)
OPTIONS FOR REDUCTION OF SUBSTANCE CONCENTRATIONS IN
EFFLUENTS

Table 5.1 Summary: Nonylphenol

BMP Textiles Sector (NAICS 313)
OPTIONS FOR REDUCTION OF SUBSTANCE CONCENTRATIONS IN
EFFLUENTS

Table 5.2 Summary: Nonylphenol Ethoxylates

BMP Textiles Sector (NAICS 313)
OPTIONS FOR REDUCTION OF SUBSTANCE CONCENTRATIONS IN
EFFLUENTS

Table 5.3 Summary: Chromium

6. KEY REFERENCES

The following documents were key in preparing this BMP:

1. Barclay, Susan and Chris Buckley, *Waste Minimization Guide for the Textile Industry: A Step Towards Cleaner Production, Appendices, 2000*, The Pollution Research Group, University of Natal, Durban, South Africa, Available at URL: <http://www.c2p2online.com/documents/Wasteminimization-textiles.pdf>.
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3. European Commission of the European Union, *Integrated Pollution Prevention and Control (IPPC) Reference Document on Best Available Techniques for the Textiles Industry*, July 2003. Available at URL: <http://eippcb.jrc.es/pages/FActivities.htm> (also available at <http://www.c2p2online.com/documents/Textiles-Europe.pdf>).
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7. Smith, Brent, *Managing APEs in Textile Manufacturing*, undated, North Carolina State University College of Textiles.
8. United States Environmental Protection Agency, *Best Management Practices for Pollution Prevention in the Textile Industry*, September 1996. Available at URL: <http://www.p2pays.org/ref/02/01099/0109900.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.⁸¹ 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)⁸² 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 -

⁸¹ Refer to the CEPA 1999 Environmental Registry for more information at URL: <http://www.ec.gc.ca/CEPARegistry/default.cfm>

⁸² 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.⁸³ 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.”⁸⁴

Reference Criteria are the maximum desired final effluent concentrations for the harmful substances identified. Three reference criteria limits 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

⁸³ See the NPRI website at URL: http://www.ec.gc.ca/pdb/npri/npri_home_e.cfm

⁸⁴ 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
<i>Best Management Practices. Textiles Sector: Nonylphenol and its Ethoxylates and Chromium</i>	Textiles Sector (313) Fibre, Yarn, Thread Mills Fabric Mills Textile and Fabric Finishing and Fabric coating	Nonylphenol and its ethoxylates Chromium
<i>Best Management Practices. Fabricated Metal Product Manufacturing: Cadmium, Lead and Copper</i>	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
<i>Best Management Practices. Motor Vehicle Parts Manufacturing: Cadmium and Nonylphenol and its Ethoxylates</i>	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

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BEST MANAGEMENT PRACTICES DOCUMENTS

Document Name	Sector and Sub-Sector Titles and NAICS Codes	Harmful Pollutants
<i>Best Management Practices. Automotive Repair and Maintenance: Cadmium and PAHs</i>	Automotive Repair and Maintenance (8111) Automotive Repair and Maintenance Automotive Body, Paint and Interior Repair and Maintenance Car Washes	Cadmium PAHs
<i>Best Management Practices. Dry Cleaning and Laundry Services: Nonylphenol and its Ethoxylates, Cadmium, and Mercury</i>	Dry Cleaning and Laundry Services (8123) Dry Cleaning and Laundry Services (except Coin-Operated) Linen and Uniform Supply	Nonylphenol and its ethoxylates Cadmium Mercury
<i>Best Management Practices. Chemical Manufacturing Sector: Cadmium, Chromium, Copper, Mercury, Zinc, Nonylphenol and its Ethoxylates, and Vinyl Chloride</i>	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
<i>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</i>	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

APPENDIX A
BEST MANAGEMENT PRACTICES DOCUMENTS

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

APPENDIX B

TEMPLATES (TASK 5)

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 the textiles sub-sectors are as follows:⁸⁵

- Fibre, Yarn , Thread Mills (NAICS 3131)

This industry group comprises establishments primarily engaged in spinning yarn from fibres; texturing, throwing or twisting man-made fibre filaments or purchased yarns; or manufacturing thread for sewing, crocheting, embroidery, tatting, and similar uses.

- Fabric Mills (NAICS 3132)

This industry group comprises establishments primarily engaged in manufacturing textile fabrics. Establishments classified in this industry group may finish the fabrics that they manufacture. Establishments primarily engaged in manufacturing both fabrics and textile products, except knitted clothing, are included. Excluded establishments from this NAICS group include those primarily involved in:

- Finishing textile fabrics; and coating fabrics (3133, Textile and Fabric Finishing and Fabric Coating); and
- Manufacturing tire cord fabric (3149, Other Textile Product Mills).

- Textile and Fabric Finishing and Fabric Coating (NAICS 3133)

This industry group comprises establishments primarily engaged in finishing yarn and thread, textile fabrics, textile products (except carpets and rugs), and clothing; and manufacturing coated or laminated fabrics. Excluded establishments from this NAICS group include those primarily involved in:

- Finishing carpets and rugs (3141, Textile Furnishings Mills);
- Embroidering textile products and clothing (3149, Other Textile Product Mills);
- Knitting and finishing clothing in the same establishment (3151, Clothing Knitting Mills);
- Manufacturing (cut-and-sew) and finishing clothing in the same establishment (3152, Cut and Sew Clothing Manufacturing);
- Fur dressing and dyeing (3161, Leather and Hide Tanning and Finishing); and
- Printing on articles of clothing, not made in the same establishment (3231, Printing and Related Support Activities).

⁸⁵ <http://stds.statcan.ca/english/naics/2002/naics02-class-search.asp?criteria=313> (accessed December 20, 2005)

APPENDIX D

***AGREEMENTS FOR TOXIC REDUCTION AND SUBSTANCES OF
CONCERN***

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:

CASE STUDY EXAMPLES DEMONSTRATING BENEFITS OF P2 MEASURES

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>