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Our file: 3163

June 27, 2012

Regional District of Nanaimo
6300 Hammond Bay Road
Nanaimo, BC
V9T 6N2

Attention: Ms. Ellen Hausman, Wastewater Program Coordinator

Dear Sirs:

Re: Hydrogeological Assessment of Land Application of Biosolids
Vancouver Island University Forest (WL 20), Nanaimo, BC

As per our proposal submitted to the Regional District of Nanaimo (RDN), dated March 9, 2012, Piteau Associates Engineering Ltd. (Piteau) has conducted a hydrogeological assessment of the potential impacts on local groundwater supplies due to land application of biosolids at a treatment area within the Vancouver Island University (VIU) Forest, also known as Woodlot License (WL) 020 (the Site; Fig. 1).

Piteau previously conducted a similar hydrogeological assessment for the Site in 2003 (Piteau, 2003), which concluded that the proposed application of biosolids would not have any impact of groundwater quality in any of the wells located in the region of the Site.

The current assessment was conducted in the context of satisfying the requirements of the Organic Matter Recycling Regulation (OMRR; B.C. Reg. 18/2002, including amendments up to B.C. Reg. 198/2007) of the *B.C. Environmental Management Act* (EMA) and *Public Health Act* (PHA), as well as verifying that the conclusions defined in the Piteau (2003) report are still appropriate for the current area of biosolids land application.

## WORK PLAN

As indicated in our proposal, the hydrogeological assessments were conducted by Matthew Cleary, P.Geo., a hydrogeologist with Piteau, and involved the following:

- Review of information pertaining to historical biosolids application and details of proposed future biosolids application for the Site.
- Review of existing reports on local area hydrogeology and the previous assessment conducted for the Site.
- Review of surficial and bedrock geology mapping information in the vicinity of the Site.

- Conducing a Site visit to confirm soil and groundwater conditions, observe biosolids storage and application areas (historical and proposed), and meet with RDN and VIU personnel with knowledge of the Site.
- Preparation of a summary report for the RDN.

## BIOSOLIDS APPLICATION SITE

The Site includes 1,700 hectares (ha) of forestland located approximately 12 km northwest of the City of Nanaimo on the lower slopes of Mount Benson. Land application of biosolids has been limited to a 250 ha area of the Site, north of Weigles Road. This area combined with future proposed areas make up the Application Area. Topography in the area is gently undulating with a slope of approximately 8 to 10% towards the east in the vicinity of the areas of biosolids land application (Fig. 1).

The Site is managed by VIU under forest tender agreement WL 020, per the information provided in the VIU WL 020 Land Application Plan (Appendix A). As part of an ongoing fertilization program, VIU is applying both Class A and Class B biosolids to demonstrate the benefits of biosolids as a forest fertilizer.

Douglas fir and minor lodgepole pine are the dominant commercial tree species observed at the Site. Most of the stands within the Application Area support 50- to 75-year-old second growth; however, there has also been an application to stands of younger Douglas fir. Forest fertilization with biosolids was originally conducted as a pilot project in 1992, and again from 2003 to 2006. VIU resumed the biosolids application project in 2007, and has continued until the present within the Application Area shown on Fig. 1. Land application of biosolids occurs throughout the year, typically four to six days per month. In general, biosolids application ceases during conditions of inclement weather (i.e., intense rainfall events) or at the discretion of the project manager.

Biosolids are sourced from the RDN's Greater Nanaimo Pollution Control Centre and French Creek Pollution Control Centre, as well as from the District of Cowichan (DNC) Chemainus Sewage Treatment Plant. A detailed description of each of the biosolids sources is provided in the VIU WL 020 Land Application Plan, including trace element and nutrient concentrations, and physical, chemical, and microbiological characterization (Appendix A).

## REGULATORY FRAMEWORK

Land application of biosolids is regulated under the Organic Matter Recycling Regulation (OMRR; B.C. Reg. 18/2002, including amendments up to B.C. Reg. 198/2007) of the EMA and PHA. The OMRR includes provisions for the protection of groundwater resources, with specific reference to that of Class B biosolids (Schedule 8), detailed as follows:

1. Class B biosolids and Class B compost with fecal coliform levels greater than or equal to 1000 most probable number (MPN) per gram of total solids, or that have not been processed to reduce vector attraction, must comply with the following:
   (a) not be applied to land where the groundwater table at the time of application is within one metre of the surface; and
   (b) be applied with the following minimum distances:
      (i) 30m to potable water sources and irrigation wells, lakes, rivers, streams, farm dwellings and off-property occupied dwellings or boundaries of property zoned for residences or recreation;

2. Class B biosolids and Class B compost with fecal coliform levels less than 1000 MPN per gram of total solids that meet the requirements for vector attraction reduction for Class B biosolids and Class B compost specified in Schedule 2 must:
   (a) be applied with the following minimum distances:
      (i) 30m to potable water sources and irrigation wells, lakes, rivers, streams, farm dwellings and off-property occupied dwellings or boundaries of property zoned for residences or recreation;
   (b) not be applied to land where the groundwater table at the time of application is within one metre of the surface.

## REGIONAL SURFICIAL / BEDROCK GEOLOGY

The regional bedrock geology beneath the Site has been mapped as a combination primarily middle to upper Triassic age Karmutsen Formation (Vancouver Group) volcanic rocks and Cretaceous age Nanaimo Group sedimentary rocks (Muller, 1977; Fig. 2). Karmutsen volcanics are described as pillow-basalt and pillow-breccia, massive basalt flows, and minor tuff volcanic breccia. Nanaimo Group sedimentary rocks have been mapped as three distinct formations, including: Haslam Formation, consisting of shale, siltstone, and fine sandstone; Comox Formation, consisting of sandstone, conglomerate, shale, and coal; and, Extension-Protection Formation, consisting of sandstone, conglomerate, shale and coal (Muller, 1969).

Other bedrock units mapped in the area include the Fourth Lake Formation and Nanoose Complex of the Buttle Lake Group, as well as the Island Plutonic Suite and Mount Hall Gabbro, although they have not been mapped beneath the Site, nor down gradient.

Northwest-southeast trending faults are mapped along creek valleys located in the vicinity of the Site. Similar faults are mapped throughout many parts of Vancouver Island and the Gulf Islands.

The regional surficial geology mapping (Halstead, 1963) shows that the sediments below the Site are mapped as a thin (less than 1.5m thick) veneer of ground moraine deposits, consisting of glacial till, lenses of gravel, sand and silt overlying bedrock.

The glacial till was deposited during the last major ice sheet advance. During retreat of the glacial ice, the sea level rose 150m higher than its present level, and glaciomarine deposits were deposited in the areas located below this elevation, north and east of the Site. A typical profile of this geologic sequence along the east coast of Vancouver Island is presented on Fig. 3.

## REGIONAL CLIMATOLOGY / HYDROLOGY

The nearest Environment Canada weather station for which climate normals are reported is the Nanaimo Airport Climate Station (#1025370), located approximately 25 km southeast of the Site (Environment Canada, 2012a). The 30-year average annual precipitation for the climate station is 1162.7 mm/year, with a monthly range between 25.9mm (July) and 198.6mm (November). The majority of precipitation falls as rainfall between the months of October and March; however, at the higher altitude of the Site, a larger percentage of precipitation likely occurs as snowfall. It is reasonable to assume that approximately 10 to 15% of precipitation (116 to 174 mm/year) recharges the groundwater flow system, which then discharges to proximal surface water features. The remaining 85 to 90% of precipitation is lost to evapotranspiration, sublimation (snowfall), and overland flow, which then discharges to surface water.

The Application Area, located within the bounds of the Site, is situated on an eastwardly dipping slope located northwest of Mount Benson. It is surrounded by numerous ephemeral creeks, namely Caillet Creek, Slump Creek, Flynfall Creek, and Quibblers Creek, that converge and flow eastward and discharge to Brannen Lake. Benson Creek, which flows year round, is located east of the Application Area, and discharges directly to Brannen Lake.

Surface water monitoring data is not available for any of the surface water bodies located within the watershed; however, a monitoring station situated approximately 25 km southeast of the Site, identified as Nanaimo River near Cassidy (08HB034) provides discharge information for the Nanaimo River (Environment Canada, 2012b). While the discharge reported at the Nanaimo River likely far exceeds the seasonal flows observed at rivers and creeks located near the Site, it provides a good analogue for seasonal variability in surface water discharge. Seasonal average base flows in the Nanaimo River are observed between June and September, while higher flows coupled with peaky storm flows are observed between October and May.

## REGIONAL HYDROGEOLOGY

Aquifer mapping conducted by the BC Ministry of Environment (BC MOE, 2012a) indicates the presence of numerous interpreted bedrock and unconsolidated surficial aquifers, located in the vicinity of the Site. Five mapped aquifers, identified as aquifer numbers 166, 167, 211, 213, and 215, are interpreted to be down gradient or cross gradient of the Site, and are presented on Fig. 4

and in Table I. Two of the five aquifers (167 and 215) are interpreted to consist of sand and gravel sediments of the Capilano Formation and Quadra Sands, respectively. The three remaining aquifers are defined by fractured rock of the Vancouver Group. As the degree of fracturing with bedrock aquifers is variable, the boundaries of the three bedrock aquifers should be considered less definitive.

Groundwater flows from areas of high hydraulic head (upland recharge areas) to areas of low hydraulic head (lowland recharge areas). The Application Area is situated in an upland recharge area, and infiltration precipitation will recharge the groundwater flow regime during times of seasonally high precipitation. The groundwater flow direction is interpreted to correlate with the direction of surface topography, which indicates that groundwater flows east-northeast towards Brannen Lake. The hydraulic gradient is likely more gentle than that of topography, which is approximately 8 to 10%, therefore indicating that the hydraulic gradient likely ranges between 6 and 8%.

A review of the BC MOE WELLS database indicates the presence of numerous wells located down gradient of the Application Area (BC MOE, 2012b). Well logs for some of the water wells that have been identified as being located within 1 km of the Application Area have been included in Appendix B, while their locations have been provided on Fig. 4. Actual water well locations for wells identified within the BC MOE WELLS database can be inaccurate, as is anticipated to be the case with three of the water wells (Well Tag Numbers 94374, 94375, and 94376), where the civic addresses place the wells approximately 1.5 to 3 km to the east.

Information provided in the VIU (WL 020) Land Application Plan (Appendix A) indicates the presence of a residential water well located approximately 1 km east of the Application Area, at 6292 Doumont Road. Based on the aforementioned information, there does not appear to be any known water wells located within 500m of the Application Area. Information provided within the water well logs (Appendix B) indicates that the groundwater ranges from a depth of greater than 12 m-BGS (metres below ground surface) up to near surface artesian conditions (flowing well). Based on the interpreted hydraulic gradient of 6 to 8%, the depth to the groundwater table likely ranges between 10 and 50 m-BGS, beneath the Application Area.

Groundwater depth likely fluctuates seasonally, depending on precipitation rate and storage within the snow pack. As surface water discharge and stage elevation are a function of groundwater recharge, high surface water discharge and stage elevation correspond with higher groundwater table and hydraulic gradients beneath the Application Area. As the Nanaimo River provides for a good analogue for seasonal fluctuations in surface water discharge within creeks near the Application Area, higher groundwater table elevations likely occur between October and May.

## FIELD RECONNAISSANCE

After conducting a preliminary review of pertinent geological and hydrogeological information, a Site visit was conducted by Matthew Cleary, of Piteau, on May 24, 2012, to observe areas of historical and proposed biosolids applications, as well as to confirm geological, hydrological, and hydrogeological conditions at the Site.

Areas of historical and proposed future biosolids application were observed at the Site, north of Weigles Road (Photos 1 to 3). Consistency and texture of the biosolids, and thus ease of application, is dependent on moisture content and humidity, as per Paul Lucas of VIU. Biosolids containment is maintained with the use of an asphalt pad, surrounded by concrete lock blocks (Photo 4). In addition, during the winter months biosolids containment areas are covered with a plastic tarp, to reduce leaching of nutrients from the biosolids.

Numerous borrow pits, used as sources for road construction within the Site, provided for good exposure of both soil and bedrock. Surficial sediments and soils are observed to be present as thin veneers of less than 1m thickness, overlying bedrock (Photos 5 and 7). Bedrock exposures consisted of both sandstone, interpreted as Nanaimo Group sediments (Photos 5 and 6), and pillow-basalts, interpreted as Karmutsen Formation (Photos 7 and 8).

While there were no water wells located within the Site to allow for direct measurement of the depth to groundwater, observations of bedrock outcrops described above, note the absence of any groundwater seepage. This indicates that the depth to groundwater table is greater than the height of the bedrock exposure (5m).

Surface water flow was observed within Caillet Creek, and is indicated to be ephemeral based on observations from VIU personnel. Therefore, the observed flow is interpreted to represent recharge from direct precipitation and overland flow, as opposed to groundwater recharge.

## REVIEW OF POTENTIAL IMPACTS TO GROUNDWATER

Biosolids include both pathogens and toxic substances that are of concern from a health effects viewpoint. The pathogens include bacteria, viruses, and parasites (protozoa and helminths). Toxic substances include trace elements (heavy metals) and nitrates. The potential impact these pathogens and toxic substances may have on groundwater quality is discussed in the following within the context of the regional hydrogeology.

### Pathogens

*Bacteria*

In general, coliform bacteria emanating from land application sites normally only move a few dozen centimetres with percolating waters in unsaturated soils (Bitton and Gerba, 1984). The

main process of attenuation is filtration (i.e., physical straining) and to a lesser degree, reversible adsorption onto soil particles. Due to the relatively fine nature of soils throughout the Application Area bacteria are not considered to pose a significant threat to groundwater quality.

*Viruses*

While viruses near the soil surface are rapidly inactivated due to combined effects of sunlight, drying, and antagonism of aerobic soil microorganisms, those that penetrate the aerobic zone can be expected to survive over a prolonged period, and to reach the groundwater table (Kowal, 1985). In contrast to bacteria, which are mainly attenuated by filtration, removal of viruses from groundwater is almost totally dependent on adsorption. Soils rich in fine-grained sediments are generally considered to be good virus adsorbers.

*Parasites (Protozoa and Helminths)*

Because of the large size of protozoan cysts and helminth eggs, compared with bacteria and viruses, it is improbable that they will find their way into groundwater at land application sites. They are therefore not considered to pose any threat in terms groundwater quality.

Toxic Substances

*Trace Elements (Heavy Metals)*

Kowal (1985) reports that trace elements do not move more than about 30 cm into the soil column at biosolids application sites. Based on this consideration, the potential for groundwater contamination at the Application Area by trace elements (i.e., heavy metals) resulting from biosolids application is considered to be very low.

*Nitrates*

Nitrates are not normally viewed as "toxic" substances, but are here so considered because of their potential hematological effects when present in water supplies at high levels. In terms of land application of biosolids, the threat to groundwater quality is low if the biosolids is applied so that nitrogen-loading rates do not exceed fertilizer nitrate recommendations for the area of application.

As with many fertilizers, over application of biosolids may result in elevated nitrate concentrations in groundwater. However, even if this were the case, due to the high degree of dilution that would occur, and the fact that release of the organically bound nitrogen in the biosolids would be relatively slow, the nitrate concentrations in groundwater withdrawn water wells located to the east of the Application Area would not be expected to be anywhere near the Guidelines for Canadian Drinking Water Quality (GCDWQ; Health Canada, 2008) guideline of 10 mg/L.

## DISCUSSION / CONCLUSION

A review of available geological and hydrogeological information indicate the following findings with respect to potential impacts to groundwater resources resulting from land application of biosolids at the Site:

- Bedrock beneath and down gradient of the Application Area consists primarily of sedimentary rocks of the Nanaimo Group and volcanic rocks (Karmutsen Formation) of the Vancouver Group. Regional faults have been mapped primarily in a northwest-southeast trend. Surficial sediments are only present as veneers of glacial till, and therefore groundwater resources in the vicinity of the Site are likely limited to fractured bedrock aquifers.
- Soils located within the Application Area have a moderate silt content and are well drained. They are typically covered with a thin layer of organics. These factors, coupled with the characteristics of biosolids leachate, lead to the conclusion that bacteria, viruses, parasites, nutrients and trace metals that could potentially leach from applied biosolids would be significantly attenuated while flowing through the shallow soil profile.
- Climate data obtained from a proximal Environment Canada climate station indicate that the majority of precipitation occurs between October and March. Surface water data, which are an analogue for groundwater response, indicate that groundwater levels are likely highest between October and May.
- Well logs for water wells reported in the BC MOE WELLS database, and information obtained during field reconnaissance, indicate that the depth to the groundwater table likely ranges between 10 and 50 m-BGS, and is therefore greater than the minimum groundwater depth of one metre, as specified in Schedule 8 of the Organic Matter Recycling Regulation (OMRR).
- As the depth to the water table in the fractured sedimentary and volcanic bedrock below the Application Area likely ranges between 10 and 50 m-BGS, there is an opportunity for further attenuation of bacteria, viruses, parasites, nutrients and trace metals as water percolates through the unsaturated zone.
- Once within the fractured rock beneath the Application Area, groundwater will likely migrate towards one of the northwest to southeast trending fault zones, and/or related fractures. It is then anticipated that groundwater will flow towards (and discharge to) Benson Creek.
- Available information indicates that groundwater resources are relatively undeveloped within about 500m of the Application Area, as indicated by the lack of water wells reported within the BC MOE WELLS database. While there may be unregistered water wells, given the lack of infrastructure and development it is very unlikely that there are any within 30m of the Application Area, corresponding to the minimum setback distance specified in Schedule 8 of the OMRR.
- Based on the information reviewed during this assessment, it is concluded that past and proposed future application of biosolids within the Application Area will have no harmful effect on regional groundwater quality. A minimum 300m setback distance between the Application Area and a water well is recommended.

## LIMITATIONS

This assessment has been conducted using a standard of care consistent with that expected of scientific and engineering professionals undertaking similar work under similar conditions in BC. No warranty is expressed or implied.

This letter report is prepared for the sole use of the Regional District of Nanaimo. Any use, interpretation, or reliance on this information by any third party, is at the sole risk of that party, and Piteau accepts no liability for such unauthorized use.

We trust this letter report is sufficient for your current requirements. If you have any questions, or we can be of further service, please contact the undersigned.

Yours very truly,

PITEAU ASSOCIATES ENGINEERING LTD.

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA M. L. CLEARY #33011 GEOSCIENTIST JUN 27 2012

Matthew L. Cleary, P.Geo.
Project Hydrogeologist, Associate

PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA D. J. TIPLADY # 16053 June 27 2012

David J. Tiplady, P.Eng.
Vice President - Groundwater
Principal Hydrogeologist

MLC/DJT/slc

Att.

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## TABLE I

## MINISTRY OF ENVIRONMENT AQUIFER MAPPING SUMMARY

| AQUIFER ID NUMBER [1] | AQUIFER TYPE | LITHOSTRATIGRAPHIC GROUP | AQUIFER SIZE [2] $km^2$ | PRODUCTIVITY | VULNERABILITY | DEMAND | WATER USE [3] |
|---|---|---|---|---|---|---|---|
| 166 | BEDROCK | VANCOUVER GROUP | 12 | LOW | MODERATE | LOW | NON-DRINKING WATER |
| 167 | SAND AND GRAVEL | CAPILANO SEDIMENTS | 2.4 | MODERATE | MODERATE | LOW | MULTIPLE USES |
| 211 | BEDROCK | | 13.4 | LOW | LOW | LOW | DOMESTIC USE |
| 213 | BEDROCK | VANCOUVER GROUP | 42 | MODERATE | LOW | MODERATE | DOMESTIC USE |
| 215 | SAND AND GRAVEL | QUANDRA SANDS | 14.3 | MODERATE | LOW | MODERATE | DOMESTIC USE |

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NOTES:

1) Aquifer ID number, as reported in the BC MOE Aquifer Database.
2) Mapped aquifer size as reported in the BC MOE Aquifer Database. Actual aquifer size for bedrock aquifers may vary significantly from that reported.
3) Actual water use may differ from that reported in the BC MOE Aquifer Database.

# FIGURES

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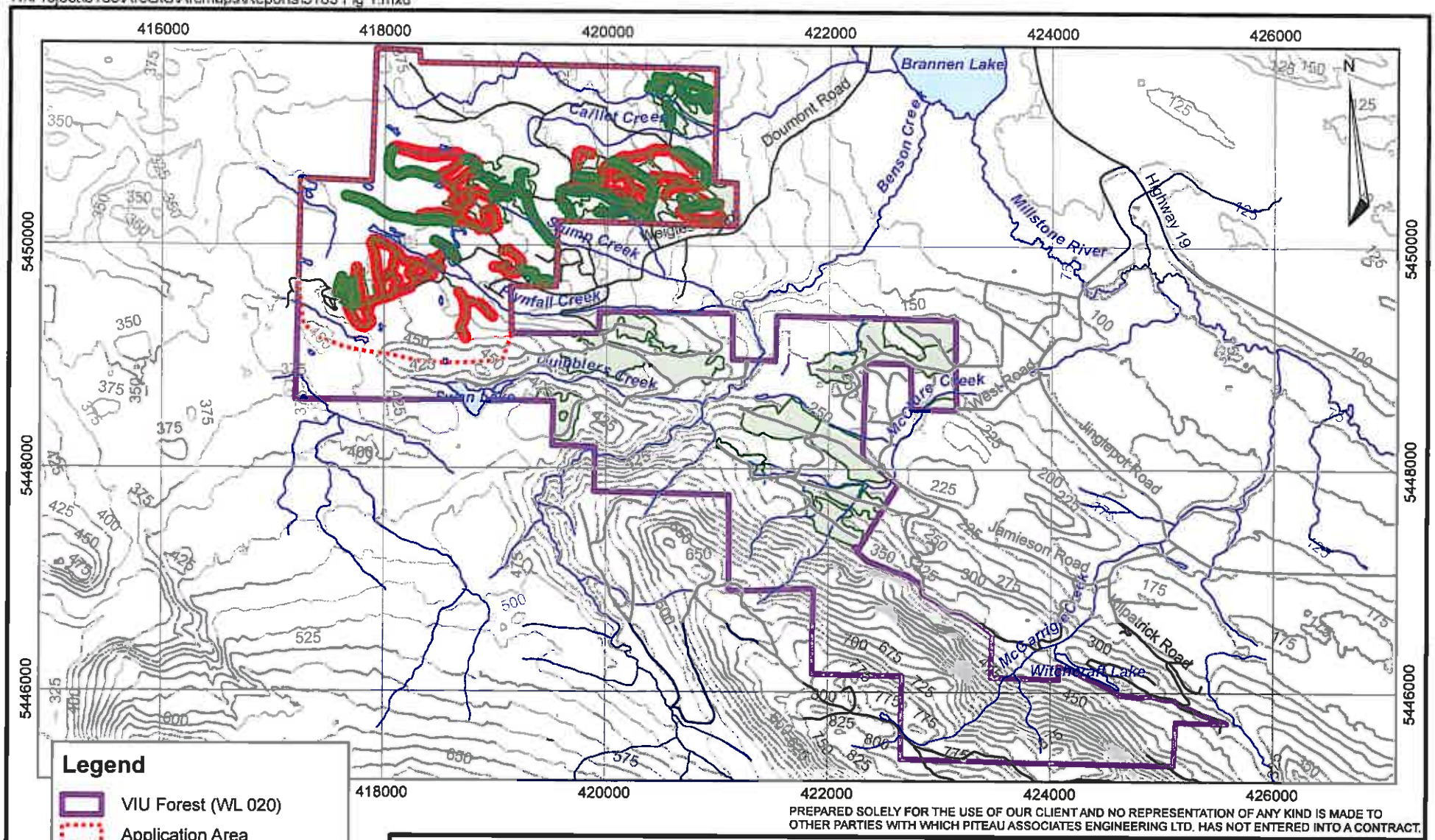




REGIONAL DISTRICT OF NANAIMO
HYDROGEOLOGICAL ASSESSMENT FOR
BIOSOLIDS LAND APPLICATION - VIU WOODLOT 20

PITEAU ASSOCIATES
GEOTECHNICAL AND HYDROGEOLOGICAL CONSULTANTS

# SITE PLAN WITH HISTORICAL AND PROPOSED BIOSOLIDS APPLICATION AREAS

| BY | DATE |
|---|---|
| MLC | JUN 12 |
| APPROVED | FIG. |
| DJT | 1 |

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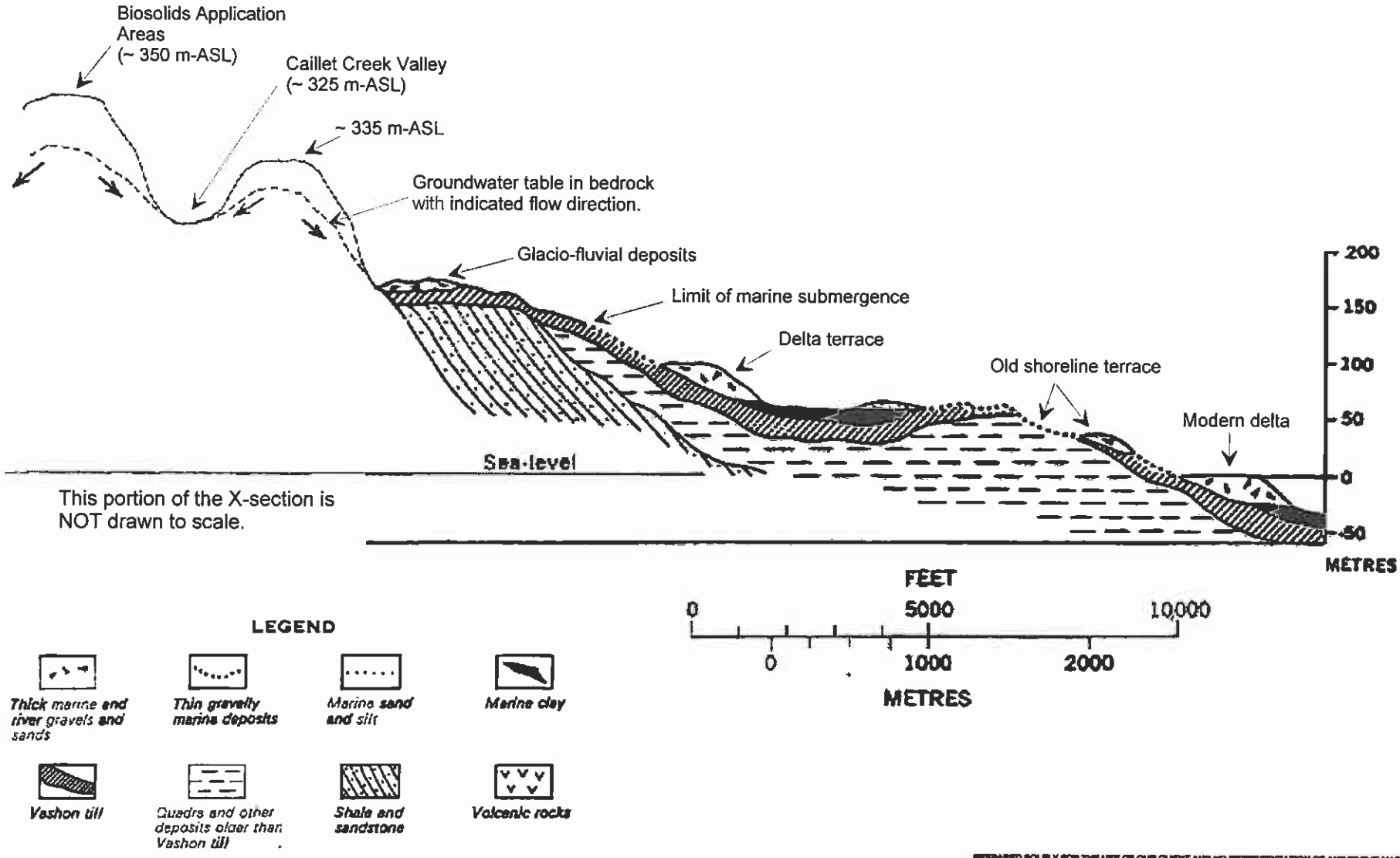




REGIONAL DISTRICT OF NANAIMO
HYDROGEOLOGICAL ASSESSMENT OF LAND APPLICATION OF BIOSOLIDS
VIU FOREST (WL 020), NANAIMO, BC

PITEAU ASSOCIATES
GEOTECHNICAL AND HYDROGEOLOGICAL CONSULTANTS

# TYPICAL GEOLOGIC PROFILE ALONG THE EAST COST OF VANCOUVER ISLAND

| BY: | DATE: |
|---|---|
| MLC | JUN 12 |
| APPROVED: | FIG: |
| DJT | 3 |

NOTES
1) Modified from Halstead & Treichel, 1966

**PHOTOGRAPHS**

**Photo 1.**
Biosolids as applied to the forest floor in an area of second growth Douglas fir trees (view looking south).

**Photo 2.**

Biosolids applied to forest floor of mature stand of Douglas fir trees (detailed view).

Photo 3.
Area of proposed biosolids application for 2012, which was recently logged and contains young Douglas fir and lodgepole pine trees (view looking northeast).

Photo 4.
Biosolids containment area (currently empty) consisting of asphalt pad with concrete lock blocks (view looking northwest).

**Photo 5.**
Borrow pit exposes thin veneer (<1m) of nutrient deficient solis overlying Cretaceous age sedimentary bedrock of the Nanaimo Group.

**Photo 6.**

Closer view of the weathering of laminated sandstone of the Nanaimo Group.

Photo 7.
Borrow pit exposes thin veneer (<1m) of soils overlying Upper Triassic age volcanic bedrock of the Karmutsen Formation (Vancouver Group).

Photo 8.

Detailed view of exfoliation weathering of pillow-basalt of the Karmutsen Formation.

# APPENDIX A

## VANCOUVER ISLAND UNIVERSITY (WL 020)
## LAND APPLICATION PLAN

# VANCOUVER ISLAND UNIVERSITY (WL 020)
# LAND APPLICATION PLAN

**Date:** July 26, 2011

**Biosolids production facilities:**

**Regional District of Nanaimo**
Greater Nanaimo Pollution Control Centre
4600 Hammond Bay Road
Nanaimo, British Columbia
V9T 5A8

French Creek Pollution Control Centre
957 Lee Road`
Parksville, British Columbia
V9P 1Z4

**District of North Cowichan**
Chemainus STP
9575 Bare Point Road
Chemanius, British Columbia

**Contacts for biosolids dischargers:**

**Regional District of Nanaimo**
Attn: Sean De Pol
Manager of Liquid Waste
6300 Hammond Bay Road
Nanaimo, British Columbia
V9T 6N2
Phone: (250) 390-6560
Fax: (250) 390-1542

**District of North Cowichan**
Attn: Clay Reitsma
Assistant Municipal Engineer
Engineering Department
7030 Trans Canada Hwy
Duncan, British Columbia
V9L 3X4
Phone: (250) 746-3159
Pager: (250) 715-9096

**VANCOUVER ISLAND UNIVERSITY (WL 020)**
**LAND APPLICATION PLAN**

## *Summary*

Vancouver Island University manages approximately 1,700 hectares (ha) of forest land under forest tenure agreement: Woodlot License (WL) 020. Also known as the Vancouver Island University (VIU) Forest, the licensed area is 12 kilometers (km) northwest of Nanaimo, on the lower slopes of Mt. Benson. As part of an operational fertilization program, VIU will apply and demonstrate the beneficial use of Class A and Class B biosolids onto the private forest lands contained within WL020. Biosolids from the Regional District of Nanaimo's (RDN) Greater Nanaimo Pollution Control Centre (GNPCC) and French Creek Pollution Control Centre (FCPCC) (hereinafter referred to as Greater Nanaimo and French Creek biosolids respectively) are proposed for use in this program. Biosolids from the District of North Cowichan (DNC) Chemainus Sewage Treatment Plant (Chemainus STP) (hereinafter referred to as DNC biosolids) will also be used.

The biosolids applications will target nutrient poor and low productivity forest stands. Forest fertilization with biosolids was originally done as a pilot project in 1992 and again from 2003 – 2006. VIU resumed the project in 2007. The beneficial use of biosolids as a forest fertilizer is a stated objective in VIU's Woodlot License Plan 2008-2018. Growth and yield operational research on WL020 clearly demonstrates significant growth gains in Douglas-fir (*Pseudotsuga menzesii*).

The site vegetation and soils are assessed; soil samples are collected and analyzed for fertility and trace element concentrations. Results consistently show that concentrations of nitrogen and phosphorus are deficient, along with low organic matter content. Biosolids will be surface applied in 2011 and 2012 by a high-speed side-discharge spreader. The maximum calculated application rate will be 22.4 dry tonne per ha (dt/ha), providing 1098 kg N/ha. Special site management considerations are identified with respect to biosolids stockpiles, transportation and application. Calculation of post-application trace element concentrations in the soil has shown that they will not exceed the standards set out in the current Organic Matter Recycling Regulation (OMRR). No post application environmental monitoring program of the soil is to be conducted. Stream water quality is monitored two to three times per year (subject to water seasonal water levels).

## *Objective*

The treatment area is located about 1.1 km west of the Biggs Road/Doumont Road intersection, just off Weigles Road. Stands will be fertilized with an agronomic application rate of biosolids to provide the nitrogen that the trees and understory vegetation require to optimize growth, while ensuring no adverse environmental impacts.

## *Site Characteristics*

Douglas fir and minor lodgepole pine *(Pinus contorta)* are the dominant commercial tree species. Most of the selected sites support 50-75 year old second growth. Two younger stands of Douglas fir (6-8 years old) will receive treatment in late fall and winter of 2011.

**Mineral Soil Analysis**[1]

| Nutrient | Concentration *(ug/g)* |
|---|---|
| Ammonium | 0.6 |
| Nitrate | <2 |
| TKN % | 0.07 |
| Phosphate | 31 |
| Potassium | 92 |
| Arsenic | < 0.2 |
| Cadmium | < 0.05 |
| Chromium | 36.4 |
| Cobalt | 2.8 |
| Copper | 42.2 |
| Lead | 4.2 |
| Mercury | 0.037 |
| Molybdenum | < 0.05 |
| Nickel | 29.9 |
| Selenium | < 0.3 |
| Zinc | 63.4 |
| pH | 5.5 |

## *Biosolids*

Biosolids originate from the RDN's GNPCC and FCPCC, and the DNC's Chemainus STP. The GNPCC serves a connection population of approximately 88,000, treating an average of 33,000 cubic metres ($m^3$) of wastewater per day. The FCPCC serves a connection population of approximately 24,000, treating an average of 9,000 $m^3$ of wastewater per day. The Chemainus STP serves approximately 3,100 residents, treating an average of 2,140 $m^3$ of wastewater per day.

Greater Nanaimo biosolids achieve pathogen reduction by mesophilic anaerobic digestion as required for biosolids pathogen reduction in Schedule 1 of the OMRR. The geometric mean of seven discrete samples analyzed for fecal coliform was 1,600,000 most probable number per gram (MPN/g), below the 2,000,000 MPN/g pathogen reduction limit required for Class B biosolids, as specified in Schedule 3 of the OMRR. Greater Nanaimo biosolids achieve vector attraction reduction (VAR) by mesophilic digestion, reducing the mass of volatile solids by 58%, exceeding the 38% minimum reduction requirement for Class A or Class B biosolids as specified in Schedule 2 of the OMRR.

French Creek biosolids achieve pathogen reduction by digestion in autothermal thermophilic aerobic digesters (ATAD) as required for biosolids pathogen reduction in Schedule 1 of the OMRR. The geometric mean of seven discrete samples analyzed for fecal coliform was 1,600,000 MPN/g, below the 2,000,000 MPN/g pathogen reduction

1 Soils samples were collected on June 21, 2011.

## Biosolids Trace Element Analysis

| Constituent[1] | Greater Nanaimo 6/21/11[2] | French Creek 6/21/11[2] | DNC 6/21/11[2] | OMRR Class A[3] | OMRR Class B[4] | Units |
|---|---|---|---|---|---|---|
| Arsenic | 0.2 | < 0.2 | < 0.2 | 75 | 75 | ug/g |
| Cadmium | 1.4 | 2.2 | 1.3 | 20 | 20 | ug/g |
| Chromium | 34 | 39 | 18 | - | 1,060 | ug/g |
| Cobalt | 1.3 | 2.8 | 1.6 | 150 | 150 | ug/g |
| Copper | 920 | 900 | 1100 | - | 2,200 | ug/g |
| Lead | 26 | 45 | 25 | 500 | 500 | ug/g |
| Mercury | 1.2 | 2.4 | 0.72 | 5 | 15 | ug/g |
| Molybdenum | 4.5 | 6.0 | 7.4 | 20 | 20 | ug/g |
| Nickel | 14 | 18 | 14 | 180 | 180 | ug/g |
| Selenium | 4.4 | 4.6 | 5.9 | 14 | 14 | ug/g |
| Zinc | 770 | 850 | 430 | 1,850 | 1,850 | ug/g |

(1) Reported on a dry weight basis.
(2) Indicates sample collection date.
(3) Limits specified in Trade Memorandum T-4-93 (September 1997), Standards for Metals in Fertilizers and Supplements as referenced by the OMRR.
(4) Limits specified in the OMRR for Class B biosolids, Schedule 4, Column 3.

## *Proposed Application Rate*

Design values used in the calculation of the biosolids application rate reflect the nitrogen demand by the crop trees and minor vegetation. The estimated nitrogen uptake and transformations are found in the table below.

**Application Rate Data**

| | |
|---|---|
| Nitrogen Uptake - Trees (kg/ha) | 115 |
| Nitrogen Uptake - Understory (kg/ha) | 40 |
| Volatilization (%) | 30 |
| Denitrification (%) | 10 |
| Immobilization (kg/ha) | 175 |
| Mineralization Rate (%) | 30 |
| Total Nitrogen Required (kg/ha) | 1098 |
| Maximum Application Rate (dt/ha) | 22.4 |
| Application Rate (Bulk Tonnes/ha) | 76.1 |

The mineralization rate of the biosolids was determined from research and experience gained in Vancouver Island University Forests' 1992 biosolids project and from the Best Management Practices Guidelines for Land Application Of Managed Organic Material (June 2002).

As a conservative measure, the average nitrogen and total solids values from the three biosolids were used in calculating the application rate. Based on the assumed nitrogen requirements, transformation rates and concentrations in the biosolids, applications to a maximum of 22.4 dt/ha of biosolids are recommended.

## *Application Method and Timing*

Biosolids will be transported and stored on the Vancouver Island University Forest site. Storage sites will be located on high ground a minimum of 400 m from any surface water body. Application of biosolids will take place for short periods throughout the year. Application will utilize a side-discharge aero-spreader. Biosolids will be surface applied and not incorporated, due to the existing root structure of the trees. Biosolids applications will cease under conditions of inclement weather (e.g. intense rainfall events) or at the discretion of the project manager.

The biosolids applications are scheduled to occur throughout the year, typically 4 to 6 days per month.

## *Special Site Management Considerations*

The active portion of the root network (i.e. the area of the root biomass that will contribute the most to nutrient uptake) in these coniferous stands occurs around the canopy drip line. As most stands are close to crown closure, the application of biosolids will be relatively uniform in terms of potential root uptake. If a truck is utilized as the prime mover than the application will be made uniformly for 30 m on either side of roads that bisects the forest stands.

Prior to biosolids applications the areas will be surveyed for high use mountain bike and known hiking trails. However, it must be noted that the application area is located on managed private forest land. All trail construction is unauthorized. Attempts will be made to avoid trails of significant use. However, due to ongoing expansion of unauthorized trails, circumstances could occur where these narrow trails are treated. In the event biosolids are applied to a section of a

## Application Rate Data-2011 to 2012

| Criteria | Units | Value | | Calculation | Comments |
|---|---|---|---|---|---|
| Initial Ammonia/Ammonium | % | 0.4 | | n/a | 2011 biosolids analysis (weighted average) |
| Initial Nitrate Nitrite | % | 0.0006 | | n/a | 2011 biosolids analysis (weighted average) |
| Organic Nitrogen | % | 4.5 | | n/a | 2011 biosolids analysis (weighted average) |
| Solids | % | 29.2 | | n/a | 2011 biosolids analysis (weighted average) |
| Nitrogen Transformations | | | | | |
| Mineralization Rate | % | 30 | | n/a | (Best Management Practices) |
| Volatilization Losses | % | 30 | | n/a | (Best Management Practices) |
| Denitrification Losses | % | 10 | | n/a | (Best Management Practices) |
| Nitrogen Uptake/Storage | | | | | |
| Tree Uptake | kg N $ha^{-1}$ $yr^{-1}$ | 115 | | n/a | Professional knowledge - 1992 project |
| Understory Uptake | kg N $ha^{-1}$ $yr^{-1}$ | 40 | | n/a | Professional knowledge - 1992 project |
| Soil Immobilization | kg N $ha^{-1}$ $yr^{-1}$ | 175 | | n/a | Professional knowledge - 1992 project |
| **Available N required** | **kg N $ha^{-1}$** | | **330** | | Sum of nitrogen uptake and storage |
| Nitrogen Transformations | | | | | |
| Initial Ammonia/Ammonium | kg $dt^{-1}$ | 4.0 | | (.4/100)*1000 kg $dt^{-1}$ | Calculate initial concentration per tonne |
| Volatilization Losses | kg $dt^{-1}$ | -1.2 | | (30/100)*4.0 \ kg $dt^{-1}$ | Calculate volatile nitrogen losses |
| Mineralization Additions | kg $dt^{-1}$ | 13.5 | | (4.5/100)*(30/100)*1000 kg $dt^{-1}$ | Calculate mineral additions |
| Ammonia/Ammonium Total: | kg $dt^{-1}$ | | 16.3 | | Sum of ammonia/ammonium transformations |
| Denitrification Losses | kg $dt^{-1}$ | 1.6 | | (10/100)*16.3 kg $dt^{-1}$ | Calculate volatile nitrogen losses |
| **Net Available N** | **kg $dt^{-1}$** | | **14.7** | | Calculate net N available per tonne applied |
| **Application Rate** | **dt $ha^{-1}$** | | **22.4** | 330/14.7 | Tonnes required to meet nitrogen needs |
| **Application Rate** | **wt $ha^{-1}$** | | **76.1** | 22.4/(29.2/100) | Convert dry tonnes to wet tonnes |
| **Application Rate** | **kg $ha^{-1}$** | | **1098** | 22.4 dt ha(4.5% +.4%)*10 | Application rate by nitrogen content |

Calculation of agronomic application rate for forest fertilization

# APPENDIX B

# WELL LOGS (BC MOE WELLS DATABASE)

BRITISH COLUMBIA

## Report 1 - Detailed Well Record

Well Tag Number: 94374

Owner: LANTZVILLE FOOTHILLS ESTATES LTD

Address: VIPOND ROAD

Area: NANOOSE

WELL LOCATION:
NANOOSE Land District
District Lot: 206 Plan: Lot: 1
Township: Section: Range:
Indian Reserve: Meridian: Block:
Quarter:
Island: VANCOUVER ISLAND
BCGS Number (NAD 27): 092F030213 Well: 1

Class of Well: Water supply
Subclass of Well: Domestic
Orientation of Well: Vertical
Status of Well: New
Well Use: Water Supply System
Observation Well Number:
Observation Well Status:
Construction Method:
Diameter: inches
Casing drive shoe: N Y N
Well Depth: 665 feet
Elevation: 751 feet (ASL)
Final Casing Stick Up: 20 inches
Well Cap Type: STEEL
Bedrock Depth: 40 feet
Lithology Info Flag: Y
File Info Flag: N
Sieve Info Flag: N
Screen Info Flag: N

Site Info Details:
Other Info Flag:
Other Info Details:

Construction Date: 2008-07-31 00:00:00.0

Driller: Drillwell Enterprises
Well Identification Plate Number: 25553
Plate Attached By: RICH BOURGET
Where Plate Attached: CLAMPED TO CASING

PRODUCTION DATA AT TIME OF DRILLING:
Well Yield: 20 (Driller's Estimate) U.S. Gallons per Minute
Development Method: Air lifting
Pump Test Info Flag: N
Artesian Flow:
Artesian Pressure (ft):
Static Level: 2 feet

WATER QUALITY:
Character:
Colour:
Odour:
Well Disinfected: Y
EMS ID:
Water Chemistry Info Flag: N
Field Chemistry Info Flag:
Site Info (SEAM):

Water Utility:
Water Supply System Name:
Water Supply System Well Name:

SURFACE SEAL:
Flag: Y
Material: Bentonite clay
Method: Poured
Depth (ft): 18 feet
Thickness (in): 1.5 inches
Liner from To: feet

WELL CLOSURE INFORMATION:
Reason For Closure:
Method of Closure:
Closure Sealant Material:
Closure Backfill Material:
Details of Closure:

| Screen from | to feet | Type | Slot Size | |
|---|---|---|---|---|
| **Casing from** | **to feet** | **Diameter** | **Material** | **Drive Shoe** |
| 0 | 18 | 9 | null | N |
| 0 | 40 | 6 | Steel | Y |
| 40 | 665 | 6 | Open hole | N |

GENERAL REMARKS:
METHOD OF DRILLING: AIR ROTARY & DRIVING.

LITHOLOGY INFORMATION:
From 0 to 8 Ft. Medium brown clay
From 8 to 20 Ft. Medium brown gravel
From 20 to 34 Ft. Medium grey silty gravel
From 34 to 40 Ft. Hard BOULDER, TILL grey
From 40 to 665 Ft. Soft 20 U.S. Gallons per Minute GREEN WITH WHITE LAYERS. 0.75 AT 80', 5 AT 180', 7 AT 220', 18 AT 400', 20 AT 440'. green bedrock


- Return to Main
- Return to Search Options
- Return to Search Criteria

BRITISH COLUMBIA

## Report 1 - Detailed Well Record

Well Tag Number: 94375

Owner: LANTZVILLE FOOTHILLS ESTATES LTD

Address: VIPOND ROAD

Area: LANTZVILLE

WELL LOCATION:
NANOOSE Land District
District Lot: Plan: Lot: 2
Township: Section: Range:
Indian Reserve: Meridian: Block: 206
Quarter:
Island: VANCOUVER ISLAND
BCGS Number (NAD 27): 092F030213 Well: 2

Class of Well: Water supply
Subclass of Well: Domestic
Orientation of Well: Vertical
Status of Well: New
Well Use: Water Supply System
Observation Well Number:
Observation Well Status:
Construction Method:
Diameter: inches
Casing drive shoe: N N N
Well Depth: 505 feet
Elevation: 779 feet (ASL)
Final Casing Stick Up: 12 inches
Well Cap Type: STEEL
Bedrock Depth: 4 feet
Lithology Info Flag: Y
File Info Flag: N
Sieve Info Flag: N
Screen Info Flag: N

Site Info Details:
Other Info Flag:
Other Info Details:

Construction Date: 2008-08-07 00:00:00.0

Driller: Drillwell Enterprises
Well Identification Plate Number: 25554
Plate Attached By: RICH BOURGET
Where Plate Attached: CLAMPED TO CASING

PRODUCTION DATA AT TIME OF DRILLING:
Well Yield: 7 (Driller's Estimate) U.S. Gallons per Minute
Development Method: Air lifting
Pump Test Info Flag: N
Artesian Flow:
Artesian Pressure (ft):
Static Level: 40 feet

WATER QUALITY:
Character:
Colour:
Odour:
Well Disinfected: Y
EMS ID:
Water Chemistry Info Flag: N
Field Chemistry Info Flag:
Site Info (SEAM):

Water Utility:
Water Supply System Name:
Water Supply System Well Name:

SURFACE SEAL:
Flag: Y
Material: Bentonite clay
Method: Poured
Depth (ft): 18 feet
Thickness (in): 2 inches
Liner from To: feet

WELL CLOSURE INFORMATION:
Reason For Closure:
Method of Closure:
Closure Sealant Material:
Closure Backfill Material:
Details of Closure:

| Screen from | to feet | Type | Slot Size | |
|---|---|---|---|---|
| Casing from | to feet | Diameter | Material | Drive Shoe |
| 0 | 4 | 10 | null | N |
| 0 | 18 | 8 | Steel | N |
| 18 | 505 | 6 | Open hole | N |

GENERAL REMARKS:

LITHOLOGY INFORMATION:
From 0 to 4 Ft. Loose brown fill
From 4 to 505 Ft. Soft 7 Gallons per Minute (U.S./Imperial) 3 GPM AT 25 FEET. 7 GPM AT 150 FEET. green bedrock


- Return to Main
- Return to Search Options
- Return to Search Criteria

BRITISH COLUMBIA

# Report 1 - Detailed Well Record

Well Tag Number: 94376

Owner: LANTZVILLE FOOTHILLS ESTATES LTD

Address: VIPOND ROAD

Area: LANTZVILLE

WELL LOCATION:
NANOOSE Land District
District Lot: Plan: Lot: 3
Township: Section: Range:
Indian Reserve: Meridian: Block: 206
Quarter:
Island: VANCOUVER ISLAND
BCGS Number (NAD 27): 092F030124 Well: 1

Class of Well: Water supply
Subclass of Well: Domestic
Orientation of Well: Vertical
Status of Well: New
Well Use: Water Supply System
Observation Well Number:
Observation Well Status:
Construction Method:
Diameter: inches
Casing drive shoe: N N N
Well Depth: 505 feet
Elevation: 984 feet (ASL)
Final Casing Stick Up: 12 inches
Well Cap Type: STEEL
Bedrock Depth: 15 feet
Lithology Info Flag: Y
File Info Flag: N
Sieve Info Flag: N
Screen Info Flag: N

Site Info Details:
Other Info Flag:
Other Info Details:

Construction Date: 2008-08-12 00:00:00.0

Driller: Drillwell Enterprises
Well Identification Plate Number: 25555
Plate Attached By: RICH BOURGET
Where Plate Attached: CLAMPED TO CASING

PRODUCTION DATA AT TIME OF DRILLING:
Well Yield: 6 (Driller's Estimate) U.S. Gallons per Minute
Development Method: Air lifting
Pump Test Info Flag: N
Artesian Flow:
Artesian Pressure (ft):
Static Level: 25 feet

WATER QUALITY:
Character:
Colour:
Odour:
Well Disinfected: Y
EMS ID:
Water Chemistry Info Flag: N
Field Chemistry Info Flag:
Site Info (SEAM):

Water Utility:
Water Supply System Name:
Water Supply System Well Name:

SURFACE SEAL:
Flag: Y
Material: Bentonite clay
Method: Poured
Depth (ft): 18 feet
Thickness (in): 2 inches
Liner from To: feet

WELL CLOSURE INFORMATION:
Reason For Closure:
Method of Closure:
Closure Sealant Material:
Closure Backfill Material:
Details of Closure:

| Screen from | to feet | Type | Slot Size |
|---|---|---|---|

| Casing from | to feet | Diameter | Material | Drive Shoe |
|---|---|---|---|---|
| 0 | 15 | 10 | null | N |
| 0 | 505 | 6 | Open hole | N |
| 0 | 18 | 8 | Steel | N |

GENERAL REMARKS:

LITHOLOGY INFORMATION:

| | | | | | |
|---|---|---|---|---|---|
| From | 0 to | 3 Ft. | Medium | brown | fill |
| From | 3 to | 15 Ft. | Medium | brown | till |
| From | 15 to | 19 Ft. | Medium | green | bedrock |
| From | 19 to | 23 Ft. | Soft | 2 Gallons per Minute (U.S./Imperial) FRACTURED, BROKEN | green bedrock |
| From | 23 to | 505 Ft. | Medium | 6 Gallons per Minute (U.S./Imperial) CONSISTANT. 6 GPM AT 400 FEET | green bedrock |


- Return to Main
- Return to Search Options
- Return to Search Criteria

BRITISH COLUMBIA

## Report 1 - Detailed Well Record

Well Tag Number: 96293

Owner: BUYS

Address: 7055 DOUMONT ROAD

Area: NANAIMO

WELL LOCATION:
WELLINGTON Land District
District Lot: Plan: Lot:
Township: Section: 20 Range: 1
Indian Reserve: Meridian: Block: 163
Quarter:
Island: VANCOUVER ISLAND
BCGS Number (NAD 27): 092F030211 Well:

Class of Well: Water supply
Subclass of Well: Domestic
Orientation of Well: Vertical
Status of Well: New
Well Use: Private Domestic
Observation Well Number:
Observation Well Status:
Construction Method:
Diameter: inches
Casing drive shoe: N Y N
Well Depth: 360 feet
Elevation: 484 feet (ASL)
Final Casing Stick Up: 12 inches
Well Cap Type: WELDED LID
Bedrock Depth: 15 feet
Lithology Info Flag: Y
File Info Flag: N
Sieve Info Flag: N
Screen Info Flag: N

Site Info Details:
Other Info Flag:
Other Info Details:

Construction Date: 2008-09-22 00:00:00.0

Driller: Drillwell Enterprises
Well Identification Plate Number: 28141
Plate Attached By: DOUG WATT
Where Plate Attached: TO CASING

PRODUCTION DATA AT TIME OF DRILLING:
Well Yield: 20 (Driller's Estimate) Gallons per Minute (U.S./Imperial)
Development Method: Air lifting
Pump Test Info Flag: N
Artesian Flow: .5 Gallons per Minute (U.S./Imperial)
Artesian Pressure (ft):
Static Level:

WATER QUALITY:
Character:
Colour:
Odour:
Well Disinfected: Y
EMS ID:
Water Chemistry Info Flag: N
Field Chemistry Info Flag:
Site Info (SEAM):

Water Utility:
Water Supply System Name:
Water Supply System Well Name:

SURFACE SEAL:
Flag: Y
Material: Bentonite clay
Method: Poured
Depth (ft): 18 feet
Thickness (in): 2 inches
Liner from To: feet

WELL CLOSURE INFORMATION:
Reason For Closure:
Method of Closure:
Closure Sealant Material:
Closure Backfill Material:
Details of Closure:

| Screen from | to feet | Type | Slot Size | |
|---|---|---|---|---|
| Casing from | to feet | Diameter | Material | Drive Shoe |
| 0 | 18 | 10 | null | N |
| 0 | 18 | 6 | Steel | Y |
| 18 | 360 | 6 | Open hole | N |

GENERAL REMARKS:
METHOD OF DRILLING AIR ROTARY & DUAL ROT.

LITHOLOGY INFORMATION:
From 0 to 15 Ft. SILTY SAND & GRAVEL brown
From 15 to 105 Ft. SHALE BEDROCK blue
From 105 to 200 Ft. SILTSTONE FLOW AT 140' - 1 GPM. blue
From 200 to 360 Ft. FLOW AT 200' - 1.3 GPM; 280' - 1.5 GPM; 300' - 1.75 GPM; 340' - 2 GPM; 355' - FRACTURE; 360' - 20 GPM grey sandstone


- Return to Main
- Return to Search Options
- Return to Search Criteria

BRITISH COLUMBIA

# Report 1 - Detailed Well Record

Well Tag Number: 102110

Owner: LANTZVILLE FOOTHILLS ESTATES INC.

Address:

Area:

WELL LOCATION:
NANOOSE Land District
District Lot: Plan: Lot:
Township: Section: Range:
Indian Reserve: Meridian: Block: 206
Quarter:
Island:
BCGS Number (NAD 27): 092F030213 Well:

Class of Well: Water supply
Subclass of Well: Domestic
Orientation of Well: Vertical
Status of Well: New
Well Use: Water Supply System
Observation Well Number:
Observation Well Status:
Construction Method: Drilled
Diameter: 8 inches
Casing drive shoe: N N
Well Depth: 345 feet
Elevation: feet (ASL)
Final Casing Stick Up: inches
Well Cap Type:
Bedrock Depth: 24.3 feet
Lithology Info Flag: N
File Info Flag: N
Sieve Info Flag: N
Screen Info Flag: N

Site Info Details:
Other Info Flag:
Other Info Details:

Construction Date: 2003-11-10 00:00:00.0

Driller: Kalicum Drilling
Well Identification Plate Number:
Plate Attached By:
Where Plate Attached:

PRODUCTION DATA AT TIME OF DRILLING:
Well Yield: 120 (Driller's Estimate) U.S. Gallons per Minute
Development Method:
Pump Test Info Flag: Y
Artesian Flow:
Artesian Pressure (ft):
Static Level: 22.23 feet

WATER QUALITY:
Character:
Colour:
Odour:
Well Disinfected: N
EMS ID:
Water Chemistry Info Flag: Y
Field Chemistry Info Flag:
Site Info (SEAM):

Water Utility:
Water Supply System Name:
Water Supply System Well Name:

SURFACE SEAL:
Flag: N
Material:
Method:
Depth (ft):
Thickness (in):
Liner from To: feet

WELL CLOSURE INFORMATION:
Reason for Closure:
Method of Closure:
Closure Sealant Material:
Closure Backfill Material:
Details of Closure:

| Screen from | to feet | Type | Slot Size |
|---|---|---|---|

| Casing from | to feet | Diameter | Material |
|---|---|---|---|
| 4 | 23 | 8 | Steel |
| 23 | 345 | 8 | Open hole |

GENERAL REMARKS:
THIS IS WELL A4 OR 2003-01.THE WELL CONSTRUCTION INFORMATION WAS PROVIDED IN A REPORT (HARRIS M, 2003.BLOCKS 206-389-471-794 DEVELOPMENT PROJECT (LANTZVILLE, BC)NAT

LITHOLOGY INFORMATION:

| | | | | |
|---|---|---|---|---|
| From | 0 | to | 2 | Ft. FILL |
| From | 2 | to | 7 | Ft. PEAT |
| From | 7 | to | 14 | Ft. BROWN TILL W/ANGULAR & ROUND COBBLES BOULDERS |
| From | 14 | to | 14.6 | Ft. SILTY SAND/GRAVEL |
| From | 14.6 | to | 18 | Ft. BROWN TILL W/COBBLES BOULDERS |
| From | 18 | to | 21 | Ft. GREY GLACIAL TILL W/ANGULAR COBBLES BOULDERS |
| From | 21 | to | 24.3 | Ft. GREY CLAY W/ COBBLES BOULDERS |
| From | 24.3 | to | 25.3 | Ft. WEATHERED BASALT |
| From | 25.3 | to | 93 | Ft. BASALT |
| From | 93 | to | 95 | Ft. FAULT H20 BEARING 1/2 GPM |
| From | 95 | to | 285 | Ft. BASALT |
| From | 285 | to | 286 | Ft. FAULT LIGHT GREEN ROCK 120 GPM (39 FT) |
| From | 286 | to | 320 | Ft. BASALT |
| From | 320 | to | 321 | Ft. SM FAULT 10 GPM |
| From | 321 | to | 345 | Ft. BASALT |


- Return to Main
- Return to Search Options
- Return to Search Criteria

BRITISH COLUMBIA

# Report 1 - Detailed Well Record

Well Tag Number: 102111

Owner: LANTZVILLE FOOTHILLS ESTATES INC.

Address:

Area:

WELL LOCATION:
NANOOSE Land District
District Lot: Plan: Lot:
Township: Section: Range:
Indian Reserve: Meridian: Block: 206
Quarter:
Island:
BCGS Number (NAD 27): 092F030213 Well:

Class of Well: Water supply
Subclass of Well: Domestic
Orientation of Well: Vertical
Status of Well: New
Well Use: Water Supply System
Observation Well Number:
Observation Well Status:
Construction Method: Drilled
Diameter: 8 inches
Casing drive shoe: N N
Well Depth: 400 feet
Elevation: feet (ASL)
Final Casing Stick Up: 12 inches
Well Cap Type:
Bedrock Depth: 27 feet
Lithology Info Flag: N
File Info Flag: N
Sieve Info Flag: N
Screen Info Flag: N

Site Info Details:
Other Info Flag:
Other Info Details:

Construction Date: 2003-11-17 00:00:00.0

Driller: Kalicum Drilling
Well Identification Plate Number:
Plate Attached By:
Where Plate Attached:

PRODUCTION DATA AT TIME OF DRILLING:
Well Yield: 40 (Driller's Estimate) U.S. Gallons per Minute
Development Method:
Pump Test Info Flag: Y
Artesian Flow:
Artesian Pressure (ft):
Static Level:

WATER QUALITY:
Character:
Colour:
Odour:
Well Disinfected: N
EMS ID:
Water Chemistry Info Flag: N
Field Chemistry Info Flag:
Site Info (SEAM):

Water Utility:
Water Supply System Name:
Water Supply System Well Name:

SURFACE SEAL:
Flag: N
Material:
Method:
Depth (ft):
Thickness (in):
Liner from To: feet

WELL CLOSURE INFORMATION:
Reason For Closure:
Method of Closure:
Closure Sealant Material:
Closure Backfill Material:
Details of Closure:

| Screen from | to feet | Type | Slot Size | |
|---|---|---|---|---|
| **Casing from** | **to feet** | **Diameter** | **Material** | **Drive Shoe** |
| 1 | 28 | 8 | Steel | N |
| 28 | 400 | 8 | Open hole | N |

GENERAL REMARKS:
WELL IS ALSO KNOWN AS A5 OR 2003-02.WELL CONSTRUCTION INFORMATION ENTERED FROM KOMEX REPORT - BLOCKS 206-369-471-794 DEVELOPMENT PROJECT (LANTZVILLE BC)

LITHOLOGY INFORMATION:

| | | | | |
|---|---|---|---|---|
| From | 0 | to | 3 Ft. | FILL |
| From | 3 | to | 10 Ft. | SAND/GRAVEL |
| From | 10 | to | 14 Ft. | BROWN CLAY COBBLES BOULDERS |
| From | 14 | to | 15 Ft. | SILTY SAND GRAVEL |
| From | 15 | to | 20 Ft. | BROWN CLAY W/COBBLES |
| From | 20 | to | 27 Ft. | GREY GLACIAL TILL W/COBBLES/BOULDERS |
| From | 27 | to | 28 Ft. | BASALT |
| From | 28 | to | 72 Ft. | BASALT |
| From | 72 | to | 75 Ft. | FAULT 5 GPM |
| From | 75 | to | 145 Ft. | BASALT |
| From | 145 | to | 150 Ft. | FAULT 25 GPM |
| From | 150 | to | 320 Ft. | MIX BEDDING PLAINS HARD/SOFT BASALT |
| From | 320 | to | 380 Ft. | VOLCANIC CONGLOMERATE |
| From | 380 | to | 381 Ft. | FAULT 10 GPM |
| From | 381 | to | 400 Ft. | BASALT |


- Return to Main
- Return to Search Options
- Return to Search Criteria