FRASER RIVER ACTION PLAN

Transcontinental Printing Inc: Full Scale Demonstration of a Treatment Technology to Reduce Contaminants and Re-use Water in the Printing and Graphics Industry

DOE FRAP 1997-12

Environment Canada Environnement Canada

TRANSCONTINENTAL PRINTING INC.: FULL SCALE DEMONSTRATION OF A TREATMENT TECHNOLOGY TO REDUCE CONTAMINANTS AND RE-USE WATER IN THE PRINTING AND GRAPHICS INDUSTRY

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Prepared for:

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EXECUTIVE SUMMARY

This report summarizes the results of an on-going full scale demonstration of a treatment technology to reduce contaminants and re-use water in the printing and graphics industry. This demonstration equipment was installed at the Transcontinental Printing facility in Delta, BC. At the time of writing, Transcontinental was the only printing facility in the Fraser Basin to use this filtration technology in treating process wastewaters.

The treatment technology demonstrated is the use of pre-, ultra- and nano-filtration units to remove contaminants from printing process wastewaters, re-using the regenerated waters in the printing facility. All of the process wastewaters generated in the pre-press and press room operations are collected in raw process wastewater holding tanks. This water is first passed through pre-filtration units to remove any residual particulate contamination which would lead to premature membrane fouling. The resulting water is passed through an ultra-filtration unit, removing particles 0.002 - 0.1 microns in size, and organics with a molecular weight of over 1,000. The permeate from the ultra-filtration unit then passes through the nano-filtration unit, where particles with a molecular weight of 300-1,000, such as humic acid and organic colour particles, are removed. The resulting regenerated water is returned to the printing operation, where it is re-used in the pre-press and press sinks, the image processing area, and the facility toilets.

On average, virtually all of the water processed through the pre-filtration units is recovered, 97% through the ultra-filtration unit, and 96% through the nano-filtration unit. The overall water recovery rate is therefore 93%. The pre-filtration disposable filter bags are removed from the site for incineration. The waste concentrate generated by the ultra- and nano-filtration units is hauled by a licensed disposal company. There are no waste filter bags generated by the ultra- and nano-filtration processes. The disposal company recovers 85% of the concentrate in a distillation process and has the remaining material incinerated. The fate of the incinerated materials is beyond the scope of this study.

As a result of the combined pre-, ultra, and nano-filtration treatment processes, the quality of the wastewater discharged to the sanitary sewer is significantly improved and its quantity is reduced. Accordingly, the contaminant loadings to the Fraser River Basin from the Transcontinental facility are reduced.

Based on the reduced contaminant loadings for this one facility, an estimate of the total contaminant loading reductions to the Fraser River Basin was made assuming that the process wastewater from all printing facilities where this wastewater could reasonably be treated by filtration used this technology. Because direct information regarding the process wastewater flow rates from the numerous facilities in the province was for the most part unavailable, an approximate ratio between the number of employees and wastewater flow rates was used to estimate the total wastewater flow rates in the Fraser River Basin. The resulting contaminant loading reduction estimates are meant to be within an order of magnitude only. The annual contaminant loading reductions to the Fraser River Basin are approximated as 0.94 tonnes/year (99% reduction) for total suspended solids (TSS), 5.38 tonnes/year (99%) for biochemical

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oxygen demand (BOD), 9.68 tonnes/year (99%) for chemical oxygen demand (COD), 1.54 tonnes/year (99%) for total oil and grease (total O&G), 0.39 tonnes/year (99%) for hydrocarbon oil and grease (HC O&G), 194 kg/year (99%) for phosphorous, and 1.15 kg/year (93%) for silver.

A cost benefit analysis for two alternate scenarios was done. For the first scenario, a comparison was made between the cost of installing the filtration technology (pre-, ultra-, and nano-filtration) to treat the wastewater on-site and the cost of hauling the process wastewater from the site. For this scenario, the capital cost of $126,000 and annual O&M costs of $24,700 were balanced by the annual savings of $130,350 within 1.3 years. This analysis did not include any savings for less tangible benefits such as increased sales revenues and improved environmental relations. The second scenario examined the costs of installing the filtration technology vs. discharging the process wastewater directly to sewer. The annual savings of $10,350 were less than the annual O&M cost, $24,700, of installing the technology. Without taking into consideration any less tangible benefits, there was, therefore, no pay-back period. However, if the less tangible benefits were worth $20,000 annually, the cost of the technology would be payed back in 22.3 years.

SOMMAIRE À L'INTENTION DE LA DIRECTION

Ce rapport résume les résultats d'une étude de démonstration à l'échelle réelle en cours portant sur une technologie d'épuration visant la réduction des contaminants et la réutilisation de l'eau dans les industries de l'imprimerie et des arts graphiques. Ce matériel de démonstration a été installé dans les installations de la Transcontinental Printing à Delta, Colombie-Britannique. À l'heure actuelle, ces installations sont les seules, dans tout le bassin du Fraser, à utiliser cette technologie de filtration pour l'épuration des eaux usées des traitements.

Cette technologie d'épuration utilise des unités de préfiltration, d'ultrafiltration et de nanofiltration pour enlever les contaminants des eaux usées des procédés d'impression et elle réutilise les eaux régénérées dans les installations d'imprimerie. Toutes les eaux usées des traitements produites dans l'atelier préparatoire et dans la salle des impressions sont recueillies dans des bassins de rétention des eaux usées brutes des procédés. Ces eaux passent d'abord par des unités de préfiltration servant à éliminer toutes contamination due aux matières particulaires pouvant encrasser prématurément la membrane. L'eau obtenue passe ensuite par une unité d'ultrafiltration qui élimine les particules de 0,002-0,1 micron, ainsi que les matières organiques de poids moléculaire supérieur à 1 000. Le liquide sortant passe ensuite par l'unité de nanofiltration, qui élimine les particules de poids moléculaire compris entre 300 et 1 000 comme les acides humiques et les particules de colorants organiques. L'eau régénérée qui en résulte est retournée aux opération d'impression et réutilisée dans les éviers des ateliers préparatoires et des salles d'impression, dans les ateliers de traitement des images et dans les toilettes des installations.

En moyenne, on récupère presque toute l'eau traitée par les unités de préfiltration, 97 % de celle traitée par l'unité d'ultrafiltration et 96 % de celle traitée par l'unité de nanofiltration. Le taux d'ensemble de récupération est donc de 93 %. Les filtres jetables de l'unité de préfiltration sont expédiés à l'extérieur du site pour incinération. Le concentré de résidus des unités d'ultrafiltration et de nanofiltration est enlevé du site par une entreprise d'élimination autorisée; ces deux procédés n'utilisent pas de sacs jetables. L'entreprise d'élimination récupère 85 % du concentré à l'aide d'un procédé de distillation et le résidu final est incinéré. L'étude du devenir des substances incinérées n'entre pas dans le cadre de cette étude.

La combinaison des étapes de préfiltration, d'ultrafiltration et de nanofiltration permet d'obtenir une amélioration significative de la qualité des eaux usées déversées dans l'égout séparatif, ainsi qu'une réduction de leur volume. De même, on note une réduction des charges de contaminants déversées dans le bassin du Fraser par les installations de la Transcontinental.

En se basant sur la réduction des charges obtenue dans cette installation, on a estimé la quantité totale des réductions des charges de contaminants rejetées dans le bassin du Fraser en supposant que cette technologie était utilisée pour l'épuration des eaux usées des traitements de toutes les installations d'imprimerie auxquelles se prête cette technologie de filtration. À cause de la non-disponibilité de la plupart des informations directes concernant les débits des eaux usées des traitements des nombreuses installations d'imprimerie de cette province, on a utilisé un rapport approximatif entre le nombre d'employés et le débit d'eaux usées pour estimer le débit total des eaux usées rejetées dans le bassin du Fraser. La précision des réductions des charges estimées est donc d'un ordre de grandeur seulement. Les réductions annuelles des charges de contaminants rejetées dans le bassin du Fraser sont d'environ 0,94 tonnes/an (réduction de 99 %) pour le total des solides en suspension (TSS), de 5,38 tonnes/an (99 %) pour la demande biochimique en oxygène (DBO), de 9,68 tonnes/an (99 %) pour la demande chimique en oxygène (DCO), de 1,54 % (99 %) pour les huiles et les graisses totales, de 0,39 tonnes/an (99 %) pour huiles et graisses à base d'hydrocarbures, de 194 kg/an (99 %) pour le phosphore et de 1,15 kg/an (93 %) pour l'argent.

On a effectué une analyse coût-avantage pour deux scénarios possibles. Selon le premier scénario, on a comparé le coût de l'installation de la technologie de filtration (à étapes de préfiltration, d'ultrafiltration et de nanofiltration) pour le traitement sur place des eaux usées, d'une part, et le coût du transport hors site des eaux des traitements, d'autre part. On obtenait ainsi des coûts en capital de 126 000 $ et des frais généraux de 24 000 $, contre des économies de 130 350 $ en 1,3 an. Cette analyse ne tenait pas compte d'économies pour des avantages moins tangibles comme des augmentations des revenus des ventes et une meilleure image environnementale. Selon le deuxième scénario, on examinait les avantages de la technologie de filtration par rapport à ceux du déversement direct à l'égout des eaux usées. Les économies annuelles de 10 350 $ étaient inférieures aux frais généraux annuels (24 700 $) requis pour la mise en place de la technologie. Si l'on excluait les avantages moins tangibles, on ne pouvait donc prévoir aucune période de récupération des frais. Toutefois, si l'on attribuait une valeur annuelle de 20 000 $ aux avantages moins tangibles, on obtenait une période de récupération de 22,3 ans.

ACKNOWLEDGMENTS

NovaTec Consultants Inc. and Maratek Environmental Inc. would like to acknowledge the co-operation and assistance of the following people in providing information for this report:

- Mr. Yvan St.Germain of Transcontinental Printing contributed many hours and resources towards the implementation and operation of this project. Transcontinental Printing is recognized for their environmental leadership in implementing a strict environmental mandate.

- Mr. Reg Skippen of Unisource is also recognized for his financial support of this initiative.

The following people were also instrumental in providing the information necessary for this report:

- Barry Azevedo BC Environment
- Andrea Loewie GVRD, Source Control
- Michelle Mignault BC Printing Association

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1 INTRODUCTION

Under the pollution abatement component of the Fraser River Action Plan, Environment Canada works with various industrial sectors towards preventing and reducing pollution from industrial sources in the Fraser Basin. Demonstrating new and innovative techniques and technologies for treating wastes and minimizing the creation of pollutants at source is part of this work. In this project, Transcontinental Printing and Unisource, with assistance from Environment Canada, demonstrate a full scale treatment technology which reduces contaminants and reuses water in the printing and graphics industry.

Transcontinental Printing Inc. of Delta, BC, is a state of the art, high volume printing facility specialising in the printing of newspapers. Unisource is the exclusive graphic arts material distributor for DuPont Canada, a manufacturer of printing chemicals. Transcontinental Printing and Unisource are committed to the philosophy of reduce, reuse and recycle as an environmentally effective method of pollution control. In this joint project agreement with Environment Canada, these corporate citizens have demonstrated and evaluated the full scale application of a technology that dramatically reduces the contaminant concentration in the printing and graphics industry's wastewaters.

The technology demonstrates how wastewaters from the printing process can be regenerated and recycled into the original process. It involves passing process wastewaters through a series of filtration units to remove the contaminants. The majority of the process water is returned to the process. The small portion of water bearing the bulk of the contaminants is removed from the site for treatment and disposal.

2 OBJECTIVES

The principle objectives of this project were to develop, implement and evaluate a full scale nano filtration unit operating in conjunction with existing on-site environmental equipment. In particular, the objectives of the developmental and implementation phases of the project were:

< to increase the percentage of water presently being reused at the facility from 5-10% up to 90-95%;
< to reduce contaminant discharge to sanitary sewer; and,
< to reduce the cost of operations due to lower transportation costs for hazardous material disposal.

The goals of the evaluation phase of the project were:

< to determine the contaminant loading reduction in the sewer discharge from Transcontinental Printing;
< to determine the contaminant loading reduction in the combined effluents from printing facilities in the Fraser River Basin should similar technology find industry wide acceptance; and
< to evaluate the cost/benefits of the proposed technology.

3 BACKGROUND

Prior to this study, the Transcontinental Printing facility had already undergone a detailed effluent analysis to determine wastewater characteristics and source generation. Effluent sources and characteristics were identified by Maratek Environmental Technologies, an environmental consultant to Transcontinental Printing. Maratek was commissioned to install the best available technologies, starting at source, in each process area. The purpose of this approach was to reduce the total volume of wastewater generated by the process before sizing and installing a wastewater treatment system.

As a result of this preliminary work, some environmental equipment was already in place before this study began. The process wastewater was partially treated by pre- and ultra-filtration units. Source reduction equipment was used in both the prepress and the press room areas of the printing process. These modifications to the facility reduced the volume and strength of the process wastewater. The technology demonstrated in this study is in addition to the already existing waste reduction and water conservation measures. Appendix A lists some of the existing environmental systems, technologies and products already in place at Transcontinental.

Recently, the Transcontinental facility was awarded the right to use the **AEcologo@** by the federally approved environmental labelling program. This honour is in recognition this printing operation meets all stringent environmental criteria for environmental excellence, attaining an almost zero discharge rating. In recognition of their environmental leadership, Transcontinental=s manufacturing manager Yvan St.Germain was presented with the ALocal Heroes@ award by the federal Minister of the Environment, Sergio Machi in February of 1997. These awards recognize actions that all Canadians can take in their own communities to help protect Canada=s environment.

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4 FILTRATION TECHNOLOGY DESIGN AND DEMONSTRATION

4.1 PROCESS APPLICATION OVERVIEW

Before the application of this technology, the process waters at the Transcontinental facility were only treated by pre-filtration and ultra-membrane filtration units (see Figure 1). These units reduced the contaminant concentrations to comply with the existing discharge criteria at source, i.e. before the wastewater was diluted by sanitary wastewaters, as measured at the property line. Only a small percentage (approximately 5-10 %) of these treated wastewaters was re-used in the non-potable press room sinks. The treated water still contained contaminant concentrations which precluded its re-use in most of the printing process. An attempt was made to re-use the treated water in the toilets. However, this proved to be unfeasible because of problems with re-growth and associated odours in the toilet bowls and water tanks. The majority of the treated waste water was discharged to the GVRD sewer system.

In order to improve the treatment process and increase the amount of water available for re-use, Maratek Environmental Technologies designed a process which enables treated process water to be re-used in the printing imaging process area and toilets (see Figure 2), as well as in the non-potable press room sinks. The treatment process is a nano-filtration unit which is installed in series following the existing pre- and ultra-filtration units. All of the wastewater regenerated by this new process can be recycled to some part of the process operations. A contaminant concentrate resulting from the ultra- and nano-filtration processes is collected in totes and removed from the site. Maratek recovers about 85% of the water from this concentrate using a distillation process, and has the remaining material incinerated.

4.2 FILTRATION TERMINOLOGY

A number of terms are commonly used to describe this new technology. This section provides a brief overview of these terms in order to facilitate the detailed process description which follows.

4.2.1 Filter Media

Filter media are the selected materials in a filter that form the barrier to the passage of filterable suspended solids or dissolved molecules. Filter media are used to remove undesirable materials, tastes, and odours from a water supply, and to adjust the pH in a water supply.

Filter designs include:

< Loose media filters with grains, resin, or other particles lying in beds; or loosely packed in column-form in tank-type filters.

< Cartridge-type filters, which may contain membranes, fabric, fibre, bonded-ceramic, precoat, or cast solid-block filter media.

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Figure 1
Transcontinental Printing
Process Before Nano-filtration

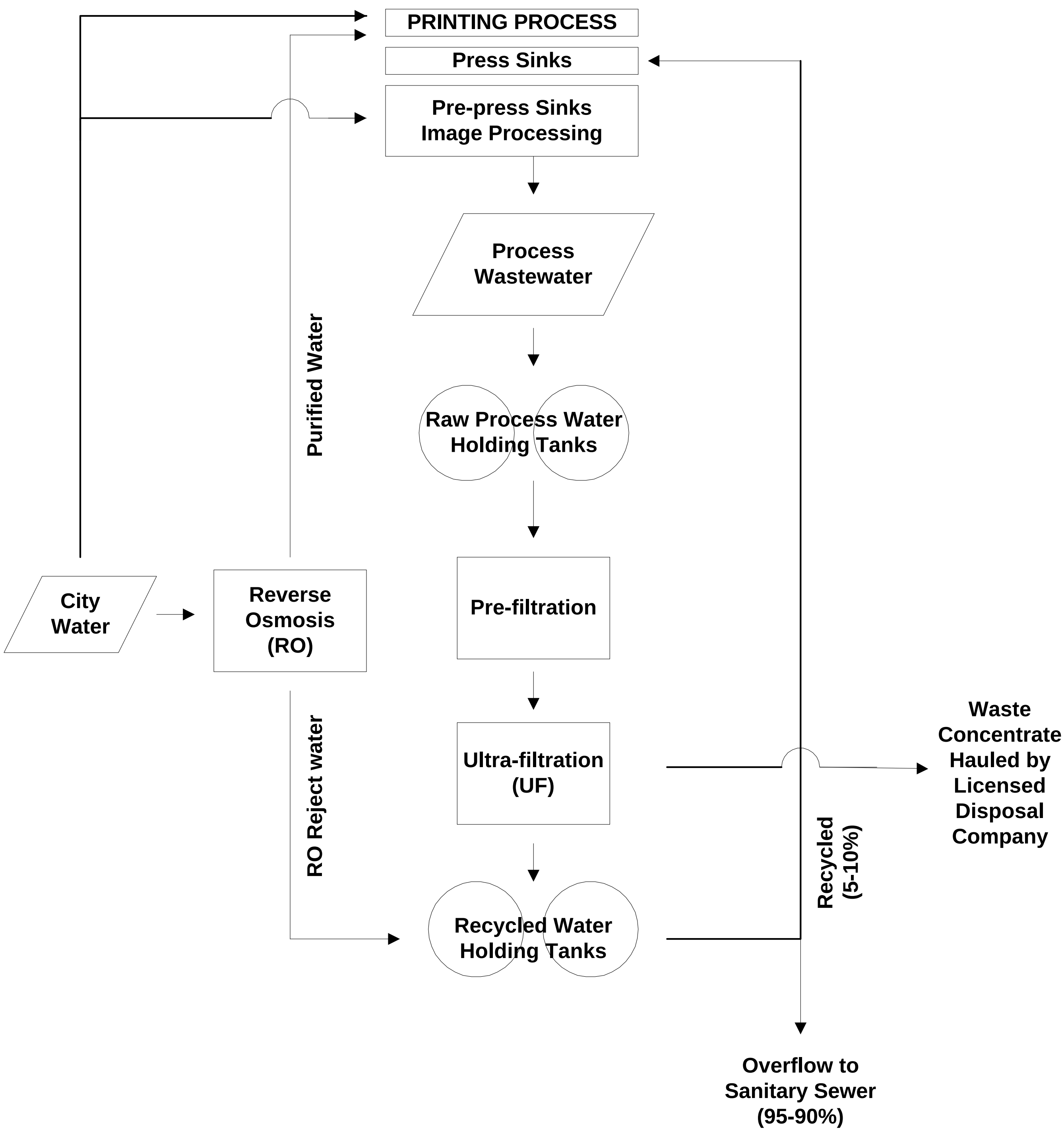

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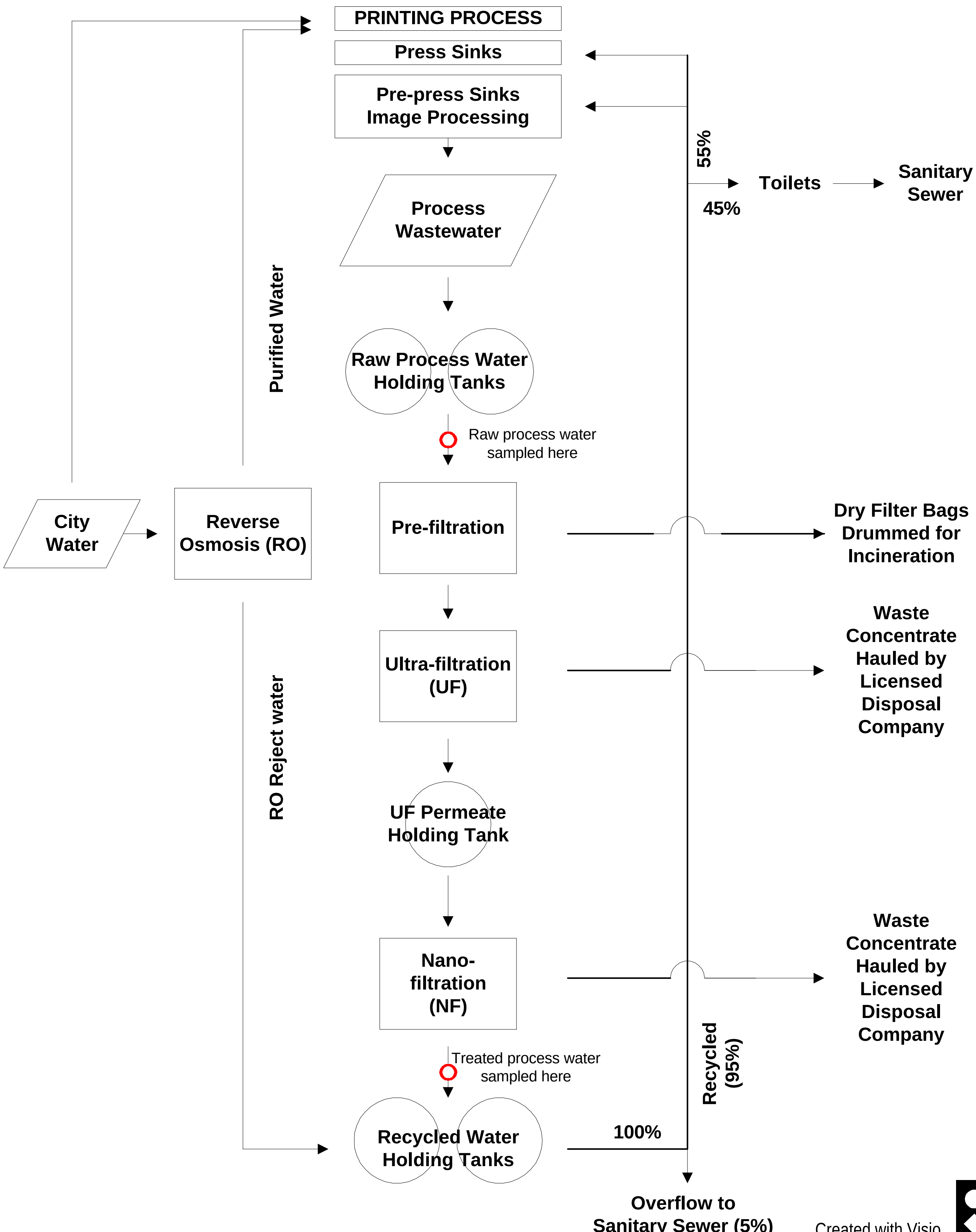
Figure 2
Transcontinental Printing
Process Modified to Include Nano-filtration



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The media used in some filters are chemically inert (i.e. sand) and perform only a mechanical filtration. Other filter media are multi-functional, chemically-reactive media such as calcite, activated carbon, magnesia, manganese dioxide, and manganese greens.

4.2.2 Membrane

A membrane is a thin sheet or surface film, either natural or manufactured (synthetic), of microporous structure that performs as an efficient filter of particles down to the size range of molecules or ions. Such membranes are termed Asemi-permeable@ because some substances will pass through, while others will not. Usually, small ions, water, solvents, gases, and other very small molecules can pass easily through a membrane; other ions and macromolecules like proteins and colloids are barred. Synthetic membranes are highly engineered polymer films about 100 angstroms thick (1 angstrom = 10^{-7} mm), with controlled distributions of pores ranging from 5 to 5000 angstroms in diameter. Membranes are used in reverse osmosis, electrodialysis, nano-filtration, ultra-filtration, and as pleated final filter cartridges in water treatment.

4.2.3 Ultra-filtration

Ultra-filtration is a method of cross-flow filtration (similar to reverse osmosis, but using lower pressures) which uses a membrane to separate small colloids and large molecules from water and other liquids. The ultra-filtration process falls between reverse osmosis and ultra-filtration processes in terms of the size of particles removed, with ultrafiltration removing particles from the 0.002 to 0.1 micron range, and typically rejecting organics over 1000 molecular weight, while passing ions and smaller organics.

4.2.4 Nano-Filtration

Nano-filtration is a membrane treatment process which falls between reverse osmosis and ultrafiltration on the filtration/separation spectrum. The nano-filtration process can pass more water at lower pressure operations than can reverse osmosis, can remove particles in the 300 to 1,000 molecular weight range (like humic acid, and organic colour bodies present in water) and can reject selected (typically polyvalent) salts. Nano-filtration may be used for selective removal of hardness ions in a process known as Amembrane softening@.

4.3 TECHNOLOGY DESIGN CRITERIA

The evolution of the nano-filtration technology to its presently applicable state involved the optimisation of membrane technology. The desired membrane must to meet three criteria in order to be acceptable to the private sector. These criteria are:

< Contaminant removal efficiency
< System integration
< Process design flow rate

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4.3.1 Contaminant Removal Efficiency

The membrane must be able to remove the contaminants present in the waste stream to meet required performance criteria (i.e. water reuse, compliant discharge, downstream technology requirements, etc...).

4.3.2 System Integration

The new technology must take into consideration upstream and downstream technologies to simplify system integration and minimize capital and energy costs. In this case, the quality and variability of the ultra-filtration unit permeate must be incorporated into the design of the nano-filtration equipment, as well as the downstream water quality demand. The system must designed to achieve the lowest overall energy and resource expenditures (i.e. maintenance costs, process efficiency, etc...).

4.3.3 Process Design Flow Rates

The process flow rates required by the facility employing the technology must considered in the design. In this case, the wastewater streams are isolated and collected in a central area for storage prior to treatment by the membrane technology to ensure suitable flow rates. The design flow rate required through the membrane will determine membrane size and membrane system configuration. An in-depth understanding of the plant's waste streams and their respective flow rates is required in order to develop plant effluent profiles and design a membrane treatment system.

4.4 FILTRATION PROCESS DESCRIPTION

The following is a detailed filtration process description. The process flow described is illustrated in Figure 2 (process flow) and Figure 3 (system component diagram). The average residence time of water in the process is five hours.

4.4.1 Raw Process Wastewater Collection

Wastewaters are generated in the printing process from the prepress and press areas. All process wastewaters are transferred via liquid pump transfer stations to the centralized treatment area and held in the raw process water holding tanks. As previously mentioned, at Transcontinental the volume of wastewaters to be treated has already been reduced significantly at source by the application of other technologies.

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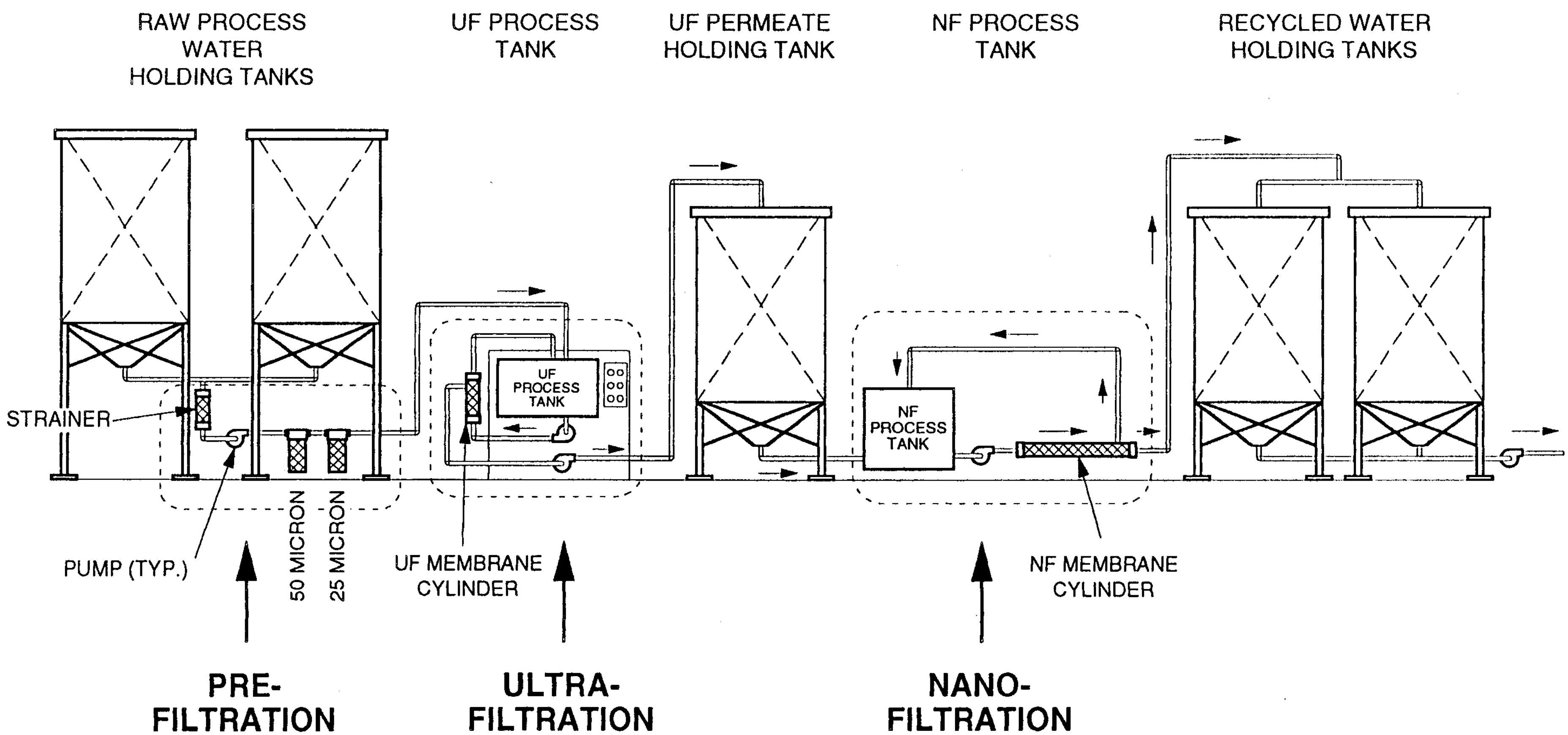
Figure 3

TRANSCONTINENTAL PRINTING
SYSTEM COMPONENT DIAGRAM



4.4.2 Pre-filtration

The wastewater passes through a pre-filtration system. This system comprises of a strainer and two 20@ filter bag housings (50 and 25 microns, respectively). The purpose of this phase is to eliminate any residual particulate contamination which would lead to premature membrane fouling. (As an anti-fouling measure, the 25 micron filter was upgraded to a 10 micron filter following this testing period.) The system pumps the effluent through the filters using a small diaphragm pump, filling the ultra-filtration process tank with the required batch quantity of 45 gallons. Filter bags are changed on average about twice a month. Wastewater collects in the raw process water tanks for five minutes while the filters are being changed. The spent filter bags are collected in a drum and removed for incineration. The fate of the material accumulated on the filter after incineration is beyond the scope of this study. The filters are a consumable item and a new waste product generated by this technology.

4.4.3 Ultra-Filtration

Following processing through the pre-filtration system, the wastewater passes through the ultra-filtration membrane. The membrane is a permanent metal filter, so no new consumable filters are required for ultra-filtration. The permeate from the ultra-filtration unit is collected in a permeate holding tank. The ultra-filtration system processes the pre-filtered water at a rate of approximately 1 litre per minute. Reclamation efficiency at this stage is approximately 97% by volume. For example, if 100 L of process water enters the unit from the pre-filtration stage, then 97 L of water will be passed on to the nano-filtration stage, and 3 L of waste concentrate will be generated. The contaminants removed in this process are collected separately for disposal.

4.4.4 Nano-Filtration

In this application, permeate from the holding tank is processed through the nano-filtration membrane system. As in the ultra-filtration unit, the filter is a permanent metal sieve that does not require regular replacement. This system removes contaminants that passed through the ultra-filtration membrane=s pores. The nano-filtration permeate is automatically transferred to the recycled water tanks where it is held until required in the printing operations. The nano-filtration membrane system is the final stage in effluent treatment. Reclamation efficiency at this stage is approximately 96%.

4.4.5 Recycled Water Tanks

The recycled water tanks are the holding area for reclaimed waters. These tanks receive the regenerated water from the filtration treatment process. They also receive reject water from the reverse osmosis (RO) water purification unit. Of the water that is recycled from these tanks to the process, the majority (>90%) is reject RO waters. The reject RO waters have characteristics very similar to tap water, with slightly higher contaminant concentrations.

From the recycled water tanks, 95% of the water is reintroduced back into operations on a demand feed basis. The volume of water generated by the filtering process combined with the

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RO reject water is slightly greater than the recycled water demand. As a result, 5% is discharged directly to the GVRD sewers. The recycled water is used in the press room sinks, the toilets and the prepress wash application in the imaging department. Some of this recycled water is consumed in the printing process, either being absorbed by the paper or evaporating as steam. Almost half of the recycled water is used as flush water for the toilets. This wastewater is also discharged to the sanitary sewer.

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5 ANALYTICAL RESULTS OF SAMPLING EVENTS

The equipment for the demonstration project was installed in early October 1996. Three sets of grab samples were taken during the testing period. Samples were collected at least four months after the commissioning of the equipment. Printing practices prior to and during the sampling event reflected normal volumes and operation for the printing facility. For each sampling event, a grab raw process water sample and a grab treated process water sample were taken. Sampling points are indicated in Figure 2. The raw process water was representative of the water prior to any filtration treatment, i.e. pre-, ultra-, or nano-filtration. The treated process water was taken from nano-filtration unit permeate, being representative of the water treated by all three filtration units. The contaminant reduction between the raw process water and treated process water samples is a result of the pre-, ultra- and nano-filtration units working in series, not the nano-filtration unit only.

Although the funding for this project was used to install the nano-filtration unit, the technology assessed was the combination of all the filtration units in series. The pre- and ultra-filtration units provided the pre-treatment necessary to use a nano-filtration unit effectively. The use of pre-and ultra-filtration alone did not provide the level of treatment necessary to enable re-use in the printing facility; fouling problems in the toilet water tanks preclude its use. No comparison of ultra- and nano-filtration effluents was made in this sampling program.

The samples were sent to CanTest Analytical Services for testing. Samples were tested for a number of conventional parameters, such as pH, total suspended solids (TSS), biochemical oxygen demand (BOD), chemical oxygen demand (COD), and oil and grease (O&G), as well as for metals. These parameters were chosen for testing as they are controlled by the Sewer Use Bylaw (GVSDD, 1990) discharge criteria. Mercury, a parameter in the discharge criteria, was not monitored. Maratek Environmental decided that the extra costs for monitoring this specific metal were unwarranted as historical levels had been consistently below detection limits.

The results of the analytical sampling are provided in Table 1. Included in this table are the calculated percent contaminant removal efficiencies for each sampling event, and an average for the three sampling events.

As indicated in Table 1, the removal efficiency of the nano-filtration unit is excellent. For almost all measurable parameters, the percent removal was greater than 95%. The only notable exception to this high removal efficiency was for Boron, at 72%. The average removal over the three sampling events for several key parameters is given in Table 2.

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Table 1
Transcontinental Wastewaters - Filtration Technology
Raw Process Water and Recycled Water Analytical Results Summary

	SAMPLE DATE												
	January 28, 1997			February 4, 1997			February 13, 1997				Average	Average	
PARAMETER All results listed as mg/L unless otherwise noted.	Raw Process Water	Treated Process Water	% Removal	Raw Process Water	Treated Process Water	% Removal	Raw Process Water 1	Raw Process Water 2	Treated Process Water	% Removal	Raw Process Water	Treated Process Water	Average % Removal
CONVENTIONAL													
pH	6.77	6.92		5.3	6.18		6.52	6.94	7.02		6.4	6.7	
Conductivity (uS/cm)	3500	17	99.5%	1820	25	98.6%	2150	1650	106	94.4%	2,280	49	97.5%
Turbidity (NTU)	340	0.16	100.0%	150	0.6	99.6%	185	175	0.58	99.7%	212.5	0.4	99.7%
TSS	130	< 1	> 99.2%	170	< 1	> 99.4%	148	238	< 1	> 99.5%	172	1	> 99.5%
BOD	2120	19	99.1%	1040	17	98.4%	403	411	24	94.1%	994	20	97.2%
COD	3280	< 25	> 99.2%	1700	< 25	> 98.5%	1170	977	36	96.6%	1,782	29	> 98.1%
Total O&G	133	2	98.5%	284	2	99.3%	466	244	2	99.4%	282	2	99.1%
HC O&G	26	< 2	> 92.3%	71	< 2	> 97.2%	165	27	< 2	> 97.9%	72	1	> 96.5%
METALS													
Aluminum	2.4	< 0.2	> 91.7%	< 0.2	< 0.2		3.9	2.9	< 0.2	> 94.1%	2.4	0.2	> 92.9%
Antimony	< 0.2	< 0.2		< 0.2	< 0.2		< 0.2	< 0.2	< 0.2		0.2	0.2	
Arsenic	< 0.3	< 0.3		< 0.3	< 0.3		< 0.3	< 0.3	< 0.3		0.3	0.3	
Barium	0.077	< 0.001	> 98.7%	0.055	< 0.001	> 98.2%	0.025	0.046	< 0.001	> 97.2%	0.05	0.00	> 98.0%
Beryllium	< 0.003	< 0.003		< 0.003	< 0.003		< 0.003	< 0.03	< 0.003		0.01	0.00	
Boron	8.32	1.35	83.8%	27.6	0.22	99.2%	13.4	21.5	11.5	34.1%	17.7	4.4	72.4%
Cadmium	< 0.025	< 0.025		< 0.025	< 0.025		< 0.025	< 0.025	< 0.025		0.03	0.03	
Calcium	9.21	0.04	99.6%	4.22	0.09	97.9%	4.64	3.99	0.24	94.4%	5.52	0.12	97.3%
Chromium	< 0.03	< 0.03		< 0.03	< 0.03		0.03	0.03	< 0.03		0.03	0.03	
Cobalt	< 0.02	< 0.02		< 0.02	< 0.02		< 0.02	< 0.02	< 0.02		0.02	0.02	
Copper	0.88	0.03	96.6%	0.78	< 0.02	> 97.4%	0.51	0.56	< 0.02	> 96.3%	0.68	0.02	> 96.8%
Iron	11	< 0.03	> 99.7%	6.48	0.06	99.1%	1.68	3.9	< 0.03	> 98.9%	5.77	0.04	> 99.2%
Lead	0.13	< 0.08	> 38.5%	< 0.08	< 0.08		< 0.08	< 0.08	< 0.08		0.09	0.08	
Magnesium	0.96	< 0.05	> 94.8%	0.93	< 0.05	> 94.6%	1.45	1.2	0.07	94.7%	1.14	0.06	> 94.7%
Manganese	0.114	< 0.003	> 97.4%	0.081	< 0.003	> 96.3%	0.027	0.039	< 0.003	> 90.9%	0.07	0.00	> 94.9%
Molybdenum	< 0.04	< 0.04		< 0.04	< 0.04		< 0.04	< 0.04	< 0.04		0.04	0.04	
Nickel	< 0.03	< 0.03		< 0.03	< 0.03		< 0.03	< 0.03	< 0.03		0.03	0.03	
Phosphorus	60.5	< 0.4	> 99.3%	46.7	< 0.04	> 99.9%	11.7	23.9	1	94.4%	35.7	0.5	> 97.9%
Potassium	172	0.01	100.0%	35.2	0.53	98.5%	68.6	41.5	2.27	95.9%	79.3	0.9	98.1%
Silicon	35.7	0.9	97.5%	8.2	0.6	92.7%	11.5	10.7	2.8	74.8%	16.5	1.4	88.3%
Silver	< 0.03	< 0.03		< 0.03	< 0.03		0.3	0.54	< 0.03	> 92.9%	0.23	0.03	
Sodium	378	2	99.5%	115	2.6	97.7%	101	98.6	11.2	88.8%	173.2	5.3	95.3%
Strontium	0.045	< 0.001	> 97.8%	0.026	< 0.001	> 96.2%	0.025	0.021	< 0.001	> 95.7%	0.03	0.00	> 96.5%
Tin	< 0.03	< 0.03		< 0.03	< 0.03		< 0.3	< 0.3	< 0.03		0.2	0.0	
Titanium	0.03	< 0.006	> 80.0%	0.019	< 0.006	> 68.4%	0.1	0.28	< 0.006	> 96.8%	0.11	0.01	> 81.8%
Vanadium	< 0.01	< 0.01		< 0.01	< 0.01		< 0.02	< 0.01	< 0.01		0.01	0.01	
Zinc	0.68	< 0.02	> 97.1%	0.29	0.03	89.7%	0.48	0.43	< 0.02	> 95.6%	0.47	0.02	> 94.1%
Zirconium	< 0.02	< 0.02		< 0.02	< 0.02		< 0.02	< 0.02	< 0.02		0.02	0.02	

TSS = Total Suspended Solids
BOD = Biochemical Oxygen Demand
COD = Chemical Oxygen Demand
O&G = Oil and Grease
HC = Hydrocarbon

Table 2 Key Parameters % Removal

Parameter	% Removal
TSS	> 99.5%
BOD	97.2%
COD	> 98.1%
Total O&G	99.1%
HC O&G	> 96.5%
Phosphorus	> 97.9%

TSS = total suspended solids
BOD = biochemical oxygen demand
COD = chemical oxygen demand
O&G = oil and grease
HC = hydrocarbon

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6 LOADING REDUCTIONS TO SANITARY SEWERS

The dramatic reductions in contaminant concentrations between the raw process water and the treated process water using pre-, ultra-, and nano-filtration in series result in significantly lower contaminant loadings to the sanitary sewers. In Transcontinental=s case, the volume of water discharged to the sanitary sewer is approximately halved.

6.1 WATER VOLUMES

The following table summarizes the water use at the Transcontinental facility. Raw process water is wastewater collected from the printing process. Treated process water has passed through the pre-, ultra-, and nano-filtration units.

Table 3 Water Use Summary

Month	**Raw Process Water (Litres)**	**Treated Process Water (Litres)**	**Wastewater concentrate (Litres)**
October 1996	14,350	13,525	825
November 1996	15,785	15,485	300
December 1996	20,295	19,855	440
January 1997	21,730	20,050	1,680
February 1-15, 1997	7,995	7,745	350
TOTAL	80,155	76,660	3,595
Average per month	17,810	17,040	800

Without the filtration units in place, all the raw process water would normally be discharged directly to the sanitary sewer. As indicated in Table 3, that would be on average about 17.8 m^3/month. With the filtration units installed, that same wastewater is treated such that 93% is available as treated process water for reuse in the facility. The other 7% of the wastewater contains the concentrated contaminants.

Theoretically, 100% of the treated process wastewater could be recycled to the printing process, with no discharge to the sanitary sewer. At Transcontinental, because the volume of water available for recycling is greater than what can be used in the process, not all the is recycled. In this installation, the treated process wastewater is diluted in the recycled water holding tanks by reject waters from a reverse osmosis (RO) unit (see Figure 2). 95% of these combined waters are returned to the process for re-use. The other 5% is directly discharged. Of the 95% returned for re-use, approximately 45% is used for toilet flushing (estimation made based on the average

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number of employees working at any given time and a per capita flow rate of 50 L/employee/day). The water used in the toilets is discharged to the sanitary sewer after a single use. Therefore, in total, approximately 50% of the wastewater regenerated by the filtration process is discharged to the sanitary sewer, either through a direct discharge, or through toilet flushing. The other 50% is recycled in the process.

6.2 CONTAMINANT LOADINGS

The effect of this process on contaminant loadings to the sanitary sewer is outlined in Table 4. The loadings are first calculated for raw process water before filtration, assuming all this water is directly discharged to the sanitary sewer. The loadings are then calculated for the wastewater treated by the filtration process (pre-, ultra- and nano-filtration). Estimates of the contaminant discharges are provided on a monthly and annual basis. The Sewer Use Bylaw criteria are also included for comparison.

The reduction of contaminants to the sanitary sewer as a result of the filtration process is dramatic. The strikingly lower contaminant loadings to the sanitary sewers are primarily a result of the contaminant concentration reductions, as well as reductions to the discharged wastewater flow rate.

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Table 4
Transcontinental Wastewaters - Filtration Technology
Treated and Untreated Water Estimated Monthly and Annual Discharges

PARAMETER	GVSDD Sewer Use Bylaw Criteria (1)	BEFORE FILTRATION		AFTER FILTRATION		Estimated Discharge Reduction	
		Average Raw Process Water	Estimated Monthly Discharge	Average Recycled Water	Estimated Monthly Discharge	Transcontinental Only	
CONVENTIONAL	**(mg/L)**	**(mg/L)**	**(kg/month)**	**(mg/L)**	**(kg/month)**	**(kg/month)**	**(kg/year)**
pH	5.0 - 11.0	6.4		6.7			
Conductivity (uS/cm)		2,280		49			
Turbidity (NTU)		212.5		0.4			
TSS	2,400	172	3.1	1	0	3.0	37
BOD	2,000	994	17.7	20	0	17.5	210
COD		1,782	31.7	29	0	31.5	378
Total O&G	600	282	5.0	2	0	5.0	60
HC O&G	60	72	1.3	1	0	1.3	15
METALS	**(mg/L)**	**(mg/L)**	**(g/month)**	**(mg/L)**	**(g/month)**	**(g/month)**	**(g/year)**
Aluminum	200.0	2.4	41.8	0.2	2	40.1	481
Antimony		0.2	3.6	0.2	2	1.8	21
Arsenic	4.0	0.3	5.3	0.3	3	2.7	32
Barium		0.05	0.9	0.00	0	0.9	11
Beryllium		0.01	0.2	0.00	0	0.1	2
Boron	200.0	17.7	315.1	4.4	39	276.4	3,316
Cadmium	0.8	0.03	0.4	0.03	0	0.2	3
Calcium		5.52	98.2	0.12	1	97.1	1,165
Chromium	16.0	0.03	0.5	0.03	0	0.3	3
Cobalt	20.0	0.02	0.4	0.02	0	0.2	2
Copper	8.0	0.68	12.1	0.02	0	11.9	143
Iron	40.0	5.77	102.6	0.04	0	102.3	1,227
Lead	4.0	0.09	1.6	0.08	1	0.9	11
Magnesium		1.14	20.2	0.06	1	19.7	236
Manganese	20.0	0.07	1.2	0.00	0	1.1	14
Molybdenum	4.0	0.04	0.7	0.04	0	0.4	4
Nickel	8.0	0.03	0.5	0.03	0	0.3	3
Phosphorus		35.7	635.5	0.5	4	631.2	7,574
Potassium		79.3	1,412.0	0.9	8	1,403.6	16,844
Silicon		16.5	294.1	1.4	13	281.4	3,377
Silver	4.0	0.23	4.0	0.03	0	3.7	45
Sodium		173.2	3,082.1	5.3	47	3,035.2	36,422
Strontium		0.03	0.5	0.00	0	0.5	6
Tin		0.2	2.9	0.0	0	2.7	32
Titanium		0.11	1.9	0.01	0	1.9	22
Vanadium		0.01	0.2	0.01	0	0.1	2
Zinc	12.0	0.47	8.4	0.02	0	8.2	98
Zirconium		0.02	0.4	0.02	0	0.2	2

TSS = Total Suspended Solids
BOD = Biochemical Oxygen Demand
COD = Chemical Oxygen Demand
O&G = Oil and Grease
HC = Hydrocarbon
Assume flow rate of 17,500 L/month for untreated waters.
Assume flow rate of 8,750 L/month for treated waters.

(1) Greater Vancouver Sewerage and Drainage District, Sewer Use Bylaw, No. 164, criteria for grab sample

7 TECHNOLOGY TRANSFERABILITY

7.1 APPLICABILITY TO OTHER SIZED FACILITIES

The filtration technology demonstrated in this report (pre-,ultra-, and nano-filtration) is most suited for application in large to medium scale operations. These operations include large size imaging houses, employing traditional artwork technologies for prepress, as well as full scale printing facilities, including pre-press and press room operations. The processes of significance in these operations involve film imaging equipment, utilizing fixers, developers, and washwaters. These operations are typically classified as commercial and newspaper printers, printing flyers, weeklies, dailies, newspapers, etc. These types of facilities are most likely to generate the volumes of process wastewater necessary to operate the equipment efficiently, as well as most likely to achieve sufficient financial pay-back when installing this equipment. A daily process wastewater flow rate of 300 litres is an approximate cut-off for a minimum applicable flow rate. In order to maximize the effectiveness of this equipment, process wastewater control measures should be installed upstream of the process wastewater treatment technology demonstrated in this report.

This technology is not practically applicable to smaller scale operations. The majority of the printed product produced by small scale operations is done using digital technologies which do not use liquid chemicals or washwaters. The volumes of process wastewaters generated by individual operations range from very small to negligible amounts; volumes too small to justify the capital cost of the equipment, or to provide an adequate flow for the equipment=s efficient operation. The growth trend for operations of this size is to expand their digital technologies when demand increases. As a result, the amount of process wastewater generated by this section of the industry is not anticipated to increase in the future. The application of the filtration technology demonstrated in this report is not suitable for such small operations. However, the source control equipment identified in Appendix A can be applied as an environmental control measure.

7.2 TRANSFERABILITY TO OTHER PRINTING EQUIPMENT SUPPLIERS

The filtration technology demonstrated in this report is not retrofitted to existing equipment, but rather added on to the existing process. In this manner, it can easily be installed downstream of any printing operation generating typical printing process wastewaters. A profile of the wastewater characteristics may be recommended to ensure that no unusual chemicals are being used that may compromise the filtering system. At Transcontinental, when a new chemical is introduced into the process, a chemical profile is first done to ensure that it will not interfere with the existing treatment process.

7.3 SOURCE CONTROL EQUIPMENT

Before installing a centralized wastewater treatment technology, as demonstrated in this report, a technology audit should be conducted. Such an audit would assess volumes of water used, the chemical effluent characteristics and Best Available Technologies (BATs) suitable for the facility

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in question. Based on the results of such an audit, source control technologies should be installed where possible. This would reduce the raw material consumption and total plant effluent volume, thereby reducing the capital cost requirements for a centralized waste treatment system as well as its operating costs. The type of technology appropriate for wastewater treatment before and after implementing source control measures may be quite different. A list of source control technologies is given in Appendix A.

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8 IMPLICATIONS FOR THE FRASER RIVER BASIN

8.1 SUMMARY OF ASSUMPTIONS

The following assumptions were derived in order to estimate the reductions in contaminant loading to the Fraser River Basin.

1. The range of process wastewater flow rates per employee at a printing operation where this technology would be applicable is 1-3 m^3/year/employee (based on industry data).

2. 73% of the printing operation employees in the Fraser River basin work at facilities where the equipment used is suitable for the installation of this filtration technology.

3. There are, on average, 13.9 employees per printing facility in BC.

4. Of the employees at these printing operations, 31% are employed in facilities of a medium to large scale, where the technology can be practically applied.

5. The process wastewater characteristics of the relevant printing industries are the same as the average of the three raw process water grab samples collected in this study.

6. The recycled water characteristics of the relevant printing industries are potentially the same as the average of the three recycled water grab samples collected in this study.

7. The volume of process wastewater discharged to sanitary sewers is halved by the introduction of the filtration technology and water recycling measures.

8. The average annual process water flow from printing operations in the Fraser River Basin is in the range of 1,825-5,475 m^3/year.

Table 5 summarizes the potential changes in contaminant loadings to the Fraser River Basin should this technology be applied industry wide. Total permitted discharges to the Fraser Basin were included for comparison. Table 6 highlights some of the key discharge parameters identified in Table 5. The following discussion describes how these assumptions and calculations were developed.

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Table 5
Potential Contaminant Loading Reductions to the Fraser River From the Printing Industry in Fraser River Basin Using the Filtration Technology

PARAMETER	Estimated Monthly Contaminant Discharge from the Printing Industry Where Filtration Technology is Applicable — Without filtration (1) LOW	Without filtration (1) HIGH	With filtration (1) LOW	With filtration (1) HIGH	Total Permitted Discharges to Fraser Basin (2)	Contaminant Loading Reduction LOW	Contaminant Loading Reduction HIGH	% Reduction
CONVENTIONAL	(kg/year)		(kg/year)		(tonnes/year)	(kg/year)		
pH								
Conductivity (uS/cm)								
Turbidity (NTU)								
TSS	313	939	1	2	88,954	312	937	99.8%
BOD	1,813	5,439	18	55	63,019	1,795	5,385	99.0%
COD	3,252	9,755	26	78	113	3,226	9,677	99.2%
Total O&G	514	1,543	2	5	6,682	512	1,537	99.6%
HC O&G	132	396	1	4	4.84	131	392	99.1%
METALS	(g/year)		(g/year)		(kg/year)	(g/year)		
Aluminum	4,289	12,866	183	548	21,014	4,106	12,319	95.7%
Antimony	365	1,095	183	548	2,058	183	548	
Arsenic	548	1,643	274	821	17	274	821	
Barium	93	278	1	3		92	275	99.0%
Beryllium	18	53	3	8		15	45	
Boron	32,312	96,935	3,975	11,926		28,336	85,009	87.7%
Cadmium	46	137	23	68	335.8	23	68	
Calcium	10,065	30,195	113	338		9,952	29,857	98.9%
Chromium	55	164	27	82	484.72	27	82	
Cobalt	37	110	18	55	1,577	18	55	
Copper	1,246	3,737	21	64	2224.58	1,224	3,673	98.3%
Iron	10,521	31,563	37	110	19,617	10,485	31,454	99.7%
Lead	169	506	73	219	1261.45	96	287	
Magnesium	2,071	6,214	52	155		2,020	6,059	97.5%
Manganese	119	357	3	8	3,153	116	349	97.7%
Molybdenum	73	219	37	110	2,058	37	110	
Nickel	55	164	27	82		27	82	
Phosphorus	65,153	195,458	438	1,314	23,130	64,715	194,144	99.3%
Potassium	144,768	434,304	855	2,564		143,913	431,740	99.4%
Silicon	30,158	90,474	1,308	3,924		28,850	86,551	95.7%
Silver	411	1,232	27	82	82.41	383	1,150	93.3%
Sodium	315,999	947,996	4,806	14,417		311,193	933,579	98.5%
Strontium	53	160	1	3		52	157	98.3%
Tin	301	903	27	82		274	821	90.9%
Titanium	196	587	5	16		190	571	97.2%
Vanadium	23	68	9	27		14	41	
Zinc	858	2,573	21	64	8,066.7	836	2,509	97.5%
Zirconium	37	110	18	55		18	55	

TSS = Total Suspended Solids
BOD = Biochemical Oxygen Demand
COD = Chemical Oxygen Demand
O&G = Oil and Grease
HC = Hydrocarbon

Assume flow rate of 1,825 m3/year for untreated waters.
Assume flow rate of 5,475 m3/year for treated waters.

(1) Filtration = pre, ultra and nano-filtration
(2) Ryan Russell, Environment Canada, 1997

Table 6 Summary of Key Contaminant Loading Reductions to the Fraser River Basin

Contaminant	Loading Reduction to the Fraser River Basin tonnes/year	% Loading Reduction
TSS	0.3-0.9	99
BOD	1.7-5.4	99
COD	3.2-9.7	99
Total O&G	0.5-1.5	99
HC O&G	0.1-0.4	99
Phosphorous	64.7-194.1 (kg/year)	99
Silver	0.4-1.2 (kg/year)	93

TSS = total suspended solids
BOD = biochemical oxygen demand
COD = chemical oxygen demand
O&G = oil and grease
HC = hydrocarbon

8.2 INFORMATION SOURCES

In searching for the information necessary to characterize the component of the BC printing industry within the Fraser River Basin where the technology demonstrated in this study could be applied, a number of sources were contacted. The first objective of this search was to estimate the annual volume of wastewater currently discharged by this industry into the Fraser River Basin. A second estimate of the contaminant loading reductions to the Fraser River Basin was also calculated should the technology demonstrated in this study be adopted by the entire applicable industry in this area. The search focussed on information regarding process wastewater flow rates, production rates, number of employees, and process wastewater characterization.

8.2.1 BC Business Centre and Statistics Canada

BC Business Centre and Statistics Canada had limited information with regards to the number of people employed in the industry. According to Stats Canada, in December 1996, there were 13,300 people employed in the Apublishing, printing and allied industries@ sector. This estimate, however, encompasses too many people not directly employed in relevant printing industries to be of any significance in this estimate.

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8.2.2 BC Printing Industries Association

The BC Printing Industries Association provided a report AThe Printing Industry in Western Canada@ (Hutchings Hutchings Kennedy, 1990) in response to industry inquiries. This report profiled the printing industry in Canada, intermittently providing information on specific provinces. In this report, the printing industry was defined as a combination of segments, ranging from commercial and book printers to binderies and typographers. In 1986, the segments of the industry relevant to this report accounted for 73% of the total industry employment across Canada. It was estimated that 8,868 people were employed in the industry in 1986 in British Columbia, 73% of which (representing the relevant industry segments) is 6,474 people. In an industry profile, the report comments that Western Canada, when compared to Ontario and Quebec, is characterized by a large number of small firms whose profit margins are quite low. The estimated number of establishments in British Columbia was quoted as 637 in 1986. Based on these values, there are on average 13.9 people employed per printing establishment in BC.

8.2.3 BC Yellow Pages

A search was conducted of the BC Yellow Pages on the Internet to estimate the current number of printing establishments in British Columbia. In all of BC, 772 printing establishments were identified. Of these, 575 printing establishments were identified in the Fraser River Basin area. This area was identified in the Yellow Pages search as the following regions: Vancouver and Lower Mainland, Fraser Valley, Central Interior, and Northern BC. According to this source, the industries in the Fraser River Basin account for 75% of the total number of printing establishments province-wide. Of the 575 identified in the Fraser Basin area, 477, or 83%, were located in Vancouver and the Lower Mainland.

8.2.4 Book of Lists

The magazine Business in Vancouver provides an annual publication to all its subscribers called the Book of Lists (Business in Vancouver, 1996). Twenty-two of the biggest commercial printers in Greater Vancouver are listed in this book. The gross revenues listed range from $33 million to $2.5 million. The number of employees ranges from 200 to 18 people. In total, 1,503 staff members are identified in this list. All 22 companies were directly contacted by telephone in order to identify any available process wastewater discharge information.

8.2.5 BC Environment

BC Environment maintains a database of all waste discharge permits in the province. A search of this database was done using the standard industry codes (SIC) for the printing industry. No permits were identified. Mr. Barry Azevedo of BC Environment commented that the printing industries were most likely all located within developed areas where the local regional district or municipality would be responsible for administering any waste discharge permits.

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8.2.6 GVRD and City of Vancouver

The Greater Vancouver Regional District (GVRD) was contacted to identify any permits or other pertinent information regarding the printing industry. The majority of printing establishments in the GVRD do not have special permits, but are only required to abide by the Greater Vancouver Sewer and Drainage District Sewer Use Bylaw (GVSDD, 1990) discharge criteria. A single permit of significance to this study was identified. This permit was for a facility of 190 employees and gross revenues of $33 million, with an estimated process wastewater flow rate of 130 m^3/year.

Furthermore, the GVRD had recently commissioned a study to identify and characterize a number of sources of wastewater in the GVRD (El Rayes, 1997). This report provided an estimate of the contaminant loadings to the GVRD sewers. The estimation for the printing industry was based on the following assumptions:

< 0.8 L/d/employee (0.2 m^3/year/employee)
< 250 operating days/year
< 1,039 printing establishments in the printing industry in the GVRD
< 11.9 employees/business on average.

The estimated contaminant loadings to the GVRD from the printing industry according to the assumptions and calculations made in this report are given in Appendix B. These results are discussed in the following section.

8.3 VALUES USED IN ESTIMATING CONTAMINANT LOADING

It proved to be very difficult to identify direct information regarding process wastewater flow rates in the printing industry of the Fraser River Basin. A total of 22 local printing companies were contacted by telephone to identify any known process wastewater flow information. Only three large scale facilities, including Transcontinental, were able to provide process wastewater flow discharge information. This information is presented in Table 7.

Table 7 Estimating Process Wastewater Flow Rates

	# employees	Estimated process wastewater flow (m^3/year)	Estimated process wastewater flow (m^3/year/employee)
1.	150	210	1.4
2.	1,200	3,200	2.7
3.	190	130	0.7

Process wastewater flow rate estimates and characterization data were, for the most part, not available from the authorities responsible for accepting and treating the wastewater (BC

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Environment, GVRD, other municipalities and regional districts). A single permit was identified in BC through the GVRD, a permit in Vancouver for one of the largest commercial printers in the city. All other printing operations= process wastewaters are discharged unpermitted and primarily unmonitored. The general sewer use discharge criteria defined by each local authority specifies the discharge contaminant limitations.

Because of this lack of direct process wastewater flow information, a correlation between an aspect of the printing operation and the process wastewater flow rate for which information is more readily available, was employed to calculate the required estimate. Ratios for both gross revenues and numbers of employees to the process wastewater flow rates could be generated based on the information available from the three facilities with flow rate data. Current gross revenue data for the segments of the printing industry that would be affected by this technology was not available however, making it non-feasible to use a correlation using this aspect of the industry. In contrast, the current number of employees could be estimated based on the information collected. Although the use of the ratio of number of employees to process wastewater flow rates is not very specific for developing a Basin-wide flow estimate, in this case it was the only variable available for estimation, and was likely to provide at least an order of magnitude estimate.

The annual process wastewater flow per employee as shown in Table 7 ranges from 1.4 to 2.7 m^3/year/employee. These values are significantly higher than the value reported in the GVRD study of 0.2 m^3/year/employee. The source of this GVRD report value was identified as the City of Vancouver. However, in contacting the City, the original source of this information could not be identified. Based on the known information available, the range of 1-3 m^3/year/employee was used for carrying out the estimates.

8.4 ESTIMATING CONTAMINANT LOADING

As discussed in the previous chapter, the technology demonstrated in this report is only realistically applicable for medium to large scale printing operations. Furthermore, this technology does not apply to all processes which fall under the category of Aprinting operations@, i.e. book binderies cannot adopt this technology. In order to estimate the effects of installing this technology on contaminant loadings to the Fraser River basin, the relevant sector of the industry must first be separated.

According to information provided in the report from the BC Printing Industries Association (Hutchings Hutchings Kennedy, 1990), 73% of the employees in industries identified as Aprinting@ operations are industries to which this technology could be applied. Assuming an average of 13.9 employees per printing operation (Hutchings Hutchings Kennedy, 1990) working in the 772 companies identified by the BC Yellow pages in BC, an average of 7,840 people are employed in industries that could potentially adopt this technology. However, a number of smaller companies, for which the technology is not practically applicable, must be removed from this estimate.

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The Vancouver Book of Lists named 22 companies in Greater Vancouver, employing a total of about 1,500 people. Based on Maratek's industry knowledge, this list represents the majority of medium to large scale printing operations in Greater Vancouver. In this same area, 477 printing operations were listed in the BC Yellow pages. Assuming 13.9 people per company, 73% of which representing the sector of the industry where the technology could be potentially employed, then a total of about 4,840 people are employed in the Greater Vancouver area by printing operations where the technology could be applied. The ratio of employees in medium to large scale operations where the technology could realistically be applied to the number of employees where the technology could potentially be applied (including small operations) is estimated as 1,500:4,840, or 1:3.2.

According to the BC Yellow Pages, there are an estimated 575 printing operations in the Fraser River Basin area. Assuming that each company employs 13.9 persons, and that 73% of these 575 printing companies are in relevant areas of the industry, an estimated 5,840 people are employed in this area. Applying the ratio of 1:3.2 (medium to large scale companies' employees: total companies' employees) to the Fraser River Basin results in an estimated 1,825 people employed in medium to large scale printing operations where the technology could realistically be applied. Assuming a range of process wastewater flow rates per employee of 1-3 m^3/year/employee, the estimated range of process wastewater flow rates from these industries is 1,825-5,475 m^3/year.

Assuming that raw process wastewater is discharged directly to sewer by all printing facilities, these flow rate values were used to calculate a lower and upper-bound estimated monthly contaminant discharge to the Fraser River Basin. The results of this calculation are presented in Table 5. If this filtration technology were installed in every applicable facility in the Fraser River Basin, the reduced contaminant discharges are also listed in Table 5. It is estimated that in facilities where the filtration technology is installed, 50% of the treated process wastewater is discharged (either directly or indirectly through toilets). Therefore, the estimated flow rate for facilities where the filtration technology was applied are half of the flow rates before filtration.

It should be noted that the GVRD report (El Rayes, 1997) estimated the number of printing establishments in the Greater Vancouver Sewerage and Drainage District to be approximately 1,039. This is significantly larger than the 477 assumed here. Based on Maratek's experience in this industry, the GVRD reported number of establishments in this estimate must include a number of printing operations where the technology demonstrated in this study could not be applied. Such establishments would be copy centres and electronic media publishing devices.

At the time of writing this report, Transcontinental was the only printing facility in the Fraser River Basin to use this filtration technology to treat process wastewater.

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9 COST-BENEFIT ANALYSIS

The following tables and overview describe the capital and operation & maintenance (O&M) costs incurred in implementing the technology demonstrated in this report, as well as the direct and indirect, i.e. less tangible, resulting savings. The costs reflect the installation, operation & maintenance of pre-, ultra-, and nano-filtration units for a generic facility similar in size to Transcontinental. The savings are considered for two representative scenarios. These scenarios are:

Scenario One: Treatment vs. Waste Hauling

In the first scenario, a printing company has an environmental mandate not to discharge raw printing process wastewater to the sanitary sewer. The cost benefit analysis considers the installation and O&M of the treatment equipment as costs, and the by-passed cost of waste hauling as a savings.

Scenario Two: Treatment vs. No Treatment

This scenario represents printing companies who do not treat the raw process wastewater, discharging it directly to sewer. In this scenario, savings realized by not paying for an alternate wastewater treatment strategy do not apply.

For both scenarios, it is assumed that silver recovery units are already installed. These units are common in industry and a pre-requisite to the application of this filtration equipment.

In order to achieve a treated process wastewater quality suitable for reuse in the printing facility, all three levels of filtration working in series are necessary. For this reason, the costs were assessed for the installation of all three filtration steps, and not just for nano-filtration.

9.1 COST/BENEFIT ESTIMATE TABLES

The following tables itemise the costs and benefits of this technology.

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Table 8 Cost Benefit Analysis: Direct Costs

Capital Expenditure	Annual Value[1]	Comments
Equipment	$110,000	collection, pre- ultra- and nano-filtration equipment
Utility	$ 5,000	power hookup
Engineering and Design	$ 6,000	system configuration with specific plant layout
Commissioning	$ 5,000	phased hand over to printing plant ownership and day to day operation
Total Capital Expenditure, Year 1	**$ 126,000**	

(1) All values stated are best estimates at time of publication (incorporates manufacturing, materials, installation, etc.)

For a facility generating twice the volume of process wastewater at Transcontinental, the capital costs would increase by approximately 50%.

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Table 9 Cost Benefit Analysis: Operation & Maintenance Costs

Cost Item	Annual Value[1]	Comment
Operation Costs		
Materials	$ 4,000	consumable materials (i.e. filter bags) purchase and disposal
Labour	$ 300	monitoring process operations
Hazardous Waste Disposal[2]	$ 12,000	concentrated waste water directly associated with treatment system requiring hazardous waste disposal services; industry estimate $1.00/litre disposal
Energy	$ 530	electrical energy consumed during processing
sub-total	***$ 19,530***	
Maintenance Cost		
Labour	$ 4,800	
Material	$ 370	
sub-total	***$ 5,170***	
Total Annual Operating and Maintenance Costs	**$ 24,700**	

(1) Operation and maintenance costs have been calculated based on volume estimates and average chemical treatment characteristics experienced in the printing and graphics industry by Maratek Environmental Inc. for treatment systems under similar conditions**.**

(2) Costs for disposal include estimates for on-site preparation by an environmental firm who carries out waste identification, handling and hazardous waste documentation.

Note: Costs reflect best estimate of competitive rates at time of publication (assumptions have to be made regarding disposal methods; for these purposes all effluent is treated through distillation and or evaporation with residual waste sent for incineration.

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Table 10 Cost Benefit Analysis: Fixed Savings

Revenue Source	**Annual Value**	**Note**
Scenarios One and Two		
Maintenance[1]	$ 10,000	reduced hours for process equipment maintenance
Water Savings[2]	$ 350.00	Fresh water consumption; city water bill savings; represents 20,000 litres/month reduced consumption
Total Saving WITHOUT Waste Hauling Costs	**$ 10,350**	
Scenario One only		
Waste Hauling Costs[3]	$ 120,000	cost that would be incurred given the environmental mandate with which Transcontinental operates; cost based on market disposal estimate of $ 0.50/litre
Total Saving WITH Waste Hauling Costs	**$ 130,350**	

(1) Maintenance costs saved have been calculated at reduced hours per machine and costed at a contracted rate of $50/hour (i.e. reduced cleaning requirements due to water treatment inline with recycling technology).

(2) Based on actual costs at time of publication from the city of Delta, BC (includes associated sewer charges).

(3) Costs for disposal include estimates for on-site preparation by an environmental firm who carries out waste identification, handling and hazardous waste documentation.

Note: costs reflect best estimate of competitive rates at time of publication (assumptions have to be made regarding disposal methods; for these purposes all effluent is treated through distillation and/or evaporation with residual waste volume sent for incineration - assumed cost is $ 0.50 per litre; assumed 50% discount for volume disposal)

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Table 11 Cost Benefit Analysis: Less Tangible Benefits

Less Tangible Benefits	Annual Value	Note
Administrative	na	- reduced or simplified environmental documentation and monitoring costs
Environmental Liability Costs[1]	na	Fines for non compliance with discharge criteria. Fines could range from $ 5,000 to $ 50,000
Sales Revenue	na	gained directly or indirectly from the company=s environmental profile; green marketing has truly just begun in this industry so values are still speculative in the short term
Reduced Health and Safety Requirements	na	cost must be internally assessed
Improved Environmental Relations	na	Governing Regulatory Body, Customer Relations, Corporate Neighbourhood
Total Indirect Savings	**NA**	

(1) liability costs are quoted as a range of possible values based on historical values levied to the industry as a whole.

Table 11 does not provide any financial breakdown as the process is too new to enable such quantitative estimates. Certifiable **›Green Marketing=** has only recently been introduced into the printing industry. The term certifiable refers to a set of qualitative and quantitative measures a printer must meet before it can market itself as an environmental printer by using a federally approved labelling on its product (i.e. **›ECOLOGO=**). Transcontinental Printing represents the first full scale lithographic printing facility to achieved this level of excellence and has only just begun to incorporate it into its sales process.

Less tangible benefits should not be regarded lightly. Effective process wastewater management has many far reaching affects in maintaining current accounts, acquiring new accounts, good public

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relations and minimized environmental liability. Printers are becoming increasingly accountable to the public for the methods by which they conduct their business.

9.2 COSTS/SAVINGS DISCUSSION

As outlined in Table 8, the capital costs for implementing this system are estimated to be $126,000. The annual O&M costs are estimated at around $24,700 in Table 9. An annual savings of $10,350 realized in water conservation and reduced maintenance costs is estimated in Table 10. The cost of having the same process wastewater analysed, removed and treated by an independent company is also estimated in Table 10 as $120,000.

Because this wastewater management system is so new at Transcontinental, it was not possible to estimate the less tangible benefits of implementing this technology. However, the areas likely to be impacted by the installation of this equipment are itemized in Table 11.

9.2.1 Scenario One

With capital costs of $126,000, annual O&M costs of $24,700, and annual savings of $130,350, the estimated pay-back period is 1.3 years. This does not include any less tangible benefits, listed but not quantified in Table 11.

9.2.2 Scenario Two

In this scenario, the same capital ($126,000) and annual O&M ($24,700) costs as in Scenario One apply. The annual savings is significantly lower without the cost of alternative waste hauling, totalling only $10,350 annually . Without taking into consideration any of the less tangible benefits, listed but not quantified in Table 11, this scenario presents an annual increase in costs as the annual savings is less than even the annual O&M costs. As such, this option has no pay-back period, and only adds to the annual costs of operation. However, if the annual less tangible benefits were worth $20,000, the payback period would be 22.3 years.

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10 CONCLUSIONS

1. The nano-filtration membrane technology was successfully installed and operated in the printing process wastewater treatment operations at Transcontinental Printing=s facility in Delta, BC.

2. The nano-filtration unit, working downstream of existing pre-filtration and ultra-membrane filtration units, provided an effluent of very high quality, suitable for recycling to the printing operation and toilets. Water treated using only the ultra-filtration was unsuitable for use in toilets because of problems with bacterial re-growth and associated odours. The volume of treated wastewater suitable for recycling jumped from 5-10% to 90-95% with the use of the nano-filtration unit. Before the installation of the nano-filtration unit, the wastewater was only recycled to the press sinks. Following its installation, the water was used in the press sinks, the pre-press sinks, the image processing area, and the toilets.

3. A sampling program, testing the printing process wastewater quality before and after treatment by the pre-, ultra-, and nano-filtration units, indicated excellent contaminant removal across the treatment process. Most contaminants, including total suspended solids (TSS), biochemical oxygen demand (BOD), chemical oxygen demand (COD), total and hydrocarbon oil & grease (O&G, HC O&G), phosphorus and silver were reduced by 98-99% by the process.

4. This technology is suitable for application in medium to large scale printing facilities, but not for smaller printing facilities. Because this technology is added on to as opposed to retrofitted to existing printing equipment, it is not limited in application to any particular supplier=s equipment. Any printing facility generating standard printing process wastewaters could adopt this technology. Some preliminary characterization of any unusual chemicals used in an operation may be necessary to ensure that they will not compromise the membrane integrity.

5. Based on estimates of the printing process wastewater flow rates to the Fraser Basin from the printing industry, the contaminant loading reductions were estimated to be significant should this technology find industry wide acceptance. The TSS would be reduced by 0.3-0.9 tonnes/year (99%), the BOD by 1.8-5.4 t/year (99%), the COD by 3.2-9.7 t/year (99%), the total O&G by 0.5-1.5 t/year (99%), the HC O&G by 0.1-0.4 t/year (99%), the phosphorus by 64.7-194.1 kg/year (99%), and the silver by 0.4-1.2 kg/year (93%).

6. As an alternative to hauling process wastewaters from a facility with an environmental mandate to minimize contaminant discharges, a cost/benefit analysis indicated a pay-back period of 1.3 years for installing the filtration technology. However, in a facility without such an environmental mandate that would discharge to sanitary sewer and by-pass the costs of hauling the process wastewaters for treatment, the annual O&M costs exceed the expected annual savings. This analysis does not, however, take into account any increased

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business and less tangible benefits. If the annual less tangible benefits were worth $20,000, the payback period would be 22.3 years.

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REFERENCES

El Rayes Environmental Corporation. 1997. Wastewater Characterization and Inventory for Commercial and Industrial Sectors in the Greater Vancouver Sewerage and Drainage District. Report for the GVRD, File No. 960-511.

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APPENDIX A

SOURCE REDUCTION EQUIPMENT

Printing Process		Optional Environmental Equipment	Environmental Benefit
PrePress Operations			
Film Developing	*	Remanufactured Fixer	Eliminates 100% of waste fixer volume sanitary discharge. Supplier driven recycling programs are available (i.e. Dupont's DuCare Program).
	*	Silver Recovery Units	Contributes to a reduced fixer raw material consumption rate of approximately 60%.
	*	Washwater Recycling Equipment	Reduces raw material water consumption by 90%.
		Developer Recycling	Reduces developer consumed by 70% through increased working bath life.
Plate Developing (make ready)	*	Washwater Recycling Equipment	Reduces raw material water consumption by 90%.
		Developer Recycling	Reduce consumption of plate chemical by 60% through on-site recycling technology.
Colour Proofing	*	Washwater Recycling Equipment	Reduces raw material water consumption by 90%.
Sink Stations	*	Taps controlled by foot pedal activated solenoids; active demand feed only	Eliminates any uncontrolled/ unnecessary waste of rinse waters; approximate impact is 70% reduced consumption.
Press Room			
Fountain Solution	*	Fountain Solution Recycling Technology (FSRS)	Eliminates 95% of a traditional waste stream by converting it into a reusable product ready for press.
Press Room Solvent Recovery		On site rag/solvent recovery systems	Generates savings in the area of 70% on new solvent purchases.
Press Sink Wash Station	*	Taps controlled by foot pedal activated solenoids; active demand feed only	Eliminates any uncontrolled/ unnecessary waste of rinse waters; approximate impact is 70% reduced consumption.

* Installed at Transcontinental

APPENDIX B

GVRD REPORT EXCERPT

Table 4.5 Contaminant Loadings from Printers

Parameter	Concentration (mg/l)	Annual Discharge (Tonnes/year)	% [1] Contribution	Rank[2]
TSS	72	0.18	0.01%	14
Oil & Grease	18	0.04	0.00%	13
COD	322	0.80	0.01%	16
BOD	152	0.38	0.01%	16
Iron	0.88	0.0022	0.01%	11
Silver	0.02	0.00005	0.01%	7
Zinc	0.136	0.00	0.02%	12
Cu	0.169	0.0004	0.01%	12
Pb	0.01	0.00003	0.01%	11
Al	0.25	0.0006	0.01%	9
Mn	0.038	0.00009	0.01%	11
Ni	0.010	0.00002	0.02%	9
pH	7.2			
Phenolics	0.028	0.00	0.00%	11
TP	2.79	0.01	0.01%	11
As	0.001	0.000003	0.04%	9
B	0.185	0.0005	0.01%	10
Cyanide	1.12	0.003	0.71%	8

(1) Percent contribution refers to the ratio of loadings (expressed as a percentage) from this category to the total C&I loadings considered in this report.

(2) Rank refers to the order of magnitude of contaminant contribution by this category compared to contaminant loadings contribution from other C&I sector categories in the GVRD.