ASSESSMENT OF THE ABILITY TO REPAIR OR REPLACE THE SEPTIC TREATMENT PLANT EFFLUENT DISPOSAL FIELDS AT ANMORE GREEN ESTATES, ANMORE, BC

Prepared for

The Owners, Strata Corporation LMS 3080
100 Blackberry Drive
Anmore BC V3H 5B4
(Attention: Robert Boies, President)

("Anmore Green Estates")

Prepared by

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January 15, 2018

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Project 212
January 15, 2018

Strata Corporation LMS 3080
100 Blackberry Drive
Anmore BC V3H 5B4
(Attention: Ewen Stewart)

Email estewart@azuramanagement.com

RE: ANMORE GREEN ESTATES WASTEWATER DISPOSAL FIELDS

Dear Mr. Stewart:

Please find attached a report describing our assessment of the ability to repair or replace the wastewater effluent disposal fields at Anmore Green Estates, and the effect of the excavations around the disposal fields on local groundwater flow.

If you have any comments or require further information, please contact the undersigned.

Sincerely,

per Steve Graham P.Geo, P.Eng, Ph.D
President

PROFESSIONAL GEOSCIENTIST
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EXECUTIVE SUMMARY

Strata Corporation LMS 3080 owns and operates a wastewater treatment system for domestic sewage in south Anmore under BC Ministry of Environment (MOE) permit PE 04606 whose effluent is directed to two disposal fields for discharge to ground.

On November 23 2017 the Strata received a Pollution Abatement Order from the BCMOE requiring it to "[I]mmediately take action to implement abatement activities and impacted zone management actions in order to mitigate risk to human health", among other things. As a part of its efforts to comply with the MOE Abatement Order the Strata has requested S. Graham Engineering and Geology Inc. (SGE) to investigate two issues:

1. Can the existing STP effluent disposal fields be repaired or rebuilt so as to operate in compliance with the MOE Permit given operating criteria and current regulations?

2. Does groundwater immediately beneath the disposal fields travel to and issue from the walls of excavations to the south and west of disposal fields?

It is concluded that the existing septic effluent disposal fields cannot be repaired or replaced because of insufficient land area on the site to comply with geometric requirements of the Municipal Wastewater Regulation. Limitations include required drain pipe length, required setback from property boundaries, required depth of unsaturated soil beneath the disposal fields, and required distances where downgradient groundwater surfacing is prohibited.

Subsequent to the installation of the septic effluent disposal fields the soil near the perimeter of the south and west sides of the disposal fields has been excavated to depths of up to 10 meters to create footprints for two schools and a park. Groundwater mixed with sewage effluent in the dilution zone beneath the disposal fields surfaces at seeps along the base of the excavated embankment. This is likely a source of water and soil contamination by water-borne pathogens and represents a risk to public health.

The only practical and feasible option from an engineering perspective is to abandon the disposal fields and connect the Anmore Green Estates sewer system to a MVS&DD sanitary sewer in the adjacent park in Port Moody. The difficulties with this option are of an administrative and legal nature.

Contents

1. Introduction and Scope

Strata Corporation LMS 3080 owns and operates a wastewater treatment system for domestic sewage in south Anmore under MOE permit PE 04606 (issued 1997, amended 2002). The system consists of an activated sludge treatment plant (fixed film submerged medium) whose effluent is directed to two disposal fields for discharge to ground.

The system has been out of compliance with the MOE permit from time to time. The Strata received a warning letter from the MOE dated March 07, 2017 to the effect that the STP was out of compliance with PE 4606 with respect to water quality. The MOE requested the owner of the STP to undertake several actions, including:

- "Continue working with qualified professionals to conduct analysis and determine if breakthrough is actually septic discharge and if pollution is occurring, please provide a plan and timeline
- Work with all stakeholders to connect to sewer"

More recently the Strata received a Pollution Abatement Order dated November 23, 2017 to "[I]mmediately take action to implement abatement activities and impacted zone management actions in order to mitigate risk to human health", among other things.

As a part of its efforts to comply with the MOE Warning and Abatement Order the Strata has requested S. Graham Engineering and Geology Inc. (SGE) to investigate two issues:

1. Can the existing STP effluent disposal fields be repaired or rebuilt so as to operate in compliance with the MOE Permit given operating criteria and current regulations?

2. Does groundwater immediately beneath the disposal fields travel to and issue from the walls of excavations to the south and west of disposal fields?

2. Regulations Relating to the Design of the Disposal Fields

The existing STP effluent disposal system consists of two fields (the west field and the east field) of the same size, and an undeveloped reserve field to the south of the east field. These are shown in Figure 1 in Appendix 1. The disposal fields were designed and installed by Ashford Engineering Ltd. in 1995-1997 and permitted to operate in March 1997. They appear to have been designed to conform to the regulation in effect at that time (the Municipal Sewage Regulation, amended and changed in April 2012 to the Municipal Wastewater Regulation). While Derek Ashford P.Eng and Ashford Engineering Ltd. are still listed as practicing by APEGBC, SGE has not been able to successfully contact them. Thus Figure 1 contains all the available information on the original design of the effluent disposal fields.

If the disposal fields are substantially repaired or rebuilt they will have to conform to the current standards and criteria in the BC Municipal Wastewater Regulation (BC Reg, 87/2012) ("the Regulation"), except if the Director allows for a substitution under §8.1 of the Regulation.

The relevant criteria are contained in Part 5, Divisions 1 to 3 of the Regulation. These Divisions have been copied and are placed in Appendix 2 of this report for reference and convenience.

Several geometric criteria apply to the design of the effluent disposal fields. These include *inter alia*:

i. Travel time for effluent to the property boundary (§72)
ii. Distance to surfacing of effluent (if this occurs) (§73)
iii. Distance from the drain pipe to the water table (§76(5))
iv. Length of drain pipe required (§78, Table 4)
v. Drain pipe cover (§80)
vi. Trench geometry(§81)
vii. Number of fields required, and requirement for a reserve field (§81)
viii. Distance from the drain field to the property boundary (§82, Table 5)

The ability to meet these criteria depends on the factors such as:

- The amount of land available
- The slope of the land

- The "permeability of the soil" (usually expressed as a "perc rate")[1]
- The minimum distance to the water table (usually varies seasonally)
- Distance to a downgradient point where the groundwater will surface or enter surface water.
- STP effluent discharge and parameter concentrations

3. <u>STP Effluent Characteristics</u>

For design purposes the nominal STP discharge is 61 m^3/day[2]. However ACE Consulting Engineers Ltd. ("ACE", p. 2)[3] reported that actual flows in 2006-2008 were substantially less.[4] Nevertheless the design for repair or replacement of the existing disposal fields has to be based on the maximum permitted discharge unless a substitution is allowed by the Director.

The water quality limitations[5] in the Permit are

- BOD_5 – 20 mg/L maximum
- TSS – 20 mg/L maximum

Note that the above water quality limits (20 mg/L) are well below those in Table 3 of §75 of the Regulation (45 mg/L). The reason for the difference

[1] The so-called percolation rate or "perc rate" is measured in the field as the time for the water surface in a hole of specified geometry to fall one inch (or 25 mm in BC) due to seepage. The perc rate is not dimensionally a rate, but is rather an inverse rate. The perc rate should not be too low or too high. The range of perc rates listed in Table 4 of §78 of the Regulation is 2 to 30 minutes per inch.
[2] Permit PE-04606, §1.1.1
[3] ACE Consulting Engineers Ltd., "RE: Evaluation of Onsite Treatment System for LMS 3080, Anmore Green Estates Anmore BC", July 2008, 9 pp. A copy is placed in Appendix 3
[4] "An average flow rate of approximately 35 m^3/day was reported by Corix for the periods March 2006 –September 2007 which is approximately 60% of the permitted and assumed design flow rate for the STP. Data collected by Orion from January to June 14 2008 shows an average flow rate of 15.4 m^3 /day with the 95th percentile event of 19.4 m^3/day which represents 25% and 32% respectively of the design value."
[5] There are no water quality limitations on fecal coliforms or *e. coli* in the permit. These are not regulated for Class C effluent per §75, Table 3 of the Regulation.

is not known. ACE (2008, p.2) notes that the permitted concentrations were seldom achieved according operating records from 2006 to June 2008[6].

4. Design of the Existing Effluent Disposal Fields

The design criteria specified in the Municipal Sewage Regulation (in effect at the time of installation of the STP effluent disposal fields) and those currently in place (which would apply to major repair or replacement of the disposal fields) are described in this section. Conformance with these criteria is discussed in Section 5, following.

The existing disposal fields are shown in Figure 1 (Appendix 1). They were placed within the boundaries of a pre-existing lot that is shown in Figure 2.

4.1 Field Size

Figure 1 shows that 2 distribution fields were installed, each having 616 meters of drain pipe. By back calculation of the criteria in Table 4 of §78 of the Regulation[7] for an STP effluent discharge rate of 60 m^3/day, the percolation rate used for the design would have been 10 minutes per inch. There is no record of the percolation tests that resulted in this value.

4.2 Trenches

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[6] "Effluent quality data reviewed indicates that the STP seldom meets the permitted maximum values. The average BOD_5 and TSS results through June of 2008 are 53 mg/L and 53 mg/L respectively", ACE report, 2008, p.2

[7] This table is pasted below for convenience and reference:

Table 4 — Minimum Drainage Pipe Length for Each Field

	Meters of drainage pipe for each 10 m^3/d of maximum daily flow for percolation rates shown						
percolation rate (minutes/25 mm)	2	5	10	15	20	25	30
class A, B or C municipal effluent	50	75	100	110	120	135	150
class D municipal effluent	120	215	280	320	360	400	430

While there are also no drawings of the original design of the disposal fields in section, limited field investigations by SGE appear to confirm that the trench construction corresponded with criteria in the 1997 and current Regulation[8]; that is,

- 3 meter separation in plan between perforated pipe lines
- Pipe soil cover of 6 inches (0.15 m) or more
- Pipe trench width of 2 feet (0.6 m) or more
- Separation between pipe invert and trench bottom at least 1 foot (0.3 m)

Thus the pipe invert for a 2-inch diameter perforated pipe installed 6 inches below ground surface is 8 inches below ground surface. The bottom of the trench is 20 inches (0.51 m) or more below ground surface.

4.3 Separation Distance to the Water Table

The required separation between the pipe invert and the mounded water table is 1 meter (39.4 inches)[9] so the original design assumed that the mounded water table is at least (8 inches + 39.4 inches =) 47.4 inches (say 4 feet or 1.2 meters) below ground surface. Due to mounding, the undisturbed water table should be deeper than this.

There is no available information on the groundwater data used to design the existing disposal fields.

4.4 Travel Time

§72 of the Regulation requires that the subsurface travel time from the edge of the "disposal site perimeter"[10] field to the point where the municipal effluent surfaces or reaches a property line should be at least 10 days.

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[8] §80 and §81 of the Regulation

[9] §76(5)(b) of the Regulation

[10] It is not clear in the Regulation whether the disposal site refers to the disposal field or to the property in which the disposal field is situated. For purposes of this report it is assumed that it refers to the disposal field itself. The wording was different in the former Municipal Sewage Regulation where it more clearly referred to the disposal field.

SGE has no hydrogeologic information with which to calculate travel time, nor available information on how this parameter was used in the design the existing disposal fields.

4.5 Setback

MOE's decision to issue Permit 04606 in 1997 indicates that the original design of the disposal fields conformed to the requirements of the Municipal Sewage Regulation at that time. The current Municipal Wastewater Regulation requires a 6-meter setback of a septic effluent disposal field from a property line (per Table 5, §82).

4.6 Surfacing Groundwater

§2 of Schedule 4 of the former Municipal Sewage Regulation prohibits groundwater surfacing within 30 meters of a disposal bed, and prohibits surfacing beyond 30 meters "unless it can be demonstrated to the satisfaction of the Director that the discharge does not cause water quality parameters to exceed known water quality guidelines".

The wording of the current Regulation is similar:

> **73** A discharger must ensure that discharge does not surface, or cause the groundwater table to be raised to the surface, as follows:
>
> (a) within 30 m beyond the disposal site perimeter;
>
> (b) more than 30 m beyond the disposal site perimeter, unless
>
> (i) the discharge does not cause water quality parameters to fail to meet water quality guidelines,
>
> and
>
> (ii) there will be no adverse impacts from the surfaced municipal effluent.

§73(b)(i) does not specify the guidelines to be exceeded. Thus only the permitted water quality limits on TSS and BOD_5 would appear to apply. The wording of §73(b)(ii) is more vague; however potential effects of pathogens in the STP effluent upon persons in the adjacent schools and park would appear to qualify as "adverse impacts". Thus it is concluded that the groundwater flowing from the dilution mixing zone below the disposal fields should not surface at all due to potential risk to public health.

5. Performance and Conformance of the Existing STP Effluent Disposal Fields, and Implications for Repair or Replacement of the Fields

The design and performance criteria for the original design of the STP effluent disposal fields, and any repair or replacement of them, were presented in the previous section.

The feasibility of repair or replacement is discussed in this section, on the basis of performance and technical requirements.

5.1 Field Size and the Effect of a Higher Perc Rate

As noted in section 4.1 of this report the percolation rate used to design the existing disposal fields was 10 minutes/per inch. The information used to determine this perc value has not been found.

ACE (2008) performed six perc tests on the site to corroborate the design perc rate[11]. Three were performed in the west field and three in the east field. The results are copied below:

Field	East	East	East	West	West	West
Perc Hole #	PH1	PH2	PH3	PH4	PH5	PH6
Perc Rate min/inch	120	32	90	15	10	35

[11] ACE's results are presented in a signed and peer-reviewed engineering report. SGE reviewed the field notes at ACE's office and is satisfied that the results were valid when taken. No other percolation tests have been conducted at the site since the ACE report (2008).

ACE's measured perc rates were spatially variable, and they were higher than those used to design the fields about 13 years earlier. The mean perc rate for the west field (20 minutes per inch) is less than that for the east field (81 min/inch). The mean perc rate for the west field lies within the range of Table 4 of the Regulation (2 to 30 minutes per inch), while that of the east field does not.

If the higher perc rates measured by ACE were due to clogging of the disposal field over time, then the perc rates would be even higher now after another decade has passed.

Since the existing fields are constructed almost to the boundaries of the available site using a perc rate value of 10 minutes per inch, the fields cannot be repaired or replaced if the true actual perc rate is greater than 10 minutes per inch because there is insufficient land area.

West Field

If the true actual value of the perc rate of the soil in the west field is assumed to be 20 minutes per inch (twice the calculated design value of 10 minutes per inch) then, from Table 4 of the Regulation, the length of drain pipe required increases from 100 m to 120 m per 10 m^3/d, or 20%. The existing area of the west field is about 1888 m^2, so an additional 378 m^2 of disposal field would be required. This area is not available on the existing site unless the area of reserve field is used.

East Field

If the true actual value of the perc rate of the soil in the east field is assumed to be 81 minutes per inch (eight times the calculated design value of 10 minutes per inch) then the actual value exceeds the maximum perc rate of 30 minutes per inch on Table 4. The conclusion is that the soil is too impermeable to be suitable for a disposal field.

However if MOE allowed an exception, and if the length of pipe required were calculated to be 300 meters per 10 m^3/day by extrapolation of the functional relation in Table 4, then the length of drain pipe required increases from 100 m to 300 m per 10 m^3/d, or 300 %. The area of the east field would have to be tripled to about 5664 m^2, and an additional 3776 m^2

of disposal field would be required. This would require the area of the existing east field and two reserve fields.

Reserve Field

ACE did not perform perc tests on the reserve field.

Conclusions

The existing disposal field was sized in 1995 using a perc rate of 10 minutes per inch. It has not performed well. The layout of the existing disposal fields occupies almost the entire existing property (see Figure 2) with minimal setbacks.

ACE performed six perc tests in 2008 and found the perc rates to be higher than those used for the original design.

If ACE's measurements of 2008 perc rates are used, then the disposal fields will have to be much larger to comply with the Regulation. There is insufficient land at the site to do this. Further the east field would be considered to be inappropriate for a disposal field because the mean value of the perc rate exceeds the maximum value in the Regulation

If the higher perc rates reported by ACE were due to clogging of the perc field, then the situation will be worse in 2018.

Thus it is concluded that there is insufficient land on this site to accommodate an upgrade of the existing disposal fields by repair or replacement if the percolation rates measured by ACE are correct.

5.2 Trenches

The depth of soil appears to be sufficient to meet trench installation criteria in the Regulation

5.3 Separation Distance to Water Table

The Regulation requires a vertical separation distance of 1 meter (39.4 inches) between the drain pipe and the mounded water table.

There is only one monitoring well in the disposal field (labeled as MW1 on Figure 1) and it extends only 51 cm (20 inches) below ground surface. Thus this monitoring well cannot be used to confirm that the water table is 4 feet or more below ground surface.

SGE visited this monitoring well on August 15, 2017. It was dry at that time, so the depth to the water table exceeded 20 inches and the separation distance was at least 12 inches. SGE visited this monitoring well on January 14, 2018. The water surface was 14.75 inches (37.5 cm) below ground surface, and thus the separation distance was about 6.75 inches. There was ponded water on the surface near the northwest corner of the west field and near the southwest corner of the west field. Thus the separation distance is not currently being met, and would not be met unless a mounded system were installed.

While not confirmed at the time of writing, it is understood that the STP effluent was being directed to the east field in January 2018, so the mounding effect under the west field would have been reduced if this were the case.

It is concluded that the existing disposal field cannot be repaired or rebuilt unless the water table under it is lowered by about one meter or the drain pipes are raised on a mound by about one meter.

5.4 Travel Time

The time for the groundwater to surface or reach a property line from the edge of the disposal field cannot be calculated because there is no information on the slope of the water table and the transmissivity of the soil.

5.5 Setback

SGE has no survey data on the locations of the disposal field and the property lines, so detailed setback information on the existing fields is not available.

SGE has observed in the field that the setback appears to be minimal on the south part of the west side of the west field, on the east part of the north side of the east field, and on the east side of the east field.

The observation port at the end of the drain pipe on the west field (labeled as "OP" in Figure 1) is immediately adjacent to the fence on the property line.

MW1, shown in Figure 1 as being near the southernmost drain pipe on the west field, was measured by SGE as being 11.0 feet (3.35 meters) from the fence on the property line.

If area measurements are taken off Figure 1 using a calculated scale of 1:769.02, the perimeter of the existing disposal field is about 354.5 meters and the area is 6055 square meters. The area of a 6-meter setback (shown on Figure 1) would be (354.5 * 6 =) 2127 m^2. Thus the remaining area after removal of the setback would be about 3928 m^2, or only 65% of the existing area of the disposal fields. Even if the true perc rate is 10 minutes per inch, this would be an insufficient area to replace the existing disposal fields in.

Thus it is concluded that the existing site has insufficient area to incorporate the required setback if the existing disposal fields are repaired or replaced.

5.6 Surfacing Groundwater

ACE (2008) reported surfacing within 1 meter of the south edge of the west field in July 2008.

No surfacing groundwater was observed by SGE on a site visit on August 15, 2017 in summer conditions.

SGE observed surfacing water at the following locations on January 14, 2018:

- Along the fence at the south west corner of the west field area, about 11 feet south of the disposal field
- In the general area to the northwest of the west disposal field, extending to about 15 feet towards the west side of the west field. The source is suspected to be uncontaminated upgradient water.
- On the embankment below the disposal field about 50 feet east of the basketball court. This area is about 190 feet (58 meters) south of the southern edge of the west field.

SGE observed surfacing water at the following locations on February 6, 2015:

- From the rocks on the north side of the basketball court, about 67 meters south of the west field
- From the cut on the slope above the Field House in the park, about 50 meters south of the east field.

For purposes of this report it is sufficient to show that groundwater surfaces within about 10 feet (3 meters) of the south side of the west field. A photo taken by SGE on January 14, 2018 is pasted below.

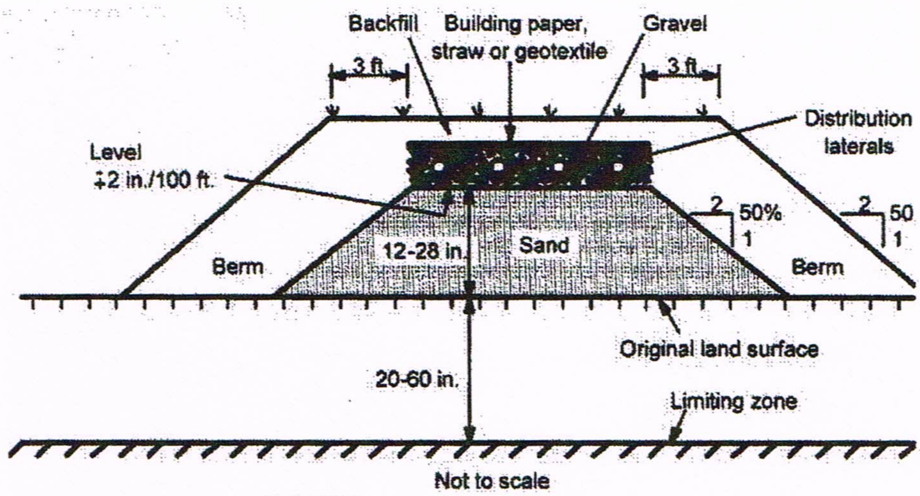
ACE (2008) suggested filling this breakout area with sand so that the water table would remain below the ground surface. However this strategy glosses over the problem that the mounded water table is too close to the drain pipes in the disposal field.

6. Alternative Options

Some alternative methods for meeting the goals of the Abatement Order are briefly discussed in this section.

6.1 Mounded System

The problem of insufficient distance from the drain pipe to the water table is often addressed by building a mounded system. As shown in the figure below[12] this consists of placing a mound of suitable soil on the existing ground surface in order to provide a unit of unsaturated soil.



As shown in the figure above, the lateral fill for a mound containing about 1 vertical meter of sand would be about 3 meters. This would increase the setback along the perimeter of the site from 6 meters to 9 meters[13]. **There is insufficient land at this site for a mound system.** §84(b) of the Regulation required authorization by the MOE Director to use a sand mound system, this is not likely to be granted if there is insufficient land.

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[12] From Penn State University extension service web site. This is a typical installation. For conditions measured at the site on Jan. 14, 2018 the sand unit in the mound would have to be about 33 inches deep.

[13] The wording in the Regulation is vague as to whether the berm can be excluded from the setback requirement.

In summary, a sand mound system is not considered to be a feasible option because the site area is too small.

6.2 Tertiary Treatment

Tertiary treatment entails further treatment of sewage beyond the secondary level. It usually entails nitrogen and phosphorous removal, and often disinfection. The cost and technical expertise to operate such a system is considered to be beyond the capabilities of Strata Corporation LMS 3080.

Even if a tertiary treatment system were installed and satisfactorily operated, the same criteria in the Regulation still apply to disposal to ground, except that the water would be Class A or B, rather than C. Criteria such as distance to the water table, distance to surfacing, and field size requirements would still apply. Further, the tertiary plant would likely have upsets from time to time, so the pathogenic risk would not be completely eliminated.

In summary upgrading to a tertiary treatment system is technically feasible, but it is not considered to be a practical option.

6.3 Disposal to Surface Water

The nearest surface water body is on the west side of the Middle school. This creek has been observed to be dry during the summer. §94 (5) of the Regulation requires a minimum dilution ratio of ten times, where this is the ratio of the low-flow discharge of the river to the discharge of sewage effluent to the receiving river. In this case the dilution ratio is zero, so the sewage effluent cannot be discharged to the closest surface water.

There are no other lakes or streams near the site that are suitable for discharge of sewage effluent to surface water.

In summary, disposal to surface water is not considered to be a feasible option.

6.4 Disposal to the MVS&DD Sanitary Sewer

A Metro Vancouver Sewerage and Drainage District sanitary sewer extends to the park just south of the disposal fields. R.F. Binnie & Associates Ltd. has determined that a connection to this sanitary sewer is technically feasible and has produced a preliminary design and cost[14]. Connecting to the sanitary sewer would allow the disposal fields to be removed from service and eliminate the pathogenic risk to the public. However the connection is limited by administrative impediments as the sanitary sewer is located in the City of Port Moody and the Village of Anmore is not a member of the MVS&DD.

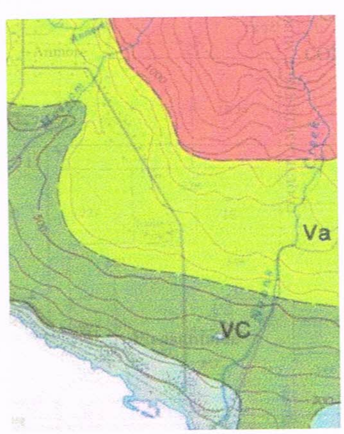
In summary this option is technically and financially feasible, but entails administrative and legal impediments. These impediments cannot be resolved by engineering.

7. Effects and Implications of Excavations

When constructed, the sewage effluent disposal field was bounded on the south and west sides by undeveloped forested park and a relatively constant downhill gradient[15]. According to original design drawings for Anmore Green Estates by Ashford Engineering Ltd. the disposal fields were constructed by making a cut into the hillside to create a flat area, and installing a perforated drain along the head of the cut to intercept and divert

[14] R.F. Binnie & Associates Ltd., Anmore, B.C. Sanitary Sewer, Drawing No. 16-0616-SS1, August 12, 2016.

[15] The pre-existing topography is shown on the Geological Survey of Canada Map 1484A, Surficial Geology, New Westminster West of the 6th Meridian, BC, 1:50,000, 1980. The area around the "Trailer Park" is pasted below.



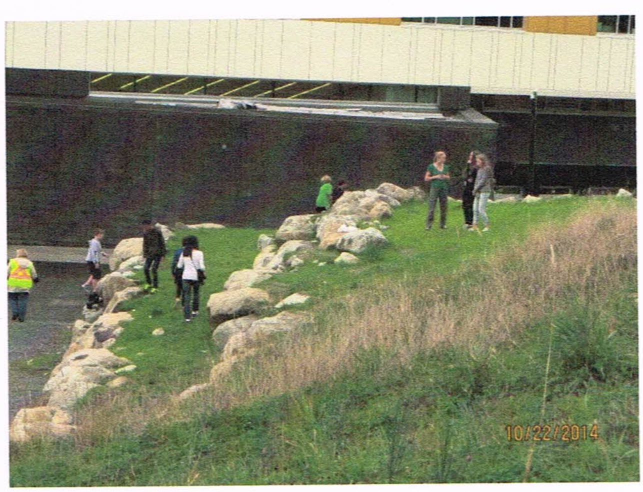
shallow groundwater laterally to the west of the flat area with the disposal fields.

With this configuration any groundwater surfacing downgradient of the disposal fields would occur in an undeveloped forest area, and would likely seep back into the ground farther downhill. The line drain just above the disposal fields would tend to lower the water table under the disposal fields.

As Port Moody grew and expanded the area near the disposal fields became developed. A flat footprint for a public park with sports fields and a high school was created in Port Moody to the immediate south of the disposal fields by excavation and construction of a retaining wall on the east side. Later a second footprint for a Middle school was created on the west side of the disposal fields by excavation and construction of a retaining wall there. Engineering drawings for the park and schools show the excavations were up to 10 meters (33 feet) high.

SGE has been told by the Strata that the extension of a line drain from above the disposal fields was cut off where it crossed the footprint of the Middle School during construction of the Middle School, notwithstanding that the extension lay within a municipal right-of-way. The right-of-way is shown in a drawing placed in Appendix 5.

The resulting current situation is that the disposal field is bounded on the south and west by excavated embankments. Retaining walls have been constructed on most of the west side, and to the east of the field house on the south side. The zone from the basketball court to the field house has an



embankment with a milder slope and no retaining wall. This slope was used by children from the Middle school for informal recreation but has recently been fenced off.

On the basis of wet season observations it is concluded that the effect of removing the upgradient line drain has been to cause the water table to surface in the northwest part of the west drainage field. The photo below was taken on January 14, 2018.

This has likely raised the natural water table under most of the west field, and perhaps part of the east field. The photo in section 5.6 shows that the water table also surfaced on the south side of the west field on this date. (No surfacing was observed in August 2017 in the summer, so the effect is seasonal).

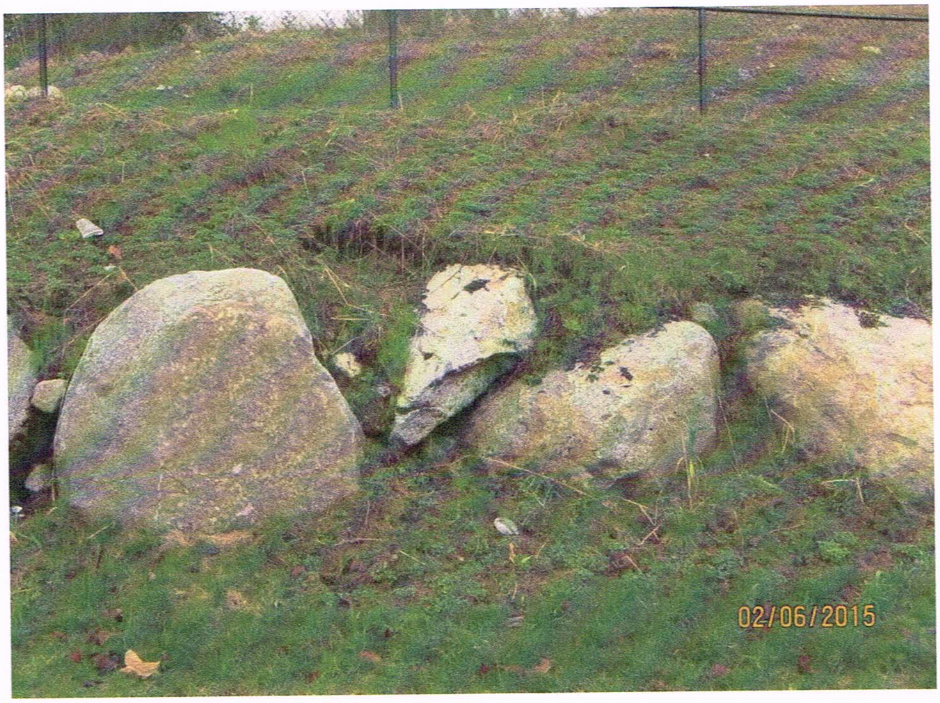
Unconfined groundwater flows in the direction of the steepest gradient, so that the excavations have locally increased the gradients to the south and west of the disposal fields. If the gradient is steep enough seeps (or springs) will occur at more permeable zones. Groundwater in the dilution zone under the disposal field will flow towards the excavated embankment and seep out there, particularly at times of higher groundwater discharge. If the travel time for the groundwater to go from the edge of the disposal field to the seep on the embankment is less than the time for pathogens to die off, then the groundwater exuding from the seeps will contain pathogens from the disposal fields.

No seeps in the excavation walls or from the bases of the retaining walls have been observed in summer periods, but they have been observed during winter at several places, including:

- On the hillside behind the field house (Feb. 2015)
- On the lower third of the hillside between the basketball court and the field house (Jan. 2018 and Feb. 2015)
- From the base and face of the retaining wall along the school sidewalk on the west side (Feb. 2015).

Some photos of these seeps are pasted below.


01/14/2018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It is noted that even if the sewage effluent disposal fields are repaired or replaced the groundwater flowing from the dilution zone beneath them is going to surface on the downgradient excavated embankment during the wet season.

There has been limited sampling of the surfaced and seep water in the past. Arden Consulting Engineers [ACE] noted surface water ponding just south of the west disposal field in a rainless period in July 2008 and concluded that it was a breakout of groundwater from under the disposal field. A sample of this ponded surface water had a fecal coliform concentration of 9900 CFU per liter. (Neither fecal coliforms nor *e. coli* are regulated by the Municipal Wastewater Regulation for Class C effluent, but the BC Water Quality Guideline for *e. coli* surface water contact for primary contact recreation is 770 CFU per liter[16]. ACE collected this sample before the Middle school was constructed. Ponded water south of the west disposal field would now flow towards the west towards the excavated Middle school footprint if the ground were saturated.

Pottinger Gaherty Environmental Consultants Ltd. reported nondetect fecal coliform concentrations in samples taken at the south embankment in January 2011, but PG sampled at a different location than ACE. PG concluded: "... it appears that groundwater associated with the septic field is seeping from an embankment and ponding on the ground surface on [the high] school property. .....Also, there are a number of locations along the embankment where septic water is seeping to the surface so the water quality along the embankment may vary".

During construction of the Middle School in 2013, Keystone Environmental took samples of water in the excavations and reported fecal coliform and *e. coli* concentrations up to 5100 CFU per liter for both parameters. A review of Keystone's data indicates that Keystone may have confused units of CFU/100 mL and CFU per liter, so that its results are difficult to interpret. It is likely that Keystone measured a maximum value of 5100 CFU/liter of *e. coli* (the BC primary contact recreation standard is 770 CFU/L) and 5100 CFU/L of fecal coliform (the BC standard is 2000 CFU/L); however these values

[16] "Water Quality Criteria for Microbiological Indicators, Overview Report", P.D. Warrington, Ph.D, R.P.Bio., BC Ministry of Environment and Parks, August 7, 2001.

cannot be confirmed due to professional quality issues with the Keystone report.

Associated Engineering (AE) took soil samples from the seep area shown in the photo with the shovel, above, on September 27, 2017[17] and found the *e. coli* concentration in the soil to be 160,000 MPN/g and fecal coliform concentration to be 160,000 MPN/g wet. On the basis of AE's results, the MOE concluded that the source of the pollution was the septic effluent from the disposal fields[18] (and not from animal waste). There was no water at the seep zone at that time. Concentrations at other sample sites were lower, possibly indicating a preferred pathway for the groundwater flow.

The foregoing reports indicate that it is likely that the bacterial and pathogenic contamination from the STP effluent is traveling to the Middle School property and surfacing via both groundwater seeps and as occasional surface water runoff.

Section 7 Summary

SGE's conceptual site model of the local hydrogeology at the site is that the groundwater table near and under the disposal fields is close to the surface in winter, so the separation distance from the perforated drain pipes in the disposal field to the water table varies from 0 to about 7 inches in the west field. This short depth of unsaturated soil does not provide sufficient biological decay, so the underlying groundwater receives a strong concentration of pathogens. This groundwater surfaces in zones along the base of the embankment where it contaminates the soil.

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[17] Technical Memorandum, Fawn Ross R.P.Bio., Associated Environmental, Burnaby BC, October 16, 2017, 16 pp.

[18] "Based on the *E.Coli* and fecal coliform assay results submitted to the Ministry by Associated Environmental on behalf of the Owners in October 2017, the Ministry has reason to believe that pollution is occurring by way of septic effluent daylighting from the cut-bank on the downgradient neighbouring property.... The property is the location of Heritage Woods Secondary School and Northshore Community Park....A Ministry onsite inspection on November 1, 2017, verified discolouration of the soil and rocks, and impacts to vegetation on the exposed slope, likely due to the migration of effluent discharged from the authorized works of PE-04606.", MOE Pollution Abatement Order, Nov. 23, 2017, File 04606.

Repair and replacement of the disposal fields might reduce the loading of pathogens to the groundwater table (particularly if a mound sand field were to be constructed[20]), but the impacted groundwater will still surface in the lower part of the embankment during the rainy season.

8. Summary

Please see the Executive Summary

[20] Recall from section 6.1 of this report that there is insufficient land to construct a sand mound system on this site. The sand mound treatment system is not a feasible option per §81 and §82 of the Regulation).

9. Legal Notices and Limitations

No constraints on reliance are placed on this report.

This report was prepared by S. Graham Engineering and Geology Inc. for the account of Anmore Green Estates. The material in it reflects S. Graham Engineering and Geology Inc.'s best judgement in light of the information available to it at the time of preparation. S Graham Engineering and Geology Inc. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

S. Graham Engineering and Geology Inc. has relied in good faith on information provided by sources noted in this report. S. Graham Engineering and Geology Inc. accepts no responsibility for any deficiency, misstatements or inaccuracy contained in this report as a result of omissions, misstatements or fraudulent acts of others.

This project was conducted and this report prepared in accordance with generally accepted professional practices for the nature and conditions of the work completed in this area at the time the work was performed. This report and its conclusions and recommendations are intended for the exclusive use of the Client for specific application to the referenced project site.

As a condition of our services it is understood that , to the fullest extent permitted by law, our Clients agree to defend, indemnify and hold harmless S. Graham Engineering and Geology Inc. and its owners , subcontractors and agents, from any past, present or future claims or damages at the site, including potential claims from third parties that may name S. Graham Engineering and Geology Inc. or S. Graham as a claimant.

This report is not meant to represent a legal opinion. No other warranty, express or implied, is given. Our professional services are provided in accordance with the terms presented in our General Conditions. Interpretation of data, conclusions, and recommendations based thereon are built on the information collected at the time this investigation was conducted and should not be interpreted as long-term geological or hydrogeological trends. Any questions regarding our work and this report, the presentation of the information, and interpretation of the data are welcome and should be referred to S. Graham.

Appendix 1

Figures

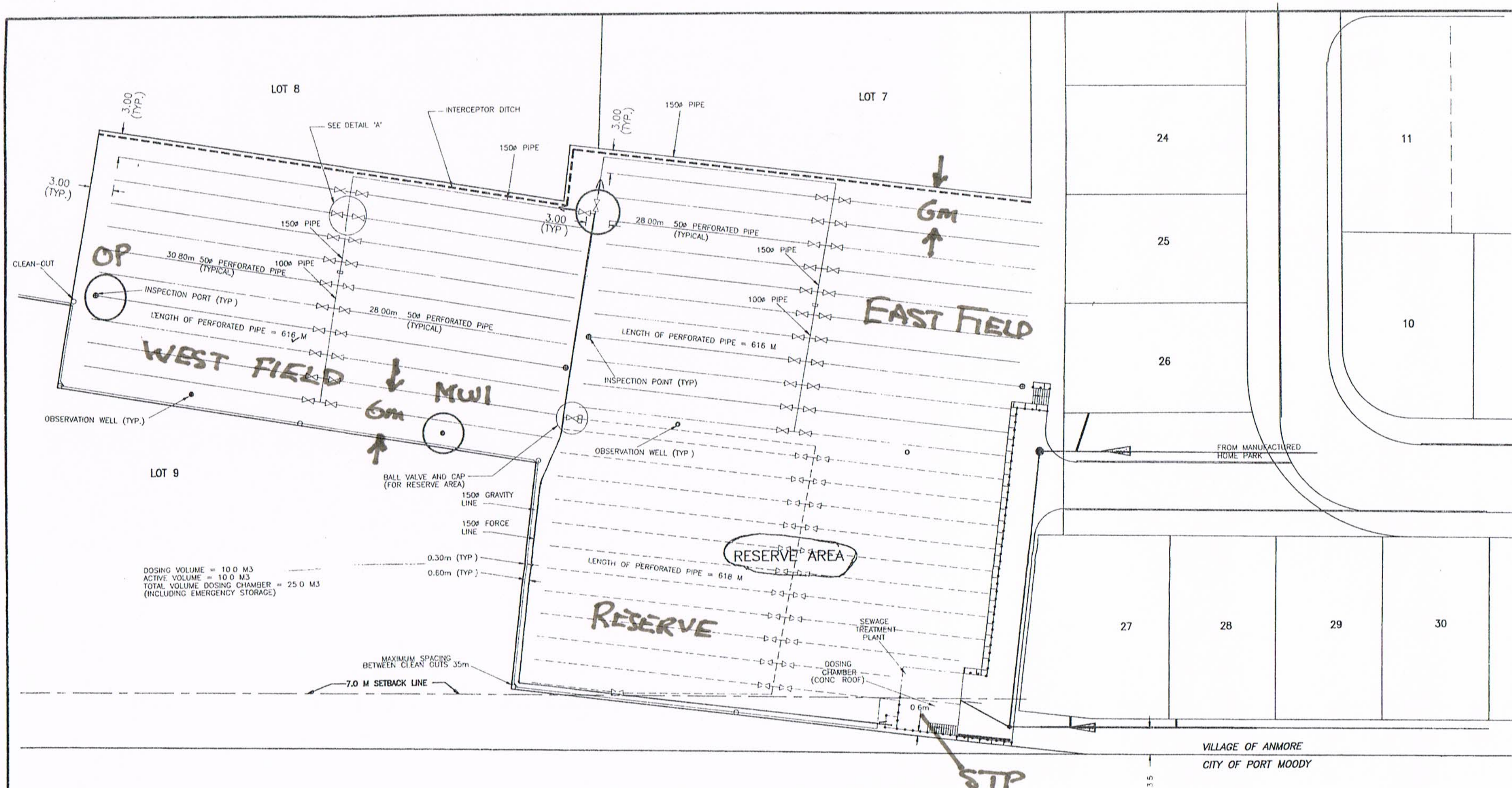


Figure 1

Original Disposal Fields Design (Plan)

B	JULY 97	AS CONSTRUCTED	FSA
A	15 04 96	AS REQUESTED BY CITY	CRL
No.	DATE	REVISION	BY

Scale 1:769.02 Approx.

CLIENT: 457690 B. C. LTD.

PROJECT: PROPOSED DEVELOPMENT 1175 EAST ROAD ANMORE, B. C.

DRAWN	DJM
DESIGNED	PL/DJA
CHECKED	DJA
APPROVED	
CADD FILE	
SCALES	HORZ 1:250 VERT

SEAL — DATE SEALED JUL 2 0 1997

File: RE 4666

ASHFORD ENGINEERING LTD.
101 - 1827 WEST 5th AVE, VANCOUVER, B C V6J 1P5

ABSORPTION FIELD
MODULAR HOME PARK

DATE AUG. 28, 1995
SHEET 23 of
DWG. No. 1047-D-23 REV. B

JUL 2 0 1997

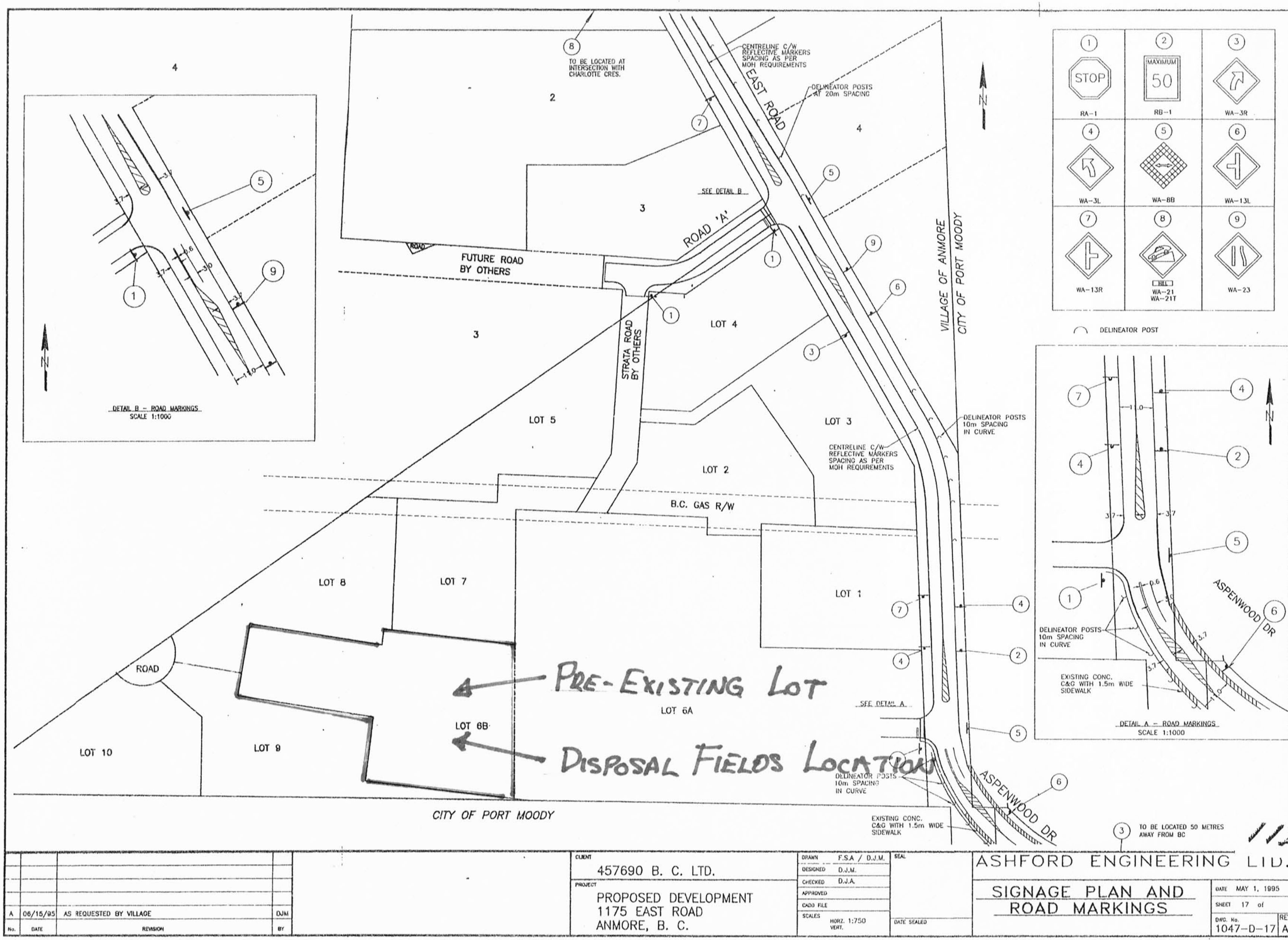


FIGURE 2 DISPOSAL FIELDS LOCATION

Appendix 2

Selected Parts of the Municipal Wastewater Regulation

Part 5 — Specific Requirements For Discharge To Ground

Division 1 — General Requirements

Application and interpretation

68 (1) This Part applies only in respect of discharging to ground.

(2) In this Part:

"aquifer" includes any soil or rock formation that has sufficient porosity and water yielding ability to permit the extraction or injection of water at rates of 5 L/minute or more;

"disposal site perimeter" means the outer edge of the subsurface treatment works;

"groundwater mounding effect" means the vertical rise in the water table that occurs in response to a discharge.

Municipal effluent classes

69 For the purposes of this Part, municipal effluent is classed as follows:

(a) class A, being high quality municipal effluent resulting from advanced treatment with the addition of disinfection and nitrogen reduction;

(b) class B, being high quality municipal effluent resulting from advanced treatment;

(c) class C, being municipal effluent resulting from secondary treatment;

(d) class D, being municipal effluent resulting from treatment in a septic tank.

Discharge

70 (1) In this section, **"zone of influence"** means the zone around a water well that, in the opinion of a qualified professional, supplies water to the well.

(2) A person must not discharge, within the zone of influence, municipal effluent to ground unless

(a) the requirements set out in this Part are met, and

(b) the discharged effluent is disinfected.

(3) A person must ensure that a discharge of municipal effluent within 300 m of a drinking water source meets class A municipal effluent requirements.

Initial dilution zone

71 If a person discharges municipal effluent to ground,

(a) the initial dilution zone is the 3-dimensional subsurface zone where mixing of the municipal effluent and groundwater occurs, and

(b) the boundary of the initial dilution zone is the vertical extension into the ground of the property boundaries of the land into which discharging occurs.

Subsurface travel time

72 (1) In this section, **"subsurface travel time"** means the actual time, including the time spent in the unsaturated and saturated zones, required for municipal effluent to travel from the disposal site perimeter to the point where the municipal effluent

(a) surfaces,

(b) reaches a property line, or

(c) is intercepted by a water well.

(2) A discharger must ensure that the subsurface travel time is at least,

(a) for class A or B municipal effluent, 6 days, or

(b) for class C or D municipal effluent, 10 days.

Surfacing of discharge

73 A discharger must ensure that discharge does not surface, or cause the groundwater table to be raised to the surface, as follows:

(a) within 30 m beyond the disposal site perimeter;

(b) more than 30 m beyond the disposal site perimeter, unless

(i) the discharge does not cause water quality parameters to fail to meet water quality guidelines, and

(ii) there will be no adverse impacts from the surfaced municipal effluent.

Calculating flow

74 (1) A qualified professional must determine the calculated or actual maximum daily flow.

(2) A qualified professional may use the actual maximum daily flow to design the wastewater facility if

(a) the actual daily flow is equal to or greater than 37 m^3/d,

(b) water conservation measures are used, and

(c) a restrictive covenant is placed on each property requiring that water conservation measures are continuously used.

(3) If actual maximum daily flow is used under subsection (2), daily discharge volume monitoring is required.

Municipal effluent quality requirements

75 (1) A discharger of class A, B or C municipal effluent must meet the applicable municipal effluent quality requirements set out in this section and listed in Table 3.

(2) The median coliform values for 7 consecutive daily tests and any single value test must be less than the value specified in Table 3.

(3) Despite subsection (1), for class C lagoon systems, the maximum TSS level must not exceed 60 mg/L.

(4) In respect of class A and B municipal effluent that is discharged to a drainfield,

(a) filtration is required to prevent solids carrying over into the disposal field, and

(b) monitoring controls must be maintained to signal an alarm when filtration begins to malfunction.

Table 3 — Municipal Effluent Quality Requirements

Requirement	Class A	Class B	Class C
BOD_5 (mg/L)	10	10	45
TSS (mg/L)	10	10	45
fecal coliform (MPN / 100 mL)	median: 2.2 any sample: 14	400, if maximum daily flow is ≥ 37 m^3/d	n/a
turbidity (NTU)	average: 2 any sample: 5	n/a	n/a
nitrogen (mg/L)	Nitrate-N: 10 total N: 20	n/a	n/a

Unsaturated soil depth

76 (1) For the purposes of this section, **"unsaturated soil"** means the soil between the land surface and the water table where the soil pore spaces contain water at less than atmospheric pressure, as well as air and other gases.

(2) The minimum unsaturated soil depth must be measured from the infiltrative surface to the highest water table, including the groundwater mounding effect or restrictive layer.

(3) For chamber distribution systems, the bottom of the sidewall, or "foot" of the chamber, is considered to be the infiltrative surface.

(4) For class A or B municipal effluent, a discharger must ensure that the minimum unsaturated soil depth is 0.5 m.

(5) For class C or D municipal effluent, a discharger must ensure that the minimum unsaturated soil depth for maximum daily flows of

(a) less than 37 m^3/d is 0.75 m, and

(b) 37 m^3/d or more is 1 m.

Advanced treatment requirements

77 A discharger must not discharge, above the following aquifer areas, municipal effluent having a total nitrogen content of more than 10 mg/L:

(a) the Abbotsford-Sumas Aquifer in Abbotsford;

(b) the Hopington and Langley/Brookswood Aquifers in Langley;

(c) the Lower Nechako River Aquifer in Prince George;

(d) the Lower Cowichan River Aquifer in Duncan;

(e) the Grand Forks Aquifer in Grand Forks;

(f) the Merritt Aquifer in Merritt;

(g) the Osoyoos West and Osoyoos East Aquifers in Osoyoos;

(h) the Vedder River Fan Aquifer in Chilliwack;

(i) the aquifers stretching from Osoyoos Lake to Tuc-el-Nuit Lake and from Tuc-el-Nuit Lake to Vaseux Lake.

Division 2 — Drainfields

Drainage pipe length requirements

78 (1) A discharger must ensure that drainage pipes are at least the length set out for the applicable municipal effluent class and percolation rate, as listed in Table 4.

(2) Despite subsection (1), a discharger may use a chamber distribution system with an equivalent length to the minimum pipe length listed in Table 4.

(3) If

(a) percolation rates are less than 2 minutes per 25 mm,

(b) the maximum daily flow is less than 37 m^3/d, and

(c) class A or B municipal effluent is discharged by pressure distribution,

a discharger may use American Society for Testing and Materials C33 sand-filled trenches to reduce percolation.

(4) If percolation rates exceed 20 minutes per 25 mm, a qualified professional must

(a) supervise construction, and

(b) ensure that construction has not reduced the trench wall permeability, except that, for maximum daily flows of less than 37 m^3/d, permeability may be reduced if the native undisturbed permeable soil depth exceeds 1.35 m as measured from the bottom of the field to the level of the water table.

Table 4 — Minimum Drainage Pipe Length for Each Field

	Metres of drainage pipe for each 10 m^3/d of maximum daily flow for percolation rates shown						
percolation rate (minutes/25 mm)	2	5	10	15	20	25	30
class A, B or C municipal effluent	50	75	100	110	120	135	150
class D municipal effluent	120	215	280	320	360	400	430

Reductions in drainage pipe length

79 (1) Despite section 78 (1) *[drainage pipe length requirements]*, a qualified professional may provide for a reduction in drainage pipe length to a maximum of 40% if both of the following requirements are met:

(a) under section 74 (2) *[calculating flow]*, a qualified professional uses the actual maximum daily flow to design the wastewater facility;

(b) the drainfield discharges class A or B effluent.

(2) In the circumstances set out in subsection (3), a qualified professional may design a drainfield with deeper, narrower trenches and reduce the drainage pipe length to a value equal to the product of

(a) the pipe length required under section 78, and

(b) a factor of $1/H^{0.5}$ or 0.8, whichever is greater, where H is the drainage trench depth below pipe invert in metres.

(3) The circumstances for the purposes of subsection (2) are as follows:

(a) percolation rates are less than 5 minutes per 25 mm;

(b) the maximum daily flow is equal to or greater than 37 m^3/d;

(c) the depth to groundwater, including any groundwater mounding effect, is more than 1 m below the bottom of the drainage trench.

Drainage pipes

80 A discharger must ensure that all of the following requirements are met:

(a) a pressure distribution system is used for drainage pipes fed by a dosing syphon or pump;

(b) unless a pressure distribution system is used, the drainage pipe is at least 70 mm in diameter;

(c) the drainage pipe cover is at least 0.15 m and meets local frost protection requirements.

Drain fields

81 (1) A discharger must ensure that visual inspection ports are installed in the drain field.

(2) A discharger must ensure that all of the following requirements are met:

(a) drainage pipes are provided in 2 drain fields, each having at least the length of drainage pipe required under section 78 *[drainage pipe length requirements]* unless a reduction is permitted under section 79 *[reductions in drainage pipe length]*;

(b) a third undeveloped drain field is retained as a standby area;

(c) drain fields are constructed with trenches spaced

(i) such that there is at least 3 m between the centre of each trench, or

(ii) if the performance of the drain field would not be adversely affected, at least 2 m apart from each other with at least double the standby area;

(d) trenches are at least 0.6 m in width, with trench bottoms at least 0.3 m below the pipe invert.

Setback requirements

82 (1) For all discharges to ground and standby areas, a discharger must ensure that setbacks from the area into which discharging occurs are at least the distance set out in Table 5.

(2) A discharger must ensure that subsurface fields, the standby area and a surrounding buffer strip as set out in row 2 ("building drain, buffer strip") of Table 5

(a) are kept free of buildings or hard surfacing of any kind, and

(b) are not used for building drains or any activity that may cause damage to the system or interfere with its operation.

(3) The wastewater facility itself is a building for the purposes of row 2 of Table 5.

(4) For the purposes of row 6 of Table 5, if, based on a hydrogeological assessment to determine the minimum distance required to protect the water quality of a water well,

(a) the distance from the water well must be extended in accordance with the hydrogeological assessment, or

(b) the maximum daily flow is more than or equal to 37 m^3/d,

the distance from the water well may be decreased, if authorized by a director, to a distance of no less than 90 m.

Table 5 — Minimum Setback Requirements

		Minimum Setback Distance (m)	
Row	**Feature**	**maximum daily flow**	
		$< 37\ m^3/d$	$\geq 37\ m^3/d$
1	property boundary	3	6
2	building drain, buffer strip	5	10
3	body of water	30	30
4	water within the Okanagan Basin	30	150

5	water well	60	90
6	water well within unconfined aquifer	60	300

Division 3 — Infiltration Basins, Sand Mounds and Seepage Beds

Infiltration basins

83 A discharger must ensure that infiltration basins meet the following requirements:

(a) at least 2 basins must be provided to allow cleaning of one basin while the other is operating and to act as a safety factor for unusual conditions;

(b) for 2 basin systems, each basin must be capable of accepting all the municipal effluent under annual average rainfall conditions;

(c) subject to Division 1 *[General Requirements]*, discharge of municipal effluent to an infiltration basin meets at least class C requirements.

Sand mounds and seepage beds

84 A discharger may use sand mounds and seepage beds only if both of the following requirements are met:

(a) sand mounds and seepage beds are constructed using American Society for Testing and Materials C33 sand to reduce percolation;

(b) the discharger is authorized by a director to use the sand mounds and seepage beds.

Appendix 3

Arden Consulting Engineers Ltd. 2008 Report [Copy]

July 31, 2008

LMS 3080 Strata Corporation
100 Blackberry Drive
Anmore, BC
V3H 5B4

COPY

Attention: Mr. Xavier Serrano.

RE: Evaluation of Onsite Wastewater Treatment System for LMS 3080 Anmore Green Estates, Anmore BC

Further to your request, Arden Consulting Engineers Ltd. (ACE) has completed a review of the existing Sewage Treatment Plant (STP) and septic field for Anmore Green Estates (AGE). The purpose of the review was to evaluate the performance of the existing STP and provide options for retrofitting or replacement of the STP. A limited review was additionally undertaken to assess the design parameters of the septic field and review the breakout occurring at the berm down gradient of the west septic field area. A site visit was conducted by ACE on June 17, 2008 in conjunction with Orion Water Services to review the STP. A second site visit was conducted on July 8, 2008 to conduct percolation tests and review the subsurface conditions within the septic field area and perform a dye test. A third visit was conducted on July 15, 2008 to check for the presence of dye down gradient of the West septic field and review the STP with Dr. Stephen Ramsey, P.Eng.

SEWAGE TREATMENT PLANT

The existing system consists of a trash tank or primary clarifier, a Rotating Biological Contactor (RBC), secondary clarifier and tertiary sand filter. Sewage flows by gravity to an existing 3,500 Igal (16m^3) trash tank, through to the RBC unit, and then the secondary clarifier. Clarifier effluent flows by gravity to a sand filter dosing tank where it is pumped through the sand filter and discharged to the final pump chamber. Effluent in the dosing tank is discharged to a low pressure distribution subsurface disposal field. The system has been designed to service 39 two bedroom homes and 12 three bedroom homes for a maximum discharge rate of 61m^3/day. Effluent quality parameters are as follows:

- Five day Biochemical Oxygen Demand not to exceed 20mg/L
- Total Suspended Solids not to exceed 20 mg/L

The existing RBC treatment plant is an activated sludge attached growth system as it uses a partially submerged rotating media for the bacteria to colonize. The bacteria are continuously inundated with organics from the wastewater and oxygenated as the media rotates.

32105 Balfour Drive, Abbotsford, BC V2T 5C2 Phone: (604) 807-1712 Fax: (604) 855-9194
www.arden-engineering.com

System Performance

ACE has reviewed the effluent quality and flow data collected by Corix Utilities encompassing the operating period from March 2006 to September 2007 as well flow and effluent quality data from Orion Water Services (Orion) from January to June of 2008. Additionally, ACE collected an effluent sample from the pump chamber and effluent sample from the trash tank (influent to RBC) for the purpose of determining the influent strength during our June 17, 2008 site visit.

An average flow rate of approximately 35 m^3/day and was reported by Corix for the periods March 2006 –September 2007 which is approximately 60% of the permitted and assumed design flow rate for the STP. Data collected by Orion from January to June 14 2008 shows an average flow rate of 15.4m^3/day with the 95th percentile event of 19.4m^3/day which represents 25% and 32% respectively of the design value.

Effluent quality data reviewed indicates that the STP seldom meets the permitted maximum values. The average BOD_5 and TSS results through June of 2008 are 53 mg/L and 53 mg/L respectively. An effluent sample collected by ACE on June 17, 2008 from the pump chamber contained BOD_5 and TSS concentration of 23 and 30 mg/L respectively. It is noted that this sample was collected immediately after the sand filter had been backwashed and as such is not representative of typical effluent quality. A sample taken from the RBC discharge and indicative of the RBC effluent quality contained BOD_5 and TSS concentration of 43 and 64 mg/L respectively. The influent to the RBC (trash tank effluent) contained BOD_5 of 188 mg/L. Dissolved oxygen readings were 0.15mg/L at the outlet of the RBC and 0.08mg/L in the secondary clarifier. Readings of 2 mg/L are typically required to satisfy the oxygen demand of the organics in the wastewater and maintain aerobic conditions.

Based on a visual review of the RBC unit, it is our opinion that it has been maintained in good working order by the operator. The biomass attached to the rotating media appears healthy and was brown in color with an earthy or musty odour as opposed to black or grey. Assuming that the RBC unit was designed for a treatment capacity of 61m^3/day, it is not currently being hydraulically overloaded. The influent wastewater strength (BOD of 188 mg/L) is typical for residential wastewater. Package treatment plants are typically designed to accommodate up to 250mg/L BOD_5. As such, the plant is also not organically overloaded. It is unlikely that any performance or operational modifications to the existing process would significantly improve effluent quality.

Review of Equipment Vendor Proposals

The Strata submitted a Request for Quotation (RFQ) package for replacing the existing system with a new treatment process. The RFQ stipulated effluent quality (BOD and TSS < 20 mg/L) and a design flow rate of 61m^3/day. Pinnacle Environmental Technologies (Pinnacle) and PTI Environmental Services (PTI) submitted proposals in response to the RFQ. Our review of each of the proposals is presented below:

Pinnacle Proposal

Pinnacle has proposed to use an activated sludge system containing submerged fixed media. It is proposed to convert a portion of the existing concrete tankage to a combined flow equalization/primary clarification tank which would precede the new aeration or reactor tank. The proposal also includes removal of the existing RBC unit and wood frame enclosure, all electrical and plumbing as well as pump and haul costs of influent during construction. The system as proposed is intended to be a turnkey proposal as opposed to equipment supply only. Integral to the proper performance of any activated sludge based treatment system are the design parameters. These include:

- The size of the aeration or reactor tank(s), which controls Mixed Liquor Suspended Solids concentration;
- Provision of a secondary clarifier with suitable surface area to ensure solids loading rates and overflow rates are within accepted design standards;
- Provisions for Return and Waste Activated sludge;
- Inclusion of a sludge storage tank;
- Sizing of primary clarifier and flow equalization tank;
- Incorporation of plug flow to optimize mixing and improve performance;

The Pinnacle proposal is silent on the inclusion of the above components and sizing. Further, it is our recommendation that the primary solids be handled in a separate tank from the flow equalization and that the primary tank be located upstream of the flow equalization tank. The Pinnacle proposal proposes to combine these two processes in a single tank. It is our opinion that the technology proposed by Pinnacle is both practical and appropriate, however, modifications to their proposal may be necessary to ensure that performance is optimized and that the system has been design in accordance with accepted engineering design guidelines for the activated sludge process. These modifications could potentially impact the pricing provided. The installation cost of $175,000 is judged to be representative of fair market value for removal of the existing RBC and installation of a new system.

PTI Proposal

PTI has proposed using a membrane bioreactor with flow equalization and biological treatment proposed up stream of the membrane. This system uses a reactor or aeration tank to stabilize the organics in the wastewater similar to the activated sludge system. The difference is the mixed liquor from the aeration tank or bioreactor is drawn by a vacuum pump through the membrane cassettes which have an opening of 0.02 microns. This effectively excludes any remaining organics (measured as BOD) and suspended solids as well as bacteria and some viruses. This is a high end system/process that would produce very high quality effluent (BOD_5 and TSS would be less under 4 mg/L and 1 mg/L respectively). The drawback is the very high capital and maintenance costs ($495,000 and $3,400 per month respectively) in comparison to the activated sludge process. The expected effluent quality would greatly exceed what is allowed under the current permit, however, it is our opinion that this type of process is not necessary to achieve the required target effluent quality and that the substantially higher capital and maintenance costs make this process financially unattractive.

OPTIONS FOR UPGRADING THE STP

Two potential options were considered for upgrading the STP:

1. Installation of a new STP adjacent to the existing STP utilizing a portion of the existing tankage for upstream treatment (i.e. primary clarification and flow equalization)

2. Retrofit the existing tankage to accommodate the activated sludge extended aeration process.

Installation of a New STP

It was initially determined that the path of least resistance would be to utilize a portion of the existing system to accommodate flow equalization and primary clarification. A new STP, which would include the reactor or aeration tanks and secondary clarifier, would be installed adjacent to the existing system. A technical specification would be prepared establishing design standards and criteria which could be then tendered to qualified contractors and equipment vendors. The design specification would serve to ensure a level playing field between equipment vendors and allow the Strata to compare costs for similar end products as opposed to relying on the equipment vendor to establish design parameters. ACE successfully completed this process recently for BC Parks at the Golden Ears Provincial Campground for a 75m^3/day flow. The system replaced the existing RBC unit that was approximately eight years old. The cost and effort associated with preparing detailed construction drawings depicting a retrofit of the existing system and tankage coupled with the level of on site supervision necessary to ensure construction was proceeding in accordance with the design objectives was judged to be more difficult and potentially expensive than establishing a design specification and reviewing the construction of a factory constructed system. Unfortunately, this option may not be feasible as entire area surrounding the existing STP has been dedicated for the reserve septic field area. ACE contacted Mr. Sisto Bosa from the Ministry of Environment to determine if the reserve area could be used for replacement of the STP. The response was that this would be possible only if the area taken out of service could be replaced with a suitable alternate area elsewhere. Based on the review of the site plan, it appears that no such area is available. Barring a new location for the reserve septic field area, we are stuck with the footprint of the existing STP.

Costs for supply and installation of the Golden Ears STP, including removal of the existing tankage and RBC unit, as well as all plumbing and electrical connections were $172,500. Costs for replacement of the AGE STP are anticipated to be similar. Engineering costs for design and technical specifications as well as provision of construction review and project management services would be on the order of 10-15% of

Retrofitting Existing STP

In its simplest form, the activated sludge process consists of an aeration chamber and a secondary clarifier in series. The aeration chamber is the heart of the activated sludge process. In this chamber, bacteria and other microorganisms thrive and multiply as they consume organic material in the wastewater. The bacteria and microorganisms require dissolved oxygen in order to synthesize and oxidize the organics in the wastewater. The activated sludge process can be further broken down into two sub categories – attached growth and suspended growth systems. Attached growth systems use filter media to mix raw wastewater with bacteria and microorganisms, whereas suspended growth systems use the water in the aeration chamber as a media for mixing the wastewater with bacteria and dissolved oxygen.

As discussed on site, the existing RBC unit could be converted from activated sludge attached growth to activated sludge suspended growth, extended aeration. This would involve removing the RBC wheel and undercarriage in the aeration tank of the existing treatment plant and replacing it with diffusers. Air would be supplied uniformly throughout the existing tank currently housing the RBC via an aeration blower and sub surface diffusers in order that the wastewater would be completely mixed and uniformly aerated, thereby providing oxygen for the bacteria, keeping the solids in suspension and allowing a rapid mix of the raw wastewater with the microorganisms for oxidation and synthesis of the organic matter. This mixture of bacteria culture and wastewater is referred to as the Mixed Liquor Suspended Solids (MLSS).

Both activated sludge processes (attached growth and suspended growth extended aeration) incorporate a secondary clarifier to allow the homogeneous mixture of microorganisms and wastewater generated in the aeration chamber (the MLSS) to gravity separate forming a clear liquid called supernatant. The sizing of both the aeration chamber and clarifier is a function of anticipated organic load, wastewater strength and design flow rate.

Settled sludge from the clarifier is returned (referred to as Return Activated Sludge) from the bottom of the clarifier to the aeration chamber in order to further oxidize the settled sludge, control the concentration of MLSS in the aeration chamber and to reduce the depth of the sludge blanket at the bottom of the clarifier. A portion of the sludge must also be wasted (Waste Activated Sludge) periodically to prevent the treatment plant from becoming choked with solids and to maintain the sludge age or solids retention time within the design values.

In order to improve efficiency and effluent quality, it is our recommendation that a primary clarifier and flow equalization tank be added upstream of the process. The primary clarifier will remove non-biodegradable or inert solids from system reducing the load to the treatment plant. The flow equalization tank is designed to reduce diurnal surges in influent flow rate that typically occur in the morning and evening by storing the wastewater generated during these events and releasing it uniformly over a 24 hour period. This helps to control the hydraulic retention time and ensure that the organics in the wastewater do not pass too quickly through the reactor tanks or secondary clarifier with incomplete treatment during periods of high flow. As a further improvement to efficiency, it is recommended the aeration chamber be divided into four separate compartments to approximate plug flow conditions. This greatly improves hydraulic mixing of the organics in the incoming wastewater with microorganisms responsible for digesting the organics in the reactor and reduces the occurrence of short circuiting.

The following is a brief summary of various components of the extended aeration process as would be applied to the AGE STP.

Aeration Chamber

In order to implement the extended aeration process in place of the RBC wheel, the minimum volumetric capacity of the aeration chamber must be determined and compared to the size of the existing concrete aeration chamber. The following design assumptions were used in calculating the minimum aeration chamber volume.

- Solids Retention time — 30 days
- [1]Sludge Yield — 0.6 kg TSS/kg BOD
- [2]Maximum Mixed Liquor Suspended Solids — 2,500mg/L
- Influent BOD_5 loading — 250mg/L
- Desired Effluent BOD_5 — 10mg/L
- [3]Endogenous decay coefficient — 0.06 d^{-1}
- Peak Design Flow — 61m^3/day

Based on the above values, it is calculated that an aeration chamber volume of 40m^3 is required for the extended aeration process. The volume of the existing chamber housing the RBC wheel is 32m^3 and as such is considered to be undersized. In order to create the additional capacity, the operating tank depth (liquid level) would have to be increased by approximately 60 cm to 2.75m (Elevation 189.70m). This could be accomplished by removing the roof and raising the sidewalls the required 60 cm.

The existing RBC unit uses the rotation of the wheel and exposure to ambient air to provide oxygen to the bacteria. The extended aeration process uses a blower and diffusers to oxygenate and mix the wastewater. The oxygen supply must be sufficient to satisfy the oxygen demand of the microorganisms and to completely mix the water in the aeration chamber. It is calculated that an air supply of 50 Standard Cubic Feet per Minute (scfm) at 120 inches water column will be required to satisfy the mixing requirement of aeration chamber as well as the oxygen demand of the microorganisms. The above operating point could be provided by a 5 hp regenerative type blower as opposed to a positive displacement type blower. The sound output of the regenerative type blower is approximately 75 decibels as opposed to 85 decibels for a positive displacement blower. It is recommended that 2 blowers be provided with the second blower acting as a standby.

Secondary Clarifier

The clarifier must have sufficient surface area to enable adequate time for gravity separation to occur. Typical clarifier overflow rates for the extended aeration process range from 8 m^3/m^2 day – 16 m^3/m^2 day for average flow rates and up to 24 m^3/m^2 day for peak flow rates (Metcalf & Eddy, 2003). The surface area of the existing concrete tank housing the current clarifier is approximately 5.3m^2 which would result in an overflow rate of 12 m^3/m^2day based on the maximum design flow of 61 m^3/day. It is noted that the existing steel clarifier has a surface area of only 3.5m^2 and as such is insufficient. The solids loading rate to the clarifier should not exceed 5 kg/m^2 hr. Assuming a sludge recycle rate of 50%, the solids loading rate would be 2 kg/m^2 hr for peak design flow (61 m^3/day). Therefore, the surface area of the existing tankage housing the existing clarifier should be sufficient for conversion to the extended aeration process. It is recommended to install a hopper at the bottom of the secondary clarifier similar to the existing one, but with larger surface area and geometry to fit the re-vamped tankage. This will facilitate sludge removal from the bottom of the clarifier. The sloped sides direct the settled solids to a small bottom area where they can be readily removed. The hopper could be constructed of cast in place concrete or stainless steel. The side slopes should not be less than 60 degrees to the horizontal.

[1] Adapted from Figure 8-7 of Metcalf & Eddy, 4th edition 2003
[2] Adapted from Table 8-16 of Metcalf & Eddy, 4th edition 2003
[3] Adapted from Table 7-9 of Metcalf & Eddy, 4th edition 2003

Flow Equalization and Trash Tank

The existing sand filter backwash tank could be converted to a trash tank or primary clarifier. As the wall height must be increased to accommodate the required aeration tank capacity, the wall height and liquid depth would also have to be raised accordingly in the upstream tanks (flow equalization and Trash) to accommodate a hydraulic grade line through the STP. Allowing for a 5cm increase in height through each of the preceding tanks, the new liquid depth of the trash tank would be 2.85m (Elevation 189.80m) with an inlet invert of 189.85m. The resulting hydraulic capacity would be 21.8m^3 (4,800 Igal).

The next compartment of the original concrete tank (labeled the dosing chamber on Dwg # 1047-D25 Rev D July 20, 1997) has an existing capacity of approximately 27.3m^3 or 6,000 Igal. This tank could be partitioned to accommodate both the existing pump chamber and to create a new flow equalization tank. The increase in wall height would result in maximum liquid level depth of 2.81m based on an emergency overflow gravity outlet invert elevation of 189.75m (inlet invert to aeration chamber). It is desired to have a minimum flow equalization tank capacity of 22.7m^3 (5,000 Igal). This would require a partition to be placed at distance of 2.65m from and parallel to the existing concrete wall separating the current sand filter backwash tank. Assuming a wall thickness of 100mm, the resulting pump chamber capacity would be 14.3m^3 or 3,140 Igal. This is based on a depth of 2.71m (inlet invert elevation 189.65m).

Return and Waste Activated Sludge

Provisions for Return Activated Sludge (RAS) and Waste Activated Sludge (WAS) from the secondary clarifier are an essential feature of the activated sludge process. The purpose of the RAS is to maintain a sufficient concentration of activated sludge in the aeration chamber such that influent organics in the wastewater can be digested readily by the active biomass contained in the RAS thus enabling treatment to occur within the desired time frame. RAS also ensures that the sludge blanket formed at the bottom of the quiescent zone does not continue to build up and escape from the STP. WAS is required to control the concentration and age of the activated sludge in the aeration tank. Both processes may be accomplished through an airlift pump energized via the aeration blowers. A minimum capacity of 7.3m^3 or 1,600 Igal is recommended for the sludge storage tank. The WAS storage tank could be located on the west side of the existing clarifier.

REVIEW OF EXISTING SEPTIC FIELD

A subsurface investigation was conducted within the existing West and East septic field areas for the purpose of assessing subsurface conditions, in-situ permeability and to review the breakout noted along the downslope edge (south end) of the west septic field adjacent to the soil berm. The investigation was conducted on July 8, 2008 and included the advancement of 3 hand dug testholes to a depth of 910mm and a review of the septic field layout provided by Ashford Engineering Ltd. (AEL). Fluorescent dye was added to the pump chamber and the effluent was diverted to the west septic field as the breakout was suspected to originate from the west septic field. The purpose of the dye test was to check for the appearance of dye along the berm. A water sample was collected from the surface water adjacent to the berm and tested for fecal coliform and Nitrate Nitrogen, both indicators of septic effluent. Additionally, six percolation tests were performed in the septic field area (3 in the west and 3 in the east field).

In general the subsurface conditions consisted of the following:

0-910mm Silty SAND, some gravel, brown, dense to very dense.

Wood debris was observed in one of the testholes. Seepage was observed in a testhole excavated near the south edge of the west septic field at a depth of 500mm BGS. The percolation test results are presented below in Table A:

Table A – Summary of Percolation Test Results

Percolation Hole #	PH 1	PH 2	PH 3	PH 4	PH 5	PH 6
Rate (min/inch)	120	32	90	15	10	35

Percolation tests 1-3 were performed in the east septic field area and percolation test 4-6 were performed in the west septic field area. It is noted that the maximum allowable percolation rate under the *Municipal Sewage Regulation* (MSR) is 30 minutes per inch for ground disposal. The average of the above is 50 minutes per inch. The high percolation rates were expected given the dense or compact nature of the soil. The design percolation rates were not available for comparison; however, based on the design flow of 61m^3/day and the provided length of 616 lineal meters per field, we can extrapolate that the design percolation rate would have been 10 minutes per inch for treatment plant effluent. Accordingly, the permeability has been reduced substantially post construction.

In spite of the relatively low permeability rates, there were no obvious signs of failure along the surface of either septic field area that are typically evident in failed or failing systems. These include:

- Soggy or saturated soils in the vicinity of the septic field during dry periods; and,
- Heavy lush green vegetation growth at the surface of the lateral runs.

The AEL drawings show the southern most septic lateral of the west septic field to be approximately 30m from the toe of the rock wall at the north property boundary. The first sign of seepage occurs at 31m from the rock wall and the ponded water occurs at a distance of approximately 33.5m from the toe of the rock wall. The elevated berm is located a distance of 35m from the rock wall. Accordingly, the berm is only 5m south of the south edge of the west septic field.

No dye from the pump chamber was observed in the ponded area during our July 15, 2008 site visit. The ponded water contained Nitrate and Fecal coliform concentrations of 1.75 mg/L and 990 CFU per 100mL respectively. The nitrate concentrations and fecal coliform counts point to partially treated effluent surfacing at the edge of the berm,. It is noted that the drinking water standard requires Nitrates to be less than 10mg/L and the recreation water quality limit for fecal coliform bacteria is 200 CFU per 100mL. The elevated fecal coliform counts cannot be unequivocally attributed to the septic field as other factors such as geese, ducks or dogs could have also contributed to the elevated counts.

Given that the ponding was still evident during a dry time a year with no rainfall occurring between July 3rd and 15th, it is our opinion that the construction of the berm 5m downslope of the west septic field has resulted in the day lighting or breakout of partially treated effluent. The quantity and concentration of the breakout, however are not cause for immediate concern. This could be alleviated by filling in the ponded area with a free draining sand fill such as ASTM C-33 sand. The sand should be placed to a height of 300mm above the liquid level. Filtration of the water through the sand should render and standing water innocuous.

We trust that this provides the information you currently require. If you have any questions or require comment, please feel free to contact the undersigned.

Yours Truly,

ARDEN CONSULTING ENGINEERS LTD.

PER:

Rob Arden, P.Eng.

Reviewed by Stephen Ramsay, Ph.D., P.Eng

Appendix 4

MOE Pollution Abatement Order
(November 23, 2017)

BRITISH COLUMBIA

Date: November 23, 2017

Order: 109192
File: 4606

Registered Mail

Owners of Strata Plan LMS 3080
100 Blackberry Drive
Anmore, British Columbia V3H 5B4

POLLUTION ABATEMENT ORDER

The Ministry of Environment and Climate Change Strategy (Ministry), Environmental Protection Division (EPD) has reason to believe pollution is occurring from the property at 100 Blackberry Drive, in Anmore, British Columbia. The believed source is the subsurface disposal fields of the wastewater treatment works owned by Strata Plan LMS 3080 (Owners), authorized under effluent discharge permit, PE-04606 (Permit).

Based on the *E.Coli* and *fecal coliform* assay results submitted to the Ministry by Associated Environmental on behalf of the Owners in October 2017, the Ministry has reason to believe that pollution is occurring by way of septic effluent daylighting from the cut-bank on the downgradient neighbouring property. The neighbouring property is under a permit sharing agreement between School District 43 and the City of Port Moody, whereas both parties are responsible for construction, maintenance, operations or use. The property is the location of Heritage Woods Secondary School and Northshore Community Park (herein referred to as School District/Port Moody Property).

Assay results from soil sampling conducted in response to the Ministry's Warning Letter dated March 07, 2017 (IR-45701), indicated *E.Coli* and *fecal coliforms* levels of 160,000 MPN/g in soil of the exposed slope on School District/Port Moody Property, southwest of the wastewater effluent infiltration field. A Ministry onsite inspection on November 1, 2017, verified discolouration of the soil and rocks, and impacts to vegetation on the exposed slope, likely due to the migration of effluent discharged from the authorized works of PE-04606.

An engineering assessment was also completed in response to the Ministry's Warning Letter dated March 07, 2017 (IR-45701). It concluded that reconstruction of the disposal fields within the existing systems footprint is not possible under the current Municipal Wastewater Regulation.

BACKGROUND:

On December 21, 2016, the authorized works and semi-annual data summary reports of PE-04606 were inspected by EPD staff in response to a complaint alleging open sewage effluent discharging onto the School District/Port Moody Property. That inspection (IR-45701) determined that the facility was in violation of the *Environmental Management Act* due to non-compliance with effluent quality requirements and non-compliance with facility classification and certification requirements. At the time of the December 21, 2016 inspection, the alleged unauthorized discharge of untreated septic effluent onto School District/Port Moody Property was not visible to Ministry staff due to snow cover and therefore compliance could not be determined at that time.

ORDER:

Based on the review of available information, I am satisfied on reasonable grounds that the ongoing unauthorized breakout of effluent from the subject infiltration field onto the neighbouring School District/Port Moody Property is causing pollution.

Accordingly, pursuant to Section 83 of the *Environmental Management Act*, Owners of Strata Plan LMS 3080 are hereby ordered to comply with the following requirements:

1. Retain suitably qualified professionals to develop and submit for Director's approval, an Action Plan detailing measures to be taken to implement pollution abatement activities; this must be submitted by **December 31, 2017**.
2. Immediately take action to engage with SD43 and Port Moody to implement impacted zone management actions to mitigate risk to human health, by installing temporary fencing to prevent public access to the cut banks, and post warning signage.
3. Prepare and submit a formal written report by **March 1, 2018**. The report is to include at a minimum:
   a) A description of contamination delineation, mitigation measures, cleanup activities, site restoration and management actions that were implemented;
   b) Recommendations for ongoing restoration, mitigation and monitoring, if appropriate and the long term plan to address the source of pollution and any remaining risk resultant from the sewage breakout; and
   c) A list of all qualified professionals who contributed to the report, and a summary of their qualifications;

Ministry of Environment and Climate Change Strategy
Environmental Protection Division
Regional Operations Branch
Compliance Section
Mailing Address:
200 – 10470 152 Street
Surrey BC V3R 0Y3
Telephone: 604 582-5200
Facsimile: 604 930-7119
Website: www.gov.bc.ca/env

A qualified professional is defined as:

> An applied scientist or technologist specializing in a particular applied science or technology,
> (a) who is registered in British Columbia with the professional organization responsible for his or her area of expertise, acting under that professional association's code of ethics and subject to disciplinary action by that association, and
> (b) who, through suitable education, experience, accreditation and knowledge, may be reasonably relied on to provide advice within his or her area of expertise as it relates to this regulation,

This order will remain in effect until instructed otherwise in writing by the Director.

Failure to comply with the requirements of this order is a contravention of the *Environmental Management Act* and may result in legal action. I direct your attention to Section 120(10) of the *Environmental Management Act*, which reads:

> "(10) A person who contravenes an order...that is given, made or imposed under this Act by a ...director...commits an offence and is liable on conviction to a fine not exceeding $300 000 or imprisonment for not more than 6 months, or both."

Failure to comply with the requirements of this order may also result in an administrative penalty under the Administrative Penalties Regulation (*Environmental Management Act*) (B.C. Reg 133/2014) (Regulation). I direct your attention to Section 12(4) of the Regulation, which reads:

> "(4) A person who fails to comply with an order under the [*Environmental Management*] Act is liable to an administrative penalty not exceeding $40 000."

This order does not authorize entry upon, crossing over, or use for any purpose of private or crown lands or works, unless and except as authorized by the owner of such lands or works. The responsibility for obtaining such authority rests with you. It is also your responsibility to ensure that all activities are carried out with due regard for the rights of third parties, and comply with other applicable legislation that may be in force, such as municipal bylaws relating to the discharge of waste to municipal storm or sanitary sewers.

This decision may be appealed to the Environmental Appeal Board in accordance with Part 8 of the *Environmental Management Act*. An appeal must be delivered within 30 days from the date notice is given. For further information, please contact the Environmental Appeal Board at (250) 387-3464.

If you have any questions, please call the undersigned at (250) 398-4545 or Stewart Paterson at (778) 879-1827.

Yours truly,

Daniel P. Bings
for Director, *Environmental Management Act*
Environmental Protection Division
Regional Operations Branch
Compliance Section

Appendix 5

Drawing Showing Location of Municipal Right-of-Way for Groundwater Interception Drain

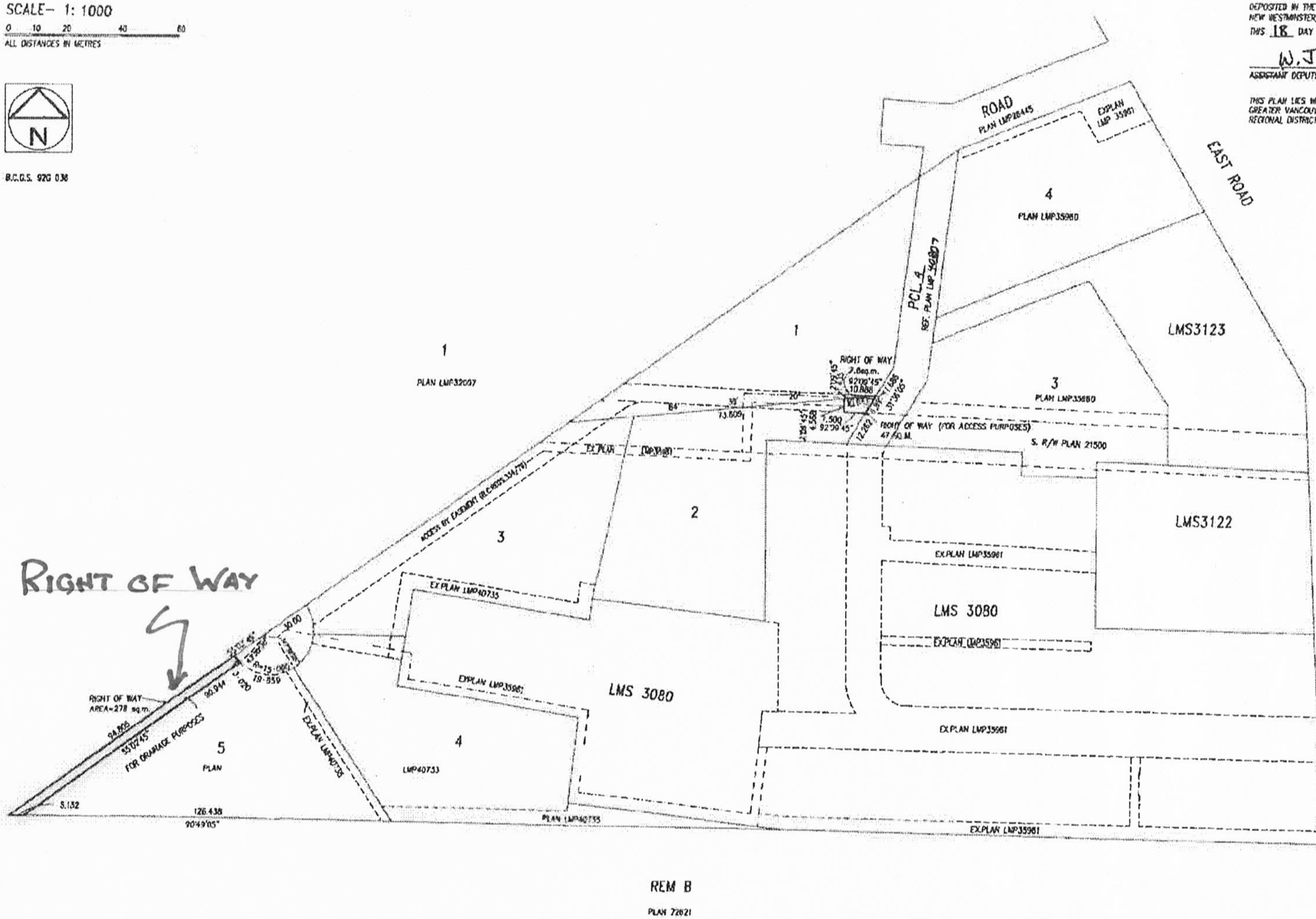
EXPLANATORY PLAN OF STATUTORY RIGHTS OF WAY OVER A PORTION OF LOTS 1, 2 AND 5, ALL OF SECTION 16, TOWNSHIP 39, NEW WESTMINSTER DISTRICT PLAN LMP40733

SCALE– 1: 1000
0 10 20 40 80
ALL DISTANCES IN METRES

B.C.G.S. 92G 038

PLAN LMP 40734
Ref. No. BN11564
DEPOSITED IN THE LAND TITLE OFFICE AT NEW WESTMINSTER, B.C.
THIS 18 DAY OF January 1999
W.J. Smallpeiece [signature]
ASSISTANT DEPUTY REGISTRAR

THIS PLAN LIES WITHIN THE GREATER VANCOUVER REGIONAL DISTRICT



LEGEND
BEARINGS ARE ASTRONOMIC AND ARE DERIVED FROM PLAN LMP35950
sq.m. INDICATES SQUARE METRES

CERTIFIED CORRECT ACCORDING TO THE LAND TITLE OFFICE RECORDS THIS 9th DAY OF OCTOBER 1998.
[signature]
B.C.L.S.

FILE NO. 14542EX5 | OLSEN & ASSOCIATES BRITISH COLUMBIA LAND SURVEYORS | 204 – 15585 24th AVENUE, SURREY, B.C. V4A 2J4 | TELEPHONE : 531 – 4067 | FAX : 531-5811