GREATER NANAIMO WATERSHED FERTILIZER RISK ASSESSMENT

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TABLE OF CONTENTS

LIST OF APPENDICES

1 INTRODUCTION

BC Research Inc. (BC Research) was contracted by Mr. Wayne Hansen, the Water Supply Superintendent with the City of Nanaimo, to carry out an assessment of the potential for fertilizers being used by the Weyerhaeuser South Island Timberlands Operation in the Nanaimo Watershed to adversely affect the City of Nanaimo's drinking water supply.

1.1 Background

The City of Nanaimo obtains its drinking water from the south fork of the Nanaimo River. Water for drinking is collected and stored in two separate surface reservoirs in the headwaters of the Nanaimo River. In total, the two reservoirs can store up to 4.1 billion gallons of water at any given time. The reservoirs were created through the installation of two dams: the Jump Creek Dam and the South Fork Dam. The City of Nanaimo's drinking water enters the distribution line at the South Fork Dam (see map of the watershed in Appendix A).

The watershed consists of a 206 square kilometre area that is privately owned by Weyerhaeuser Canada Ltd. (Weyerhaeuser). The City of Nanaimo and Weyerhaeuser have a co-operative relationship that allows the watershed to be located on Weyerhaeuser property. Weyerhaeuser and the City of Nanaimo work closely together, meeting several times per year, to ensure that the water supply is not adversely effected by the logging activities occurring on the site.

Access to the watershed and all activities on the watershed are strictly controlled. All roads leading into the watershed are gated and a security code is required to gain access. Anyone accessing the watershed is required to watch a 30 minute video and write an exam on practices to be adhered to while working in the watershed.

In 1998 Weyerhaeuser began to use fertilizer in the watershed to promote the growth of the saplings being planted in areas that had been previously clear cut. Recently, some citizens have raised concerns that the fertilizer used by Weyerhaeuser may be adversely effecting the drinking water supply for the City of Nanaimo.

1.2 Objectives

The objectives of this risk assessment are outlined below:

- To determine if the use of fertilizer by Weyerhaeuser in the watershed has been adversely effecting the drinking water supply for the City of Nanaimo and surrounding area.

- To determine if the amount of fertilizer being used in the watershed by Weyerhaeuser has the potential to adversely effect the drinking water supply, if it is not already doing so.

- If the use of fertilizer in the wateshed has been demonstrated to be effecting or has the potential to adversely effect the quality of the drinking water supply for the Greater Nanaimo area, recommendations will be made for future practices that should be implemented in the watershed to protect the drinking water supply.

This report has been prepared at the request of the Greater Nanaimo Water District in order to address the objectives outlined above. This assessment is limited to evaluating the effects of fertilizer use in thewatershed on the quality of drinking water. It is not intended to evaluate other potential impacts logging activites or fertilizer use in the watershed may have. In addition, this assessment does not evaluate occupational exposure to fertilizers.

2 FERTILIZER COMPOSITION AND USAGE

Seedlings are planted in clear cut areas inside the watershed at two times during the year. The lower elevations are planted between late February or early March until the middle of May. Higher elevations are typically seeded in the last two weeks of August.

In the spring of 1998, Weyerhaeuser began using fertilizer to assist seedlings in clear cut areas grow more quickly. Prior to 1998 seedlings were not fertilized when planted in the watershed area.

Table 2-1 below outlines the fertilizers that were used in the watershed by Weyerhaeuser between the spring of 1998 and the summer of 2000.

Table 2-1 – Fertilizers Used in the Greater Nanaimo Watershed by Weyerhaeuser Between the Spring of 1998 and the Summer of 2000

Planting Period	Fertilizer Used
Spring 1998	Dawson Seed 29-9-9 (Loose)
Summer 1998	Dawson Seed 29-9-9 (Loose)
Spring 1999	Dawson Seed 29-9-9 (Loose)
Summer 1999	Dawson Seed 26-25-0 (Loose)
Spring 2000	Nutri-pak 25-8-8 (Pre-packaged)
Summer 2000	Nutri-pak 26-9-9 (Pre-packaged)

The fertilizers used in 1998 and 1999 were not pre-packaged into allotted amounts, each planter put the loose fertilizer into a bag at their belt and using a scoop buried the fertilizer with each seedling. In the spring of 2000, Weyerhaeuser switched to using pre-packaged fertilizers due to concerns raised by the tree planters about handling the raw fertilizer.

2.1 Composition of Fertilizers Used in the Watershed

In Canada, the Workplace Hazardous Materials Information System (WHMIS) was implemented in 1988 to ensure employees working with or in proximity to hazardous materials are educated on the hazards of the materials they work with and that they understand how to protect themselves when working with these hazardous products. Products covered by WHMIS are called controlled products. The *Hazardous Product Act* and the *Controlled Products Regulation* outline the criteria that determine whether or not a substance is considered to be “controlled”. A

document called the Ingredient Disclosure List has also been compiled which outlines a large number of commonly used chemicals that have already been tested against the criteria outlined in the *Hazardous Products Act* and found to meet the criteria as a controlled product. Any chemical substance listed on the Ingredients Disclosure List, or any chemical that is not on the Ingredients Disclosure List that meets the criteria outlined in the *Hazardous Products Act* must be disclosed on an information sheet called a Material Safety Data Sheet (MSDS) if the chemical(s) are present above a specified concentration in the product.

The concentrations required for disclosure vary depending on the toxicity of the material. Chemicals that have serious adverse health effects are required to be reported if the concentration equals or exceeds 0.1% of the product by weight. Less toxic substances are required to be disclosed if the material is equal to or greater than 1% of the product by weight.

In the United States, the Occupational Safety and Health Administration (OSHA) has implemented regulations similar to WHMIS under their Hazardous Communications Regulation.

The MSDS for each product listed as being used by Weyerhaeuser in the watershed between the spring of 1998 and the summer of 2000 have been provided in Appendix B for review. A summary of the hazardous materials listed on each MSDS is provided for each fertilizer below. Additional information available on the compositions of the fertilizers is provided where available.

2.1.1 Dawson Seed 25-9-9 – Woodburn Fertilizer Inc.

Dawson Seed 25-9-9 is composed of a variety of fertilizers that have been mixed in specified proportions. The following fertilizer products are contained in Dawson seed 25-9-9:

- K-MAG
- Monoammonium Phosphate MAP 11-52-0
- Urea, Fertilizer Grade, Granular 46-0-0
- Sulphate of Potash
- Duration Polymer Coated Urea (Type 4)

A summary of the information contained on the MSDS for each of these products along with additional information known about the contents of the material are reported below in Sections 2.1.1.1 – 2.1.1.5 for your review. The MSDS for each product are included in the Appendices for review.

2.1.1.1 - K-MAG

The fertilizer K-MAG is a product of the Western AG-Minerals Company. According to the MSDS that was supplied to Weyerhaeuser there no chemicals in the fertilizer that are controlled products, or if there are they do not meet the

reporting criteria set out by the *Hazardous Products Act*. A copy of the MSDS is provided in Appendix B for review.

Sales information on the fertilizer indicates that K-MAG is primarily composed of potassium oxide (minimum of 22%), potassium (18%), calcium (0.2%), sodium (0.7%), magnesium (minimum of 10.8%), sulphur (minimum of 22%), chloride (maximum of 2.5%). The concentration of the material may vary slightly within specified parameters. Other information on the product indicates that it has a neutral pH and does not contribute to soil acidity. The product comes in a crytallized form designed to release water soluble nutrients to the seedlings at a controlled rate throughout the growing season.

2.1.1.2 Urea, Fertilizer Grade, Granular 46-0-0

The fertilizer Urea, Fertilizer Grade, Granular 46-0-0 is a product of Agrium Inc. According to the MSDS this product is composed entirely (100%) of urea which is a controlled product. A copy of the MSDS for this product is provided in Appendix C for review.

This product has been analyzed as required for sale in Washington State following the Washington State Department of Agriculture analysis standard for fertilizers. The results of this analysis are summarized below in Table 2-2.

Table 2-2 – Urea, Fertilizer Grade Granular 46-0-0 Analysis Results Washington State Department of Agriculture

Compounds Identified	Concentration
Total Nitrogen	46%
Arsenic	<0.5 ppm
Cadmium	<1 ppm
Cobalt	<5 ppm
Mercury	<0.02 ppm
Molybdenum	<5 ppm
Nickel	<3 ppm
Lead	<0.1 ppm
Selenium	<0.5 ppm
Zinc	<100 ppm

ppm – parts of chemical compound per million parts of fertilizer

2.1.1.3 Monoammonium Phosphate MAP 11-52-0

The fertilizer Monoammonium Phosphate MAP 11-52-0 is a product of Agrium Inc. According to the MSDS this product is composed entirely (100%) of monoammonium phosphate which is a controlled product. A copy of the MSDS for this product is provided in Appendix D for review.

This product has been analyzed as required for sale in Washington State following the Washington State Department of Agriculture analysis standard for fertilizers. The results of this analysis are summarized below in Table 2-3.

Table 2-3 –Monoammonium Phosphate MAP 11-52-0 Analysis Results Washington State Department of Agriculture

Compounds Identified	Concentration
Total Nitrogen	11%
Available Phosphoric Acid	52%
Arsenic	13 ppm
Cadmium	205 ppm
Cobalt	<5 ppm
Mercury	<0.02 ppm
Molybdenum	21 ppm
Nickel	235 ppm
Lead	2.6 ppm
Selenium	<0.25 ppm
Zinc	3360 ppm

ppm – parts of chemical compound per million parts of fertilizer

2.1.1.4 Sulphate of Potash

The fertilizer Sulphate of Potash is a product of the Great Salt Lake Minerals Corporation. According to the MSDS that was supplied to Weyerhaeuser there are no chemicals in the fertilizer that are controlled products, or if there are they do not meet the reporting criteria set out by the *Hazardous Products Act*. This product is composed entirely of potassium sulphate. A copy of the MSDS is provided in Appendix E for review.

No additional information was available on this product.

2.1.1.5 Duration Polymer Coated Urea (Type 4)

The fertilizer Duration Polymer Coated Urea (Type 4) is a product of Agrium Inc. According to the MSDS this product is composed almost entirely (94%) of urea which is a controlled product. A copy of the MSDS for this product is provided in Appendix F for review.

This product has been analyzed as required for sale in Washington State following the Washington State Department of Agriculture analysis standard for fertilizers. The results of this analysis are summarized on the following page in Table 2-4.

Table 2-4 –Duration Polymer Coated Urea Analysis Results Washington State Department of Agriculture

Compounds Identified	Concentration
Total Nitrogen	43%
Arsenic	<2.07 ppm
Cadmium	<0.214 ppm
Cobalt	<0.348 ppm
Mercury	<0.01 ppm
Molybdenum	<<0.795 ppm
Nickel	<1.65 ppm
Lead	<2.58 ppm
Selenium	<2.32ppm
Zinc	0.12 ppm

ppm – parts of chemical compound per million parts of fertilizer

The manufacturers of Dawson Seed 25-9-9 have published the metal analysis results in accordance with the Washington State Department of Agriculture Fertilizer Standard requirements for the entire product (the mixture of all of the products discussed above). The fertilizer was analyzed by A. L. Western Agricultural Laboratories in California. The results of this metals analysis are outlined below in Table 2-5.

Table 2-5 –Dawson Seed 25-9-9 Metals Analysis Results Washington State Department of Agriculture

Compounds Identified	Concentration with out Micro-Nutrient Package	Concentration with Micro-Nutrient Package
Arsenic	5.1 ppm	<0.5 ppm
Cadmium	<0.1 ppm	0.5 ppm
Cobalt	0.3 ppm	5.8 ppm
Mercury	<0.05 ppm	<0.05 ppm
Molybdenum	<1.0 ppm	1.1 ppm
Nickel	4.8 ppm	20.7 ppm
Lead	<1.2 ppm	6.4 ppm
Selenium	<5.5 ppm	<5.5 ppm
Zinc	15 ppm	1148 ppm

ppm – parts of chemical compound per million parts of fertilizer

In addition to the published results, two samples of this fertilizer have been analyzed by two separate laboratories for metals.

The first sample submitted for analysis was submitted to Cantest Laboratories in Burnaby, British Columbia on February 2, 2000, by the Canadian Reforestation Workers in response to a concern raised by one of it's members. The results of this analysis are presented below in Table 2-6 on the following page. Only those metals found to be above the limit of detection are reported in Table 2-6.

Table 2-6 – Dawson Seed 29-9-9 Detectable Metals Analysis Results Submitted by the Canadian Reforestation Workers to Cantest Laboratories on February 2, 2000.

Metal	Concentration (ppm/dry weight of sample)
Aluminium	5,880
Barium	1.5
Boron	30
Cadmium	31
Calcium	1,450
Chromium	75
Copper	16
Iron	1350
Magnesium	8,600
Manganese	35.3
Nickel	42
Phosphorous	110,000
Silica	1,550
Sodium	2,720
Strontium	35
Titanium	15
Vanadium	147
Zinc	394
Zircontium	6

ppm – parts of chemical compound per million parts of fertilizer

A second sample of this fertilizer was submitted to Northwest Labs by Weyerhaeuser on March 15, 2000, for analysis. Table 2-7 on the following page outlines the results of this analysis. Only those metals found above the analytical limit of detection are reported in Table 2.7

Table 2-7 – Dawson Seed 25-9-9 Analysis Results Submitted by Weyerhaeuser to Northwest Labs on March 15, 2000.

Compounds Identified	Concentration
Boron	437 ppm
Cadmium	42 ppm
Calcium	0.54%
Copper	570 ppm
Total Nitrogen	25.8%
Available Phosphorous	9.53%
Soluble Potassium Oxide	9.7%
Total Sulphur	6.64%
Iron	4280 ppm
Magnesium	1.15%
Manganese	911 ppm
Molybdenum	13 ppm
Zinc	1820 ppm

ppm – parts of chemical compound per million parts of fertilizer

2.1.2 Dawson Seed 26-25-0

Dawson Seed 26-25-0 is composed of a variety of fertilizers that have been mixed in specified proportions. The following fertilizer products are contained in Dawson seed 26-25-0:

- ESN T-150 Controlled Release Urea 41-0-0
- Micronutrient Mixture
- Enspan / Polymer Coated Sulphur Coated Urea 39-0-0
- Monoammonium Phosphate MAP 11-52-0
- Urea, Fertilizer Grade, Granular 46-0-0

A summary of the information contained on the MSDS for the first three of these products along with additional information known about the contents of the material are reported below in Sections 2.1.2.1 – 2.1.2.3 for your review. The last two products contained in Dawson Seed 26-25-0 were discussed in Sections 2.1.1.2 and 2.1.1.3 above The MSDS for each product are included in the Appendices for review.

2.1.2.1 ESN T-150 Controlled Release Urea 41-0-0

The fertilizer ESN T-150 Controlled Release Urea 41-0-0 is a product of Agrium Inc. According to the MSDS this product is composed almost entirely (60% to 100%) of urea which is a controlled product. A copy of the MSDS for this product is provided in Appendix G for review.

This product has been analyzed for sale in Washington State following the Washington State Department of Agriculture analysis standard for fertilizers. The results of this analysis are summarized on the following page in Table 2-8.

Table 2-8 – T-150 Controlled Release Urea Metals Analysis Results Washington State Department of Agriculture

Compounds Identified	Concentration
Arsenic	3.68
Cadmium	<0.214
Cobalt	<0.348
Mercury	0.014
Molybdenum	<0.795
Nickel	<0.53
Lead	2.99
Selenium	<2.32
Zinc	13.9

ppm – parts of chemical compound per million parts of fertilizer

2.1.2.2 Micronutrient Mixture

The micronutrient mixture is a product of Frit Industries Inc. According to the MSDS this product is composed of a variety of materials which are listed below in Table 2-9. A copy of the MSDS for this product is provided in Appendix H for review.

Table 2-9 –Micronutrient Mixture Hazardous Ingredients List

Hazardous Ingredients	Percentage of Ingredients
Sodium Borate	2.4% as boron
Copper Oxide Copper Sulphate	2.4% as copper
Iron Oxide Iron sulphate	14.4% as iron
Manganese Oxide Managese Sulphate	6% as manganese
Zinc Oxide Zinc Sulphate	5.6% as zinc
Lead Sulphate	Not provided

The MSDS for this product also indicates that there is 0.6% molybdenum in this product.

This product has been analyzed as required for sale in Washington State following the Washington State Department of Agriculture analysis standard for fertilizers. The results of this analysis are summarized on the following page in Table 2-10.

Table 2-10 –Micro Nutirent Metals Analysis Results
Washington State Department of Agriculture

Compounds Identified	Concentration
Arsenic	<20
Boron	2.4%
Cadmium	12
Cobalt	870
Copper	2.4%
Iron	14.4%
Manganese	%6
Mercury	0.1
Molybdenum	0.6% of <3
Nickel	66
Lead	300
Selenium	<30
Zinc	5.6% or 70,000

Concentrations are in ppm (parts of chemical compound per million parts of fertilizer) unless otherwise specified

2.1.2.3 Enspan/Polymer Coated Sulphur Coated Urea 39-0-0

The fertilizer Enspan / Polymer Coated Sulphur Coated Urea 39-0-0 is a product of Hydro Agri North America. According to the MSDS this product is composed of urea (83.6%), sulphur (12.5% and diatomaceous earth (2%). All three of these substances are controlled products. A copy of the MSDS for this product is provided in Appendix I for review.

This product has been analyzed as required for sale in Washington State following the Washington State Department of Agriculture analysis standard for fertilizers. The results of this analysis are summarized on the following page in Table 2-11.

Table 2-11 – Enspan/Polymer Coated Sulphur Coated Urea 39-0-0 Metals Analysis Results
Washington State Department of Agriculture

Compounds Identified	Concentration
Arsenic	<0.25
Cadmium	<1
Cobalt	<5
Mercury	<0.02
Molybdenum	<2.5
Nickel	<5
Lead	<5
Selenium	<0.5
Zinc	10

ppm – parts of chemical compound per million parts of fertilizer
< - means the compound was not detected above the limit of detection

In addition to the published results, a sample of this fertilizer was submitted by Weyerhaeuser to Northwest Labs on March 15, 2000, for metals analysis. The results of this analysis are presented below in Table 2-12. Only those metals found to be above the limit of detection are reported in Table 2-12.

Table 2-12 – Enspan/Polymer Coated Sulphur Coated Urea 39-0-0 Metals Analysis Results
Northwest Labs

Compounds Identified	Concentration
Boron	587
Cadmium	1
Calcium	0.54
Copper	759
Iron	6230
Magnesium	0.71
Manganese	2880
Molybedenum	7
Zinc	1770

ppm – parts of chemical compound per million parts of fertilizer
< - means the compound was not detected above the limit of detection

2.1.3 Nutri-Pak 25-8-8

The fertilizer Nutri-Pak 25-8-8 is a product of JRP International Inc. According to the MSDS that was supplied to Weyerhaeuser there no chemicals in the fertilizer that are controlled products, or if there are they do not meet the reporting criteria set out by the *Hazardous Products Act*. This product is composed of 25% nitrogen, 8% phosphoric acid and 8% potash. The main ingredients that produce the sources of nitrogen, phosphoric acid and potash are ammonium sulphate, diammonium phosphate, muriate of potash and urea. The fertilizer is packaged into 30 gram and 50 gram packages that are biodegradable. The 50 gram packages were applied to Dougles Fir seedlings and 30 gram packages were used for all other seedlings. Douglas Fir is the most common type of seedling planted. The packages are designed to control the flow of the fertilizer. The fertilizer release is temperature dependent; fertilizer is only released during warmer weather and is designed to last up to three years. In British Columbia, due to our warmer climate, the fertilizer packages are expected to last for approximately 18 months. A copy of the MSDS is provided in Appendix J for review.

Two samples of this fertilizer were submitted to independent laboratories for analysis. The results of these analyses are outlined below.

The first sample was submitted to Norwest Laboratories on March 15, 2000, for analysis for metals and other fertilizer components. The results of this analysis are outlined on the following page in Table 2-13.

Table 2-13 – Nutri-Pak 25-8-8 Analysis Results Submitted by the Weyerhaeuser to Northwest Labs on March 15, 2000.

Compounds Identified	Concentration
Boron	538 ppm
Cadmium	<0.6 ppm
Calcium	0.4%
Copper	719 ppm
Total Nitrogen	25.2%
Available Phosphorous	7.83%
Soluble Potassium Oxide	8.67%
Total Sulphur	7.53%
Iron	4990 ppm
Magnesium	1%
Manganese	2090 ppm
Molybdenum	3 ppm
Zinc	4410 ppm

ppm – parts of chemical compound per million parts of fertilizer

A second sample of the fertilizer Nutri-pak 25-8-8 was submitted to BC Research on September 2, 2000, by the Greater Nanaimo Water District for metals analysis. Table 2-14 below outlines the sampling results of this analysis. Only metals above the limit of detection are reported in Table 2-14.

Table 2-14 –Nutri-Pak 25-8-8 Detectable Metals Analysis Results Submitted by the Greater Nanaimo Water District to BC Research on September 2, 2000.

Metal	Concentration (ppm/dry weight of sample)
Aluminium	1,280
Boron	27
Beryllium	0.31
Calcium	507
Cadmium	0.82
Chromium	14
Copper	2.7
Iron	2,415
Potassium	77,657
Magnesium	1,014
Manganese	43.5
Sodium	2,053
Nickel	3.1
Strontium	17
Titanium	21
Vanadium	27
Zinc	7.2

ppm – parts of chemical compound per million parts of fertilizer

2.1.4 Nutri-Pak 26-9-9 - JRP International Inc.

The fertilizer Nutri-Pak 26-9-9 is a product of JRP International Inc. According to the MSDS that was supplied to Weyerhaeuser there no chemicals in the fertilizer that are controlled products, or if there are they do not meet the reporting criteria set out by the *Hazardous Products Act*. This product is composed of 26% nitrogen, 9% phosphoric acid and 9% potash. The main ingredients that produce the sources of nitrogen, phosphoric acid and potash are ammonium sulphate, diammonium phosphate, muriate of potash and urea. The fertilizer is packaged into 30 gram and 50 gram packages that are biodegradable. The 50 gram packages were applied to Dougles Fir seedlings and 30 gram packages were used for all other seedlings. Douglas Fir is the most common type of seedling planted. The packages are designed to control the flow of the fertilizer. The fertilizer release is temperature dependent; fertilizer is only released during warmer weather and is designed to last up to three years. In British Columbia, due to our warmer climate, the fertilizer packages are expected to last for approximately 18 months. A copy of the MSDS is provided in Appendix K for review.

2.2 Amount of Fertilized Utilized

Table 2-15 below outlines the amount of fertilizer used in the Greater Nanaimo Watershed over the last three years. In addition, the quantity of fertilizer used for each seedling is indicated in Table 2-15.

Table 2-15 – Quantity of Fertilizer Used by Weyerhaeuser in the Greater Nanaimo Watershed Between Spring 1998 and Summer 2000

Season	Number of Trees Planted	Hectares Planted	Type of Fertilizer	Fertilizer Applied per Seedling (g)	Total Amount of Fertilizer (kg)
Spring 1998	197,346	175	Dawson Seed (25-9-9)	30	5,920
Summer 1998	164,175	165	Dawson Seed (25-9-9)	30	4,925
Spring 1999	123,890	108	Dawson Seed (25-9-9)	30	3,717
Summer 1999	146,696	150	Dawson Seed (26-25-0)	30	4,401
Spring 2000	294,000	255	Nutri-Pak (25-8-8)	50	13,823
Summer 2000	235,777	205	Nutri-Pak (26-9-9)	50	10,135

g – grams
kg – kilograms (1000 g = 1 kg)

The large number of trees / hectares replanted in 2000 is unusually high. Good weather permitted a longer planting season in both the spring and summer this past year. It is anticipated by Weyerhaeuser that the amount of planting will not be this high every year.

2.3 Location of Fertilzer Usage

Logging activities are carried out throughout the watershed. Replanting the area is performed one to two years after the clear cutting has occurred. Details on the exact planting locations for each year are not in a readily accessible format. A map outlining the approximate locations where planting occurred in 2000 is attached in Appendix K for review. The dots on the map approximately indicate the middle of the planting area.

By examining the map it can be seen that planting activities occurred fairly uniformly about the two reservoirs and the Nanaimo River and that the planting activities are not focused on one area within the watershed.

2.4 Weyerhaeuser Canada Fertilizer Handling Procedures

Based on an internal memo sent to Jim Sears, Manager of Weyerhaeuser South Island Timberlands from Jim Loftus, Weyerhaeuser Timberland Forester, and discussions between BC Research and Jim Loftus on November 16, 2000, it is BC Research's understanding that the following procedures are utilized by Weyerhaeuser when applying fertilizer.

Weyerhaeuser does not store bulk quantities of fertilizer inside the watershed area. Off site storage facilities with appropriate containment are used to store bulk quantities of fertilizer for both the spring and summer planting seasons.

Only the approximate amount needed each day for planting is taken out to site. It is estimated that each truck of 4-6 planters takes between 100 to 150 kg of fertilizer with them for a days work.

During the 1998 and 1999 planting seasons, the Dawson Seed fertilizer was supplied in 50 kg bags which were stored in the back of the truck cab or on the side of the road well away from any creeks or culverts in case of a spill. Each tree planter filled up a small pouch that was worn around the waste with fertilizer from the main bag as necessary through-out the day. A 30 gram film cannister was utilized by planters as a measuring device. In 1998 and 1999 the film cannister was utilized to measure out 30 grams of fertilizer for each seedling. The fertilizer was buried with the seedling approximately one to three inches below the surface of the ground.

The Nutri-Pak fertilizer that was used in 2000 came pre-packaged in 30 gram and 50 gram bags. These bags were triple packaged for spill protection. One hundred of the packages of fertilizer were placed together in a larger bag, four of these bags were then packaged together in a box. Similar to the loose fertilizer, the Nutri-Pak fertilizer packages were buried with the seedling approximately one to three inches below the surface of the ground to prevent erosion.

Due to problems with the Nutri-Pak packages, Weyerhaeuser advised BC Research that they will in the future be returning to 30 grams of fertilizer per tree and they will be using a teabag like packaging devise rather than the plastic casing used by Nutri-Pak.

All tree planters working in the Greater Nanaimo Watershed were required prior to beginning work to watch the City of Nanaimo's "Protecting of Watershed" video and pass the written exam.

It is the policy of Weyerhaeuser not to log below the high-water mark of streams. Planting of seedlings usually begins approximately one to two meters above the high water mark of the river / the tree line.

It is our understanding that any fertilizer spilled (large quantities, such as an entire bag of loose fertilizer) was required to be cleaned to the best of the crews ability. Mr. Loftus was not aware of any large spills that had been reported to him. Small quantities of fertilizer (loose) was normal while tree planting as a small amount of loose fertilizer may fall out of a planters pouch while they are bent over. Planters were instructed to clean up this lost fertilizer if it was noticed. Weyerhaeuser estimated that approximately 0.5% additional fertilizer was required to cover these small losses in the field. Mr. Loftus was not aware of any loss of the pre-packaged fertilizers due to accidental spillage.

With respect to co-operation between Weyerhaeuser and the Greater Nanaimo Water District staff, three to four formal meetings are held each year to discuss upcoming logging and planting activities. At these meetings the Greater Nanaimo Water District staff have an opportunity to review all planned activities and discuss any concerns they might have on those activities impacting the watershed. Discussions by BC Research with both parties revealed that this process is very beneficial and there have not been any water quality issues arisingsince this format began several years ago.

In addition to these meetings, staff from the Greater Nanaimo Water District have conducted onsite inspections of areas being replanted to assess for themselves the practices being utilized by Weyerhaeuser.

3 DRINKING WATER

3.1 Drinking Water Guidelines

3.1.1 Canadian

Table 3-1 below outlines the Guidelines for Canadian Drinking Water Quality (1996). Only those guidelines applicable to this assessment have been included in Table 3-1 below.

Table 3-1
Canadian Drinking Water Guidelines

Parameter	MAC	IMAC	AO
Arsenic		0.025	
Barium	1.0		
Boron		5.0	
Cadmium	0.005		
Chromium	0.05		
Copper			1.0 (at point of consumption)
Iron			0.3
Lead	0.01		
Manganese			0.05
Mercury	0.001		
Nitrate		45 (10 mg/L as nitrate-nitrogen)	
pH			6.5-8.5
Selenium	0.01		
Sodium			200
Sulphate			500
Total Dissolved Solids			500
Turbidity	1 NTU		<5 NTU
Uranium	0.1		
Zinc			5.0

MAC – Maximum Acceptable Concentration
IMAC – Interm Maximum Acceptable Concentration
AO - Aesthetic Objectives
Units of measurement are milligrams/litre unless otherwise specified.
NTU – nephelometric turbidity unit

Ammonium, calcium, magnesium and silver have been reviewed and identified by Health Canada as not requiring numerical guidelines as current health data does not indicate a health risk to the public, or any aesthetic concerns (e.g.: calcium and aluminium), or the compound is not likely to occur in drinking water at harmful levels (e.g.: silver).

The original Guidelines for Canadian Drinking Water Quality were developed through a review of scientific, technical and medical literature in 1968. Since 1968, several committees have reviewed existing guidelines and added or modified several parameters. The most recent copy of the Drinking Water Guidelines can be found on-line at www.env.gov.bc/wat/gws/gwdocs/gweddocs/watqual.html. Aluminium, antimony, nickel and uranium were scheduled for review in 1996 for possible revision or addition to the Guidelines for Canadian Drink Water Quality.

The Maximum Acceptable Concentration (MAC) has been established for substances known or suspected to cause adverse health effects in the general population. Each MAC has been derived to safeguard the health of the public assuming lifelong consumption of drinking water containing the substance of concern. The use of drinking water for domestic purposes, including personal hygiene have also been considered in deriving the guidelines. However, higher water quality may be required for some individuals with special medical conditions.

Drinking water that continually contains a substance that exceeds it's MAC will contribute significantly to exposure of the public to the substance and may, in some instances, result in deleterious health effects. However, a short term exposure above a substances MAC does not necessarily mean the water constitutes a health risk to the public.

Interm Maximum Acceptable Concentrations (IMAC) are listed for those substances for which there is insufficient toxicological data to derive a MAC with reasonable certainty. Interm values are recommended, taking into account the available health-related data, but employing a larger safety factor to compensate for the additional uncertainty involved.

Interm Maximum Acceptable Concentrations are also established for those substances for which the lifetime risk of cancer due to exposure to eachsubstance are greater than the acceptable background risk levels.

Aesthetic Objectives apply to those substances or characteristics of drinking water that can effect it's acceptance by consumers. Where a MAC or IMAC are present along with an AO, the MAC or IMAC is the guideline that should be applied to the drinking water. Where only an AO is present, the concentration below the AO is not considered to constitute a human health hazard.

3.1.2 British Columbia

Table 3-2 below outlines the British Columbia Drinking Water Guidelines. These guidelines were derived from the British Columbia Drinking Water Quality Standards (1998).

Table 3-2
British Columbia Drinking Water Guidelines

Parameter	Maximum Value	Interm Maximum Value	Proposed Maximum Value	Aesthetic Objective
Aluminium	0.2 (at pH >6.5)			
Antimony			0.006	
Arsenic		0.025		
Barium	1.0			
Boron		5.0		
Cadmium	0.005			
Chromium	0.05			
Copper	0.5 (raw drinking water)			1.0 (at point of consumption)
Iron				0.3
Lead	0.01			
Magnesium	700			100 (sensitive people) 500 (average person)
Manganese				0.05
Mercury	0.001			
Nitrate	45 (10 mg/L as nitrate-nitrogen)			
Nitrite	1 (as nitrite-nitrogen)			
pH				6.5-8.5
Phosphorus	0.01			
Selenium	0.01			
Sodium				200
Sulphate				500
Total Dissolved Solids				500
Turbidity	1 NTU			5 NTU
Uranium	0.1			
Zinc				5.0

Maximum Value – Maximum recommended concentration based on health effects data
Units of measurement are milligrams/litre unless otherwise specified.
NTU – nephelometric turbidity unit

The guidelines recommended by the British Columbia Ministry of Environment are similar to those put forth by Health Canada. The following additional substances are included in the British Columbia Drinking Water Guidelines:

- Aluminium
- Antimony
- Copper
- Magnesium
- Nitrite
- Phosphorus

3.2 City of Nanaimo Drinking Water Testing Protocols

It is BC Research's understanding that prior to 1998, the City of Nanaimo performed a complete analysis of the water entering the main distribution line once per year. This analysis included general chemistry parameters (pH, turbidity, etc.), metals, halogenated volatile organic compounds, polyaromatic compounds, radioactive compounds, phenolic compounds, pesticides, PCBs and herbicides. The exact parameters varied slight between years depending on the laboratory that performed the analysis.

Starting in 1998, the analysis for metals and general chemical parameters was increased to two times per year. Recently, the Greater Nanaimo Water District has increased their metals and general chemistry analyses to a monthly schedule. The full spectrum analysis for all chemical compounds of concern is still completed on a yearly basis.

It is our understanding that this increase in sampling frequency was undertaken to be able to better detect changes in water quality before the water quality guidelines are exceeded. By monitoring the parameters of concern on a monthly basis, increases in any of the measurement parameters will be caught early enough to be able to take corrective actions.

In addition to the analysis outlined above, the Greater Nanaimo Water District collects samples three times per week for biological analysis.

3.3 City of Nanaimo Drinking Water Sampling Results

Water samples from 1989 until the fall of 2000 were reviewed for the purposes of this assessment. The pH, nitrate, nitrite, sulphate, turbidity and total dissolved solid levels were reviewed for each sample along with the complete range of metals analyzed.

The analytical results were broken into two groups: prior to 1998 (before the fertilizing began) and post 1998 (after the fertilizing began). For each parameter the

average, minimum and maximum values were determined. In addition, the standard deviation, and variance were determined. This data was utlized to perform a two tailed t-test to test the hypothesis that the two sample groups were statistically the same.

In addition to the above information, the number of times the Drinking Water Guidelines (British Columbia and Canadian) had been exceeded or fallen outside the acceptable range was calculated for each parameter.

The differences between the pre-1998 and post-1998 data were then compared to determine if there were any significant trends in the water quality parameters using statistical testing methods.

Based on a review of the data the following comments are made regarding the water data:

- The recommended MAC and AO were exceeded or the value was outside the acceptable range four times prior to 1998. The concentration of iron exceed the AO slightly in 1992 and the pH was slightly less than the recommended range in 1991, 1995 and 1997. In comparison, there have been no exceedences of the Canadian Drinking Water Criteria levels since fertilizing began in 1998.

- In all samples collected, the concentration of sulphide exceeded the AO. The analytical reports indicate that the concentration of sulphide exceeded the AO for sulphide because the limit of detection for sulphide is higher than the AO. The analytical reports state that a panel determined that there was no odour to any of the samples which would be present if the concentration of sulphide had exceeded the AO.

- Prior to 1998, 59% of the parameters evaluated exceeded the limit of detection at some point over the nine year period. After fertilizing began in 1998, this level has dropped to 38%, meaning a smaller proportion of the parameters have been reported to be above the analytical limit of detection.

- The statistical sampling results indicate that the water monitoring data from before 1998 is statistically the same as the water quality data from after 1998. There is no statistical difference between the reported concentrations before 1998 in comparison to the concentrations reported after fertilizing began in 1998. This test is 95% accurate.

A list of the parameters evaluated is outlined in Appendix L of this report. This table outlines the average concentration for each parameter, as well as the range for pre-1998 and post-1998 water quality sampling. In addition, a column for each set of samples has been inserted to indicate whether or not the compound was ever reported above the limit of detection pre-1998 and post-1998. A “no” in these columns indicates that all of the samples were reported as below the limit of detection. The variability between the minimum and the maximum is a product of the limits of detection being different for the various laboratories used and

sensitivities of different analytical instruments utilized. A ”yes” in these columns indicates that at least one of the samples was reported at a concentration above the limit of detection in that data set.

4 SOILS

4.1 Background Soil Concentrations

Background concentrations in soil on Vancouver Island are provided below in Table 4-1 for review. This data was obtained from the BC Environmental Contaminated Sites website. These values represent the estimated concentration of metals on Vancouver Island based on a limited number of sampling sites surveyed by the British Columbia Ministry of Environment and may be used as baseline background levels unless it is otherwise known that the background concentration may be higher.

Table 4-1 Vancouver Island Background Soil Quality Estimates for Inorganic Substances.

Substance	Concentration in Soil (ug/g)
Antimony	(4.0)
Arsenic	10
Barium	300
Beryllium	1.5
Cadmium	0.35
Chromium (total)	90
Cobalt	50
Copper	150
Lead	30
Mercury[6]	(0.025)
Molybdenum	(1.0)
Nickel	55
Selenium	(4.0)
Silver	(1.0)
Tin	(4.0)
Vanadium	250
Zinc	100

1. Values in brackets indicate that greater than 50% of values were less than the mean detection concentration for the substance, consequently the value in the table is listed as one half the mean detection limit.
2. Each estimate represents the 95th percentile value obtained for a substance in the region or area.

An older source, less specific to British Columbia and Vancouver Island, reports the average concentration in the earth's crust of various elements of interest. These values are reported below in Table 4-2 for the purposes of comparison and to provide a complete list of elements of concern for this assessment.

Table 4-2 Average Concentration of the Elements in the Earth's Crust

Substance	Concentration in Soil (ug / g)
Aluminium	8.2×10^4
Antimony	0.2
Arsenic	1.8
Barium	425
Beryllium	2.8
Bismuth	0.17
Boron	10
Cadmium	0.2
Calcium	4.2×10^4
Chromium (total)	100
Cobalt	25
Copper	55
Iron	5.6×10^1
Lead	12.5
Magnesium	2.0×10^4
Manganese	950
Mercury	0.08
Molybdenum	1.5
Nickel	75
Phosphorus	1.0×10^3
Potassium	2.4×10^4
Selenium	0.05
Silicon	28.2×10^4
Silver	0.07
Sodium	2.4×10^4
Strontium	375
Sulphur	260
Thallium	0.45
Tin	2
Titanium	5.7×10^3
Uranium	2.7
Vanadium	135
Zinc	70

In comparing estimated concentration of elements in the earth's crust with the British Columbia Ministry of Environment estimates it can be seen that there is considerable variation in concentrations between locations throughout the world.

In comparing the concentration of metals reported for Vancouver Island with those found in the fertilizers used by Weyerhaeuser (once they have been converted to ug/g) it can be seen that the concentration of boron, cadmium, copper, iron, mercury, molybdenum, phosphorus, selenium and zinc are higher than background levels reported above. All other metals and/or elements are equal to or below the concentrations reported above.

4.2 Soil Concentrations in Nanaimo Watershed

A recent study by Weyerhaeuser looked at the concentrations of representative metals and trace elements within the Greater Nanaimo Watershed. According to Mr. Jim Loftus, the objective of this study was to determine whether or not there was any significant difference in the soil between areas which had been planted without fertilizer and areas that had been fertilized.

To assess this issue, 150 samples were collected from areas which had been planted without the use of fertilizer (prior to 1998) and 150 samples were collected from areas that had been planted with the use of fertilizer (planted in the spring and summer of 2000).

Samples were collected 45 centimetres away, on the down hill side, from the seedlings. Soil samples were collected from the organic layer on the surface, at a depth of 0 – 15 inches below the organic layer and 15 to 30 inches below the organic layer. These three samples were then mixed equally to form a single sample.

These samples once collected were consolidated, 10 samples from the same area were combined to create a total of 30 samples (15 from fertilized areas and 15 from unfertilized areas). These samples were then labelled and submitted to an accredited laboratory for analysis. The laboratory personnel were blind to which samples were from the fertilized area and which samples were from the non-fertilized area.

Upon completion of the analysis, the samples were submitted to Weyerhaeuser personnel who were not involved in the site selection process. These individuals carried out statistical tests to determine if the results from the two areas (personnel were not aware of which area was the non-fertilized and which was the fertilized area) were equal or statistically different.

The results of this report concluded that there were no statistical differences between the two groups. It was beyond the scope of the BC research project to verify the statistical comparison made by Weyerhaeuser, therefore the results of their comparison were accepted at face value.

4.3 Migration Potential

The potential for metals and other elements such as phosphorus, and calcium to migrate depends on a large number of complex factors including the properties of the soil, the drainage patterns for each area and the distance from the water source of concern to name a few. An assessment of the potential for the metals and other elements of the fertilizer to migrate into the Greater Nanaimo Water Reservoirs is too complex for the scope of this report. For a more detailed analysis a hydrogeologist would be required to collect samples and develop predictive models.

However, some general comments can be made about the potential of the fertilizer elements to migrate based on general principles.

- The fertilizer is buried with the seedling approximately one to three inches beneath the surface of the ground. The potential for the fertilizer to immediately wash away is thus limited unless major erosion occurred due to heavy rainfall (i.e./ mud slide) or unstable slopes (i.e./land slide).

- The amount of fertilizer released at any one time is limited by the characteristics of the fertilizer. The fertilizers used by Weyerhaeuser are meant to release the fertilizer over a long period of time (1.5 – 3 yrs depending on the conditions) and when the seedlings need the nutrients the most to grow. Therefore, the amount of nutrients carried away by the ground water and/or surface water would only represent a portion of the total amount of fertilizer used.

- The fertilizer pellets are heat sensitive making more nutrients available during the warmer months of the year. The highest period of nutrient concentration in the soil therefore occurs during the driest period of the year minimizing the amount of fertilizer that is carried away by surface and/or ground water.

- It is expected that much of the fertilizer released will be taken up by the seedling. The amount of the fertilizer taken up by the seedling will be dependent upon the natural concentration of the minerals and elements in the soil and the amount of water present to act as a conduate for the uptake of the material.

- In addition, any fertilizer not utilized by the seedling would be expected to be absorbed by the microbials in the soil, the opportunistic plants that have taken root in the clear cut area and the trees that are left to act as a barrier between the clear cut area and any water source. The amount of uptake of the migrated fertilizer would be dependent upon the amount and quantity of microbes, opportunistic plants and trees between the clear-cut area and the water source.

In addition to these general comments, a worse case scenario can be used to demonstrate what impact the fertilizer could potentially have on the water reservoir. The information used to calculate the worse case concentration in the reservoir is outlined below along with the findings of the calculation.

The reservoirs in the Nanaimo watershed hold 4.1 billion imperial gallons of water when full. For the purposes of this worse case scenario, it was assumed that the reservoirs were only half full (2.05 billion imperial gallons or 9.32 billion litres).

For the purposes of this assessment, it was assumed that the amount of fertiliser present in the watershed at any given time is equal to the total amount applied during the current year and half of the total amount applied during the previous year. This is based on information provided by Weyerhaeuser which indicates that the fertilizer is completely used after 18 months in our climate. For reasons described below, half of the amount of fertilizer used in 1998 will be added to (5442 kg) the entire amount of fertilizer used in 2000 (23958 kg) to obtain the estimated total amount of fertilizer in the watershed at any given time (29,400 kg).

In order to predict the worse case, the maximum concentrations reported for the fertilizers used during 1998 and 2000 were used, along with the total volume of fertilizer applied, as calculated above, to determine the total amount (in grams) of each metal and/or element of interest. The data for the fertilizer used in 1998 was selected instead of the 1999 data, because at the time this report was written BC Research did not have any information on one of the fertilizers used during 1999, this information was later supplied by Weyerhaeuser. The total amount of each metal and/or element for each year were then added to obtain the total amount of each metal and/or element (in grams) present in the watershed at any given time.

The total amount of each metal and/or element was then converted to milligrams and divided by the amount of water in the reservoirs (in litres) to obtain a maximum concentration in mg/L. The highest concentration predicted was 0.001 mg/L for phosphorus. All of the other maximum concentrations calculated were less than 0.0001 mg/L which is well below any of the Canadian and British Columbia Drinking Water Guidelines for any of the controlled metals.

5 HEALTH CONCERNS

A total of 28 of the 36 metals and elements evaluated during this assessment have established Canadian or British Columbia Drinking Water Guidelines.

These guidelines are recommended based on risk assessments conducted by Health Canada. Health Canada reviews all of the available toxicology and medical literature available at the time in making it's assessment. Using this information, a no observed adverse health effect level and a lowest observed health effect level are determined for each of the parameters based on the information available. This information, along with information on the background levels of each parameter in air, water and soil, a tolerable daily intake (TDI) is calculated for each parameter. Where incomplete or insufficient data is available, a larger than normal safety factor is applied proportional to the amount of uncertainty surrounding the toxicological information available. The water quality guidelines are then determined using the tolerable daily intake value.

The water quality guidelines recommended by Health Canada are derived to safeguard the health of the public assuming lifelong consumption of drinking water containing the substance of concern. The use of drinking water for domestic purposes, including personal hygiene, have also been considered in deriving the guidelines.

The water quality guidelines and the rational behind them is reviewed on a periodical basis by an advisory committee which reports to Health Canada. Updates to the water quality guidelines, and additions are made each year based on new information presented.

Due to the fact that the 28 substances with water quality guidelines were all well below the recommended guidelines, it is not anticipated that any adverse health effects would occur as a result of exposure to these materials.

Of the remaining 14 compounds without water quality guidelines, six are reported as never having exceeded the analytical limit of detection and are therefore not likely to present a health concern. These compounds were beryllium, cobalt, molybdenum, nickel, thallium, tin and vanadium.

The remaining nine compounds that have been found to exceed the analytical limit of detection at least once during the nine years of sampling. The maximum values reported for each compound are outlined on the following page in Table 5-1 for review.

Table 5-1 Metals and/or Elements without Water Quality Guidelines that have Exceeded the Analytical Limit of Detection

Chemical Compounds	Pre-1998 Maximum Reported Value	Post-1998 Maximum Reported Value
Bismuth	All <LOD	0.1
Calcium	6.2	5.3
Manganese	0.027	0.03
Potassium	0.3	0.12
Silicon	9.4	1.73
Silver	All <LOD	0.01
Strontium	0.025	0.028
Titanium	0.0016	0.01

Values are reported in milligrams per litre
All <LOD – indicates that all of the samples in this set of data were less than the limit of detection

In looking at the compounds above that were found to be above the limit of detection it can be noted that in many cases the maximum concentration reported before 1998 is higher than the maximum concentration after 1998 (calcium, potassium, and silicon). The fact that the concentrations before 1998 are higher than after 1998 would indicate that the use of fertilizer is not a contributing source to the levels reported.

It is also important to note that the 1996 Guidelines for Canadian Drinking Water Quality indicates in their publication that calcium, magnesium and silver do not have drinking water guidelines as the health data currently available does not indicate a health risk through ingestion. Similarly, the other compounds, although not mentioned in the 1996 Guidelines for Canadian Drinking Water Quality are poorly absorbed by the body through ingestion and they are rapidly eliminated from the body through the urine and or feces therefore making them poor candidates for toxicity concerns at these concentrations.

6 CONCLUSIONS AND RECOMMENDATIONS

Based on the information provided in this report, the following conclusions can be made about the risk the use of fertilizer presents to the Greater Nanaimo Watershed and the people of Nanaimo reliant upon it as a source of drinking water:

- There is no evidence that the drinking water supply has been effected to date by the use of fertilizers in the watershed.

- There is no evidence to date to support the fact that ongoing use of the fertilizer in the watershed will present a drinking water hazard, providing the type of fertilizer utilized and amount are the same as that currently utilized. The reduction in the amount of fertilizer used per seedling back to 30 grams from 50 by Weyerhaeuser will further reduce any potential there might be for contamination of the drinking water supply.

Based on the information presented in this report, the following recommendations are made to ensure to continued safety of the drinking water supply:

- All new fertilizers should be reviewed for their potential to adversely effect the watershed by Weyerhaeuser, in conjunction with the Greater Nanaimo Water District, before being used in the watershed. As a minimum, the contents of the fertilizer (including trace metals and other elements) should be reviewed, along with the locations the fertilizer is to be applied, the application method and the amount of fertilizer to be used.

- The Greater Nanaimo Water District and Weyerhaeuser should have in place a protocol to respond to increasing concentrations of “fertilizer” parameters in the water samples. This protocol should include what corrective actions should be taken in the event that the concentration of a fertilizer parameter in the water samples starts to approach and or exceeds the recommended guideline values.

- The Greater Nanaimo Water District should continue to monitor the water quality on a regular basis (monthly is sufficient) for components of the fertilizer that could indicate that leaching is occurring. This monitoring should be undertaken to ensure that increases in water quality measures can be detected and corrective action can be implemented in a timely manner.

7 REFERENCES

1. Washington Department of Agriculture Fertilizer Registry, www.wa.gov/agr, 2000

2. British Columbia Drinking Water Quality Guidelines, www.env.gov.bc.ca/wat/wq/Bcguidelines/approved.html, 1998 Edition

3. Guidelines for Canadian Drinking Water Quality, Sixth Edition, Health Canada, 1996

4. Guidelines for Interpreting Water Quality Data, www.for.gov.bc.ca/ric/pubs/aquatic/interp.htm, 1997

5. InterOcean Systems Inc., Abundance of the Elements

6. Protocol 4: Determining Background Soil Quality, Table 1, http://www.elp.gov.bc.ca/epd/epdpa/contam_sites/policies and procedures

The following information was provided to BC Research by the Greater Nanaimo Water District

- water analysis results for 1989 to 2000
- map of the watershed
- fertilizer analysis results submitted by the Greater Nanaimo Water District
- the fertilizer analysis results submitted to Cantest by the Canadian Reforestation Workers
- newspaper and journal articles on the issue of water quality and fertilizer usage in the watershed
- communications between Weyerhaeuser and the Greater Nanaimo Water District regarding the use of fertilizers in the watershed
- communications between Mr. Lee and the Greater Nanaimo Water District

The following documentation was provided to BC Research by Weyerhaeuser:

- MSDS for the fertilizers used between 1998 and 2000 in the watershed
- the analytical results of any fertilizers analyzed
- a list of the types and quantities of fertilizers utilized each year
- a map outlining the planting locations for 2000
- soil sample analysis results
- communications between Weyerhaeuser and the Greater Nanaimo Water District regarding the use of fertilizer in the watershed.

Much of the information used in this report was obtained through interviews with Mr. Wayne Hansen of the Greater Nanaimo Water District, Mr. Jim Loftus of Weyerhaeuser and Mr. Brian Saunders of Weyerhaeuser.

APPENDIX A

Map of Greater Nanaimo Watershed

APPENDIX B

Material Safety Data Sheet – K-MAG

APPENDIX C

Material Safety Data Sheet – Urea Fertilizer Grade – Granular - 46-0-0

APPENDIX D

Material Safety Data Sheet – Mono Ammonium Phosphate MAP - 11-52-0

APPENDIX E

Material Safety Data Sheet – Sulfate of Potash

APPENDIX F

Material Safety Data Sheet – Duration CR Polymer Coated Urea - 43-0-0

APPENDIX G

Material Safety Data Sheet – ESN T-150 Controlled Release Urea 46-0-0

APPENDIX H

Material Safety Data Sheet – Micronutrient Mixture

APPENDIX I

Material Safety Data Sheet – Enspan/Polymer Coated Sulphur Coated Urea 39-0-0

APPENDIX J

Material Safety Data Sheet – Nutri-Pak - 25-8-8

APPENDIX K

Material Safety Data Sheet – Nutri-Pak - 26-9-9

APPENDIX L

Map of 2000 Seedling Planting Locations

APPENDIX M

Summary of Water Sample Results