CITY OF WINNIPEG
BIOSOLIDS LAND APPLICATION
PILOT PROGRAM
SUMMARY REPORT

DECEMBER 22, 2017

April 12, 2018 This report has been amended to protect privacy of cooperating individuals.

CITY OF WINNIPEG BIOSOLIDS LAND APPLICATION

PILOT PROGRAM

SUMMARY REPORT

CITY OF WINNIPEG

PROJECT NO.: 17M-00008-00
DATE: DECEMBER 22, 2017

WSP
1600 BUFFALO PLACE
WINNIPEG, MB, CANADA R3T 6B8

T: +1 204 477-6650
F: +1 204 474-2864
WSP.COM

WSP CANADA GROUP LIMITED

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1 INTRODUCTION

The City of Winnipeg (City) is currently implementing several strategies that support diverting Class B biosolids produced at the City's sewage treatment plants from disposal at the Brady Road Resource Management Facility (Brady Facility) to programs that support the beneficial reuse and recycling of the biosolids. As such, the City is currently pursuing an Environment Act License in support of a full-scale biosolids land application program as one means of reusing biosolids. In order to assess the logistics and demonstrate the feasibility of a full-scale land application program, the City executed a small-scale land application pilot program between September and October 2017.

1.1 OBJECTIVE

The purpose of the pilot program was to demonstrate the feasibility of a land application program for biosolids in support of a full-scale program to be undertaken by the City starting in 2018 (with regulatory approval) and to demonstrate the effectiveness of the program for re-using nutrients in the biosolids to agricultural producers, to rural municipalities (RM) of Macdonald, Rosser and Cartier and to other stakeholders/interested parties.

1.2 ENVIRONMENTAL APPROVAL AND PUBLIC NOTIFICATION

In June 2017, the City submitted a notice of alteration (NOA) to their current Environment Act License (EAL) 1089E RR (sludge de-watering system, temporary storage of biosolids, transportation of biosolids and land application) to the Manitoba Sustainable Development (MSD), Environmental Approvals Branch (EAB) requesting approval to conduct a pilot program for the land application of approximately 5,000 wet tonnes of Class B biosolids. Approval for the pilot program was received from the EAB on September 19, 2017 (letter attached in Appendix A) with four conditions applied.

The following four conditions were applied:

1. Biosolids and all associated materials shall be transported between the North End Water Pollution Control Centre (NEWPCC) and the sites of the Biosolids Land Application Program pilot in covered containers so as to prevent the loss of biosolids and associated liquids to the satisfaction of the assigned Environment Officer;
2. The initial application rate for this pilot shall be based on an estimate of 25% of total phosphorus being plant available. The Director may approve requests for alternative proposed application rates based on new information obtained and submitted for consideration during and subsequent to the pilot. Land application based on two times annual crop removal of phosphorus is permitted;
3. A report summarizing all activities and results associated with this Biosolids Land Application Program pilot shall be submitted to the Environmental Approvals Branch, Manitoba Sustainable Development by not later than December 29, 2017; and
4. This approval shall terminate January 31, 2018.

The biosolids pilot program was managed in accordance with the Manitoba regulatory framework, the following Acts and Regulations were adhered to throughout the pilot program:

- The *Environment Act* C.C.S.M. c. E125 (1987)
- *Livestock Manure and Mortalities Management Regulation* 42/98
- The *Water Protection Act* C.C.S.M. c. W65 (2005)
- *Nutrient Management Regulation* 62/2008
- EAL 1089E RR and pilot program approval letter – File 963.20 dated September 19, 2017 from Tracey Braun, Director, EAB.

Prior to the commencement of the pilot program, a "good neighbour" practice was implemented whereby letters of notification were hand-delivered to all adjacent landowners. The letters provided an overview of the pilot program and advised adjacent landowners to visit the City's project website for additional information regarding the overall biosolids land application project and to contact the WSP Public Engagement Lead with any concerns or comments. A log of all letters delivered was recorded by WSP staff. A copy of the letter of notification to adjacent landowners is included in Appendix B. The Municipal Council of the RM of Macdonald was also notified via letter, of the pilot program by the City. In addition, warning signs were also posted at the entrance to the field access to the pilot application area, asking the public not to enter the area for health and safety purposes.

2 LAND SUITABILITY

2.1 PARTICIPATING AGRICULTURAL PRODUCER

During the Public Engagement Program, an agricultural producer in the RM of Macdonald was sourced to provide land for the pilot program. The participating agricultural producer for the pilot program land application was [redacted] with [redacted] (land use agreement is provided in Appendix C). The agricultural fields that received biosolids during the pilot program included NE31-8-1EPM and the north half of SE31-8-1EPM (refer to Figure 1). The crop rotation established for these fields by the producer is: oats or corn, then canola, then wheat followed by soybeans. In 2017, the crop was oats with a harvest yield of 157 bushels per acre (bu/ac) and the crop for 2018 will be canola with a target yield of 55 bu/ac.

2.2 CONSTRAINTS

The biosolids pilot program complied with requirements outlined in the MSD Approval Letter (File No. 963.20 dated September 19, 2017 [refer to Appendix A]) as well as all applicable regulations, including the provincial *Nutrient Management Regulation*, the *Water Protection Act*, the *Environment Act*, the *Livestock Manure and Mortalities Management Regulation* and the *Workplace Safety and Health Act*. As per environmental regulatory requirements, the biosolids pilot program met the following restrictions:

- The depth of clay or clay till was greater than 1.5m between the soil surface and water table based on the pedological development of the soil series.
- The dryland agricultural capability of the fields met regulatory requirements.
- Application field was:
  - Greater than 1000 metres (m) from a designated residential area;
  - Greater than 10 m from any property line of a property with a residence;
  - Greater than 8 m from a major wetland, bog, marsh or swamp;
  - Greater than 15 m from first order waterway, 30 m from a second order or higher waterway; and,
  - Greater than 50 m from any groundwater well.
- Land was not subject to annual inundation.

2.3 DOMINANT SOIL SERIES

A review of the soil survey report for the area was completed in order to ensure that the dryland agricultural capability of the agricultural fields receiving the biosolids met requirements as per the *Nutrient Management Regulation* (refer to Figure 1). Interpretation of the soil survey report indicated that the dominant soil series identified in the agricultural fields includes: Red River, Osborne (RIV7-OBOd3) and Myrtle and Scanterbury (MYT5-SCY5) (Figure 1). Outlined in Table 1 are the classification of soil and the Canada Land Inventory for dryland agricultural capability for each of the four identified soil series. None of the dryland agricultural capabilities precluded the fields or areas within the fields from being included in the land application pilot program.

Table 1. Four Soil Series Identified within NE and SE31-08-1EPM

Order	Great Group	Subgroup	Soil Series, Family Description	Dryland Agricultural Capability
Chernozemic - Soils with chernozemic Ah horizon more than 10 cm thick and with B or C of high base saturation divalent cations, calcium usually common. Well to imperfectly drained soil.	Black horizon with dry colour Munsell values darker than 3.5	Orthic Black	**Myrtle** (MYT) well to moderately well drained Orthic Black soil developed on moderately to strongly calcareous fine textured lacustrine and alluvial deposits.	Class 1, No limitations
		Gleyed Black	**Scanterbury** (SCY) developed on moderately to strongly calcareous lacustrine clay, Imperfectly drained	**2W**
		Gleyed Rego Black	**Red River** (RIV) developed on moderately to strongly calcareous lacustrine clay, Imperfectly drained.	2W
Gleysolic Poorly drained soils which may have an organic and/or an A horizon. The subsoils show gleying and are dull coloured, but may have brighter colored prominent mottles. Soils associated with wetness.	Humic Gleysol	Rego Humic	**Osborne** (OBO) developed on moderately to strongly calcareous lacustrine clay, poorly drained. Drained phase	3W

3 METHODOLOGY

3.1 TRANSPORT TO FIELD

In accordance with MSD NOA (September 19, 2017) condition #1, the biosolids were transported directly from the NEWPCC to the field by Wintec Building Services in enclosed highway transport units to prevent the loss of biosolids and associated liquids during transport. Specifics of the enclosed trailers are as follow; ejector trailer, sealed and gasket tailgate, rigid cover with four recessed load chutes, hydraulic operated end gate and 26 tonne capacity.

The Wintec highway transport units were compliant with Manitoba Infrastructure maximum gross vehicle weight restriction for the provincial highway and road network as required. The transport trucks travelled from the NorthEnd Sewage Treatment Plant (NEWPCC) to the field site via Main Street north, perimeter highway (PTH101), southwest on highway #3 and provincial road 334 or local municipal road as weather permitted.

3.2 NUTRIENT MANAGEMENT AND LAND APPLICATION PRESCRIPTIONS

The land application pilot program was completed in an agri-environmentally sustainable manner whereby the prescription rate for biosolids land application was:

1. Allied with the participating agricultural producer's fertilization and crop management practices.
2. Determined to target optimum available nitrogen and phosphorus levels for small grain – oil seed crops and to set metal loading limits for the agricultural fields in the application program.

These prescription rate objectives met the principals of environmentally sustainable land applications outlined by MSD and within the Canadian Council of Ministers of the Environment (CCME) Guidance Document for the *Beneficial Use of Municipal Biosolids, Municipal Sludge and Treated Septage* (December, 2012).

Prior to the development of the prescription rate for land application of the biosolids, soil samples from the participating agricultural fields were collected for analysis of existing nutrient and metal conditions. Sample analysis of the biosolids material was provided by the City of Winnipeg as outlined in Sections 3.2.1 and 3.2.2.

3.2.1 SOIL SAMPLES

Two bench mark, composite soil samples were collected for each quarter section (NE31-8-1EPM: W001 and W002; SE31-8-1EPM: W003 and W004) and UTM coordinates were recorded for each location (refer to Figure 1). Each composite soil sample was comprised of 10 sub samples and collected from two depths, 0-15 cm and 15-60 cm. Sample analysis parameters included:

Table 2. Soil Sample Analysis Parameters

Sample Analysis (0-15 cm)		Sample Analysis (15-60 cm)
Available Phosphate-P (Olsen)	Arsenic	Total Nitrogen
Available Potassium	Cadmium	Nitrate-N
Total Nitrogen	Chromium	Nitrate + Nitrite-N
Nitrate-N	Copper	Nitrate-N
Nitrate + Nitrite-N	Lead	
Nitrate-N	Mercury	
pH	Nickel	
	Zinc	

Laboratory results for the soil analysis are outlined in Tables 2, 3, 4, and 5 in Appendix D as part of the prescription rate determination and the Certificate of Analysis for the soil samples is included in Appendix E.

3.2.2 BIOSOLIDS ANALYSIS

As a component of the overall biosolids management program, the City maintains a comprehensive biosolids quality monitoring program by completing laboratory analysis for a wide spectrum of nutrients and metals. Biosolids analysis is completed every two weeks by the City's Laboratory and an independent laboratory, ALS Laboratory. A summary of the results are included in Table 6, Appendix D and the results are reported annually by the City as required by EAL #1089E RR. Appendix D also outlines the details regarding nutrient levels available in the City's biosolids in relation to determining the prescription rate for land application.

3.2.3 NUTRIENT MANAGEMENT PLAN

The prescription rates were submitted in a letter to MSD on September 11, 2017. Based on NOA approval, condition #2, the land application program was based on two times annual crop removal of phosphorous with an estimated 25% of total phosphorous being plant available. This approach to the prescription rate was applied and is outlined in Table 2 (Appendix D).

It is important to note that since 2007, the City's wastewater treatment process has included chemical treatment with the iron salt Ferric Chloride ($FeCl_3$) at the NEWPCC to precipitate total phosphorus out of the waste stream. The addition of $FeCl_3$ affects the availability of phosphorus for land application.

The 2018 crop is planned to be canola, with a target yield of 55 bu/ac, thus requiring an estimated 168 kg/ha (150 lb/ac) of nitrogen and 62 kg/ha (55 lb/ac) of P_2O_5 (Personal Communication with Cooperating Farm Producer). Canola nutrient uptake and removal of P_2O_5 is reported to be between 33 to 44 lbs/ac for a 35 bu/ac yield, this is approximately 1 lb P_2O_5 per bushel of canola or 55 lb/ac for the target yield (Manitoba Soil Fertility Guide, 2007).

The fall (2017) soil nutrient levels demonstrate a field nearly depleted in plant available nitrogen and phosphorus, therefore permitting an application rate that was sufficient for suitable redevelopment of the plants' nutrient base. The basic assumptions for the prescription rate are as follows:

- Fall 2017 soil residual nitrogen and phosphorus concentrations, while low, were accounted for as a resource for plant uptake and removal in the 2018 cropping year.
- Biosolids solids content was consistent at an average 27%.

$FeCl_3$ biosolids Phosphate-P was approximately 4% of total phosphorous content. The advised estimate of 25% total phosphorus was assumed for plant available phosphate.

- Organic nitrogen mineralization in Year 1 was estimated at 20%, Year 2 at 12% and Year 3 at 6%.
- Biosolids were surface applied and incorporated within 48 hours. The assumed volatilization loss was estimated to be 15% for ammonium-nitrogen.

This established a phosphate based application (123 kg/ha (110 lb/ac) of P_2O_5) of approximately 12 dry metric tonnes per hectare (48 wet metric tonnes per hectare) to provide 99 kg/ha (88 lbs/acre) of plant available nitrogen.

Based on review of literature, there is significant concern that the $FeCl_3$ biosolids will not meet the estimated plant available phosphate in year 1 due to the means that the iron salt will fix with the phosphorus ion and not allow it to be mineralized. Throughout the growing season of 2018 it is recommended that the crop be monitored for phosphorus deficiency and managed appropriately if identified. The cooperating farm producer has been advised of these potential effects of ferric chloride and anticipated deficiencies.

TRACE ELEMENT LOADING

Table 4 and 5, Appendix D outline the cumulative (soil + biosolids) trace element concentrations based on the land application loading rate of 12 dry metric tonnes per hectare. None of the metals required to be monitored exceed the applied cumulative weight permitted in both NE31 and SE31-08-01EPM based on the guideline established in the appendix of land application licences permitted by the Province of Manitoba.

3.3 LAND APPLICATION

The land application pilot program was initiated on September 21 and continued for approximately 22 days over six weeks. Biosolids were delivered from the NEWPCC to the application field site by the City's contractor, Wintec. The volume (number of truck loads) of biosolids delivered, and the timing of delivery varied each day based on the weather and the availability of biosolids. The quantity of biosolids available for land application was reduced due to the biosolids composting program and the maintenance of one of the NEWPCC sludge digesters. The application of 2,621 tonnes of biosolids took 22 days because there was a limited quantity of biosolids delivered to the site each day, and no means to store the biosolids. Table 7 provides the sequence of biosolids delivery and application with corresponding photographs:

Table 3. Summary of Land Application Methods

	1. Upon arrival at the field site the Wintec truck unloaded the biosolids onto the field edge.

2. After deposition of biosolids into a “windrow”, Assiniboine Injections (land application contractor) utilized a front-end loader adapted to collect the biosolids off of the ground and load them into the applicator.

3. Biosolids are then land spread via a calibrated applicator (spreader) towed by a tractor that is pre-programmed with GPS coordinates and auto-steer; both aspects act to produce an even "spread" of biosolids on the soil surface. Once spreading was complete, the participating agricultural producer incorporated the biosolids into the soil within 48 hours. Biosolids were applied over the east half of NE and north and east half of SE31-8-1EPM between September 21 and October 23, 2017. October 23 was selected as the cut-off date for application by the participating agricultural producer in order to allow for him to complete incorporation of the biosolids and complete the fall nutrient management program and seed bed preparations for spring 2018 of the land base utilized in the pilot program.

4 SUMMARY AND CONCLUSION

4.1 VOLUME AND RATE OF BIOSOLIDS APPLIED

Due to weather constraints and biosolids availability, in total, 2,621 wet metric tonnes of biosolids were applied on approximately 55 ha (135 ac) of land during the pilot program (Figure 2, Appendix F). Biosolids were spread over the east half of NE31-8-1EPM and the north and east half of SE31-8-1EPM between September 21 and October 23, 2017. Biosolids were applied at a rate of approximately, 12 dry metric tonnes per hectare or 48 wet metric tonnes per hectare based on the prescription rate calculated in Table 2 and 3, Appendix D. Also included in Appendix D are the City of Winnipeg report tables for September and October that record the number of loads transported to the field for land application.

4.2 SPILLS, ACCIDENTS AND MALFUNCTIONS

During the biosolids land application pilot program, no spills on or off the targeted agricultural fields occurred, no accidents or malfunctions occurred either. .

4.3 COMMENTS RECEIVED ON PILOT PROGRAM

The participating agricultural producer residence is located on SE31-08-01EPM along the south edge of the parcel. The participating agricultural producer had the following comments regarding the pilot application program:

- The application process could be improved if the biosolids were applied in a shorter period of time instead of over 22 days. This would improve efficiency for application and incorporation of the biosolids.
- During the application period (22 days), the producer noted there were two days when odour was observed, but would not consider it a significant concern.

Following the conclusion of the fall land application program, the City Project Manager reached out to the RM of Macdonald Council to further engage them as a stakeholder. The City met with the RM of Macdonald Council in early December, 2017 (Pers. Communication [redacted] December 20, 2017). At this meeting the City representatives received the following summary on the pilot application program:

- In the future, the RM Council would like to be involved in the site selection process.
- The RM Council felt that the application process could be shortened to improve efficiency and minimize odour
- The RM Council received a few local concerns about odour.
- The RM Council is open to participating in the land application for future years, as the program continues to improve efficiency, site selection processes and good neighbor practices.

During the application process, the City did not receive any feedback from the public through the project phone number or email address.

4.4 FOLLOW-UP MONITORING AND REPORTING

As required under the Notice of Alteration for EAL 1089E RR, by December 29, 2017 the City is required to provide the MSD EAB with a report that outlines the details of the 2017 pilot program including: location, spread area, tonnes applied, application rates and dates, total land applied volumes and any deviations from the original prescription rate letter submitted to MSD on September 11, 2017.

In addition, for three years following the biosolids land application pilot program, annual post-harvest soil testing of each field (NE and SE31-8-1EPM) at the bench mark sample locations will be completed for nitrate-N (0-60cm) and phosphorus using the Olsen-P test (0-15 cm). Supplemental information from the participating agricultural producer including the nutrient management program and cropping system employed will also be provided to MSD. .

In addition, throughout the 2018 growing season, it is recommended that the crop be monitored for potential phosphorus deficiency and managed appropriately if deficiencies are identified.

The annual monitoring information will be provided to MSD before the 15th day of March of each year.

4.5 CONCLUSION

The 2017 pilot program demonstrated the feasibility of biosolids land application in terms of providing an agri-environmentally sustainable means of biosolids re-use.

Upon regulatory approval, the land application program will continue to address questions about nutrient availability, specifically phosphorus availability from the biosolids, and continue to improve the logistics and efficiency of the application process including field storage and odour management, including the development of best neighbour practices.

APPENDIX

A REGULATORY APPROVAL LETTER TO PROCEED WITH PILOT PROGRAM

Manitoba
Sustainable Development
Environmental Stewardship Division
Environmental Approvals Branch
123 Main Street, Suite 160, Winnipeg, Manitoba, Canada R3C 1A5
T 204 945-8321 F 204-945-5229
www.gov.mb.ca/sd/eal

File: 963.20

September 19, 2017

Chris Carroll, P.Eng.
Manager of Wastewater Services Division
City of Winnipeg
109 – 1199 Pacific Avenue
Winnipeg, MB R3E 3S8

Dear Chris Carroll:

Re: City of Winnipeg Biosolids Land Application Program Pilot

I am responding to the September 11, 2017 letter regarding the City of Winnipeg's Biosolids Land Application Program pilot. The letter and attachments provide information regarding prescription rates, the cooperating farm producer, land use agreements, site, dominant soils and assumptions and constraints regarding the nutrient management program relative to this application program pilot. Environment Act Licence No. 1089E RR applies to these activities.

My March 10, 2016 letter to the City presented the requirement that the City implement a biosolids land application program by 2017. Since then, the City has held meetings, public forums and a workshop. The City submitted a Notice of Alteration (NoA) dated June 8, 2017 that formed the basis for this biosolids land application program pilot.

Upon consideration of the request for approval of this Biosolids Land Application Program pilot, I have decided, pursuant to Section 14(2) of The Environment Act, to approve the request subject to the following conditions:

1. Biosolids and all associated materials shall be transported between the North End Water Pollution Control Centre (NEWPCC) and the sites of the Biosolids Land Application Program pilot in covered containers so as to prevent the loss of biosolids and associated liquids to the satisfaction of the assigned Environment Officer;

2. The initial application rate for this pilot shall be based on an estimate of 25% of total phosphorus being plant available. The Director may approve requests for alternative proposed application rates based on new information obtained and submitted for consideration during and subsequent to the pilot. Land application based on two times annual crop removal of phosphorus is permitted;

3. A report summarizing all activities and results associated with this Biosolids Land Application Program pilot shall be submitted to the Environmental Approvals Branch, Manitoba Sustainable Development by not later than December 29, 2017; and

4. This approval shall terminate January 31, 2018.

All other previously approved proposed and imposed conditions, limitations and requirements remain in place during this pilot.

If you have any questions or would like to discuss matters pertaining to this Biosolids Land Application Program pilot, the continuing development of the land applications of biosolids program, or the Biosolids Master Plan in general, please contact Robert Boswick, Environmental Engineer, at 204-945-6030 or Robert.Boswick@gov.mb.ca.

Yours sincerely,

Tracey Braun

Tracey Braun, M.Sc.
Director

c. Duane Griffin, P.Eng. – Water and Waste Department, City of Winnipeg
Darren Keam, P. Eng., - WSP
Don Labossiere/Donna Smiley – Environmental Compliance and Enforcement Branch, Manitoba Sustainable Development
Siobhan Burland Ross/Robert Boswick/Asit Dey – Environmental Approvals Branch, Manitoba Sustainable Development
Public Registries

APPENDIX

B ADJACENT LAND OWNER NOTIFICATION LETTER EXAMPLE AND LOG

Notice of Biosolids Land Application Program

City of Winnipeg Biosolids Land Application Program

The City of Winnipeg is starting a biosolids land application pilot program in September 2017. Biosolids will be applied daily (Monday through Friday) for approximately six weeks on the farmland (field 4) identified in the map below. Biosolids will be applied to the surface of the fields and tilled within 48 hours for proper odour and nutrient management.

Biosolids are a nutrient-rich, solid by-product of wastewater treatment. At the City's sewage treatment plants, the solids are separated from the liquid wastewater. These solids, also known as sludge, are further treated and dewatered. After treatment, the solids are called biosolids.

Biosolids land application means applying biosolids to soil to supply nutrients and improve soil structure. Land application is a widely accepted method to reuse biosolids. The City's pilot program will apply approximately 5,000 tonnes of biosolids to local farmland in 2017. Biosolids land application is regulated by the Province of Manitoba through the Nutrient Management Regulation and a project specific Environment Act Licence which outline requirements for soil suitability, timing of application, rate of application, setback distances and nutrient management monitoring.

Application rates will be matched to crop uptake and removal for crop nitrogen and phosphorus. These rates will be developed by a registered Professional Agrologist and follow the principles of 4R Nutrient Stewardship, including the use of the right fertilizer source at the right rate, at the right time and in the right place.

Your local municipality is aware of the biosolids land application pilot program being completed by the City.

For more information, please visit the project website: winnipeg.ca/BiosolidsLandApplication

If you have any questions or comments about the program, please contact Brock Feenstra, Public Engagement Lead with WSP Canada, the consulting firm for this project, at BiosolidsLandApplication@winnipeg.ca or 1-888-882-3391.

Notice of Biosolids Field Storage Assessment Delivery Log

Legal Land Location	Parcel Index Owner	Date/Time Notice Delivered	Initials
01-10-01E			
SW01-10-01E	CA & ND & HE&JG Froese		
02-10-01E			
B, 1-25570	Sharon D. Klassen		
35-09-01E			
G	Dallas V. & Malvenia Muir		
RM Headingly Hall Road	~~Hall Road~~		
700 ~~Datomar~~ Hall Road.		Sept. 6/17 8:30	Bm.
	Dan New Anything	" "	BM
	Datomar Motor Sales	" 9:00	Bm.
	Saber Industries	" 9:00	Bm.
	M&M Teske Ltd.	" "	Bm
10 Datomar Rd.	Whitewater Logistics	" "	Bm.
6 Datomar Rd.	EWC	" 9:05	BM
2 Datomar Rd		" "	Bm.
17 Sabrina Way	Southend concrete.	" "	BM
6 Sabrina Way	Prairieview Terminals Ltd	" 9:10	Bm.
14 Wanda Way	Green Opportunities	" 9:15	Bm.
? Diedmann Way	Detailing?	" 9:15	Bm
? " "	? new	" "	Bm.
4 Diedmann	Evrane Cuys	locked, not delivered no access	
8316 Wilkes.	Superior Propane	Sept. 6/17 9:25	Bm.
5 005	? Vacant.	" 9:35	Bm.
4' 164	dog		
4 155	?	" 9:38	BM

Notice of Biosolids Land Application Program Delivery Log

Legal Land Location	Parcel Index Owner	Date/Time Notice Delivered	Initials
Section 30-08-01E			
E, 7-16661 & DESC	Edward Bergen		
D 3, 4, 5&6-16661	Donald B. Boyd		
C 2-16661	John & Mary Hamer		
B 1-16661 54	David G & Lucette M. Barber	2017-09-11 4:50	BM
Section 31-08-01E			
D, 1-20771	Paul Kennedy		
E	Philip S. Hassock & Tesia A Brooks		
B	G.H. Reimer & A.M. Yaskiw		
Section 36-08-01W			
E, 1-24934	Edna Jean MacMillan		
D, A-40184	Jeffrey P. Watson & Kelly L. Bentley		
68 Verlie		2017-09-11 4:45	BM
56 Verlie		"	BM
[illegible]			
40 Verlie		2017-09-11 4:55	BM
22 Verlie		" 5:00	BM
9 Verlie		" 5:05	BM
47 036		" "	BM
47 039		5:10	BM
47 076		" "	BM
47 100	dog		

APPENDIX

C LAND USE AGREEMENT

Land Use Agreement removed to address privacy concerns.

APPENDIX

D

LAND APPLICATION SUPPORTING DOCUMENTATION

Table 2. Field Prescription Application Rate, NE31-08-01EPM

Sept. 20, 2017

Based on Total P as directed by MSD.

Field ID:	NE31-08-01EPM	
Land Area Available (ha):		64
2018 Crop	Canola	
2018 Target Yield:	55 bu/ac	
	lb/ac	kg/ha
Target Nitrogen total less soil residual:	135	151
Fertilizer Phosphate (P2O5) total less soil residual:	40	45
1 x P2O5 Crop Removal @ target Yield:	55	62
2 x P2O5 Crop Removal @ target Yield:	110	123
3 x P2O5 Crop Removal @ target Yield:	165	185
Sulfate-S target:	20	22

Plant Available Nutrients Soil Test Data				
	W0001	**W0001**		
Sample Depth	0-15 cm	15-60 cm	Total Available	Total Available
Units	mg kg^{-1}		kg ha-1	lb/ac
Total Nitrogen	0.318	0.202		
Available Nitrate-N	02.6	2	17	15
Available Phosphate-P	12.6		25	22
Available Potassium	418		836	744
Available Sulfate-S			-	
	W0002	**W0002**		
Sample Depth	0-15 cm	15-60 cm	Total Available	
Units	mg kg^{-1}		kg ha-1	
Total Nitrogen	0.238	0.254		
Available Nitrate-N	02.0	2	16	
Available Phosphate-P	07.0		14	
Available Potassium	309		618	
Available Sulfate-S			-	

City of Winnipeg Biosolids Characteristics and Analysis

Parameter Name	Parameter Description	Unit	Biosolid Analysis Pilot Project
Estimated Biosolid Volume	In-field	m^3	5,000
Specific Gravity	As Received	g cm^{-1}	1.00
Estimated Biosolids		tonnes	5,000
Dry tonnes biosolids available (=wet tonnes x %solids)	Dried Basis	tonnes	1,345
Moisture	As Received	**%**	73.1
Total Solids	As Received	**%**	26.9
Total Volatile Solids	Dry Basis	%	
Organic Matter	Dry Basis	%	-
Inorganic Content	Dry Basis	%	-
Total Organic Carbon	Dry Basis	%	29.42
N:P Ratio	Dry Basis	x:1	2.14
pH	Saturated Paste		6.15
Total N	Dried Basis	%	3.8
	Dried Basis	mg kg^{-1}	38,014
	Dried Basis	kg $Tonne^{-1}$	38.0
Ammonium - N (NH4-N)	wet	mg kg-1	4,795.0
	Dried Basis	mg kg^{-1}	1,290.4
	Dried Basis	kg $Tonne^{-1}$	1.3
Available Nitrate-N	Dried Basis	mg kg^{-1}	3.77
Available Nitrate-N		kg $Tonne^{-1}$	0.004
Total Phosphorous	Dried Basis	mg kg^{-1}	17,789
Phosphate-P (Modified Kelowna solution)	Dried Basis	mg kg-1	623
Total P:Phosphate-P ratio	Dried Basis	x:1	29
Percent Phosphate of Total		%	4

Amount of Biosolids Nutrient Available to Crop

Organic N (=TN-ammonium N)	Dried Basis	mg kg^{-1}	36,724
Organic N	Dried Basis	kg $Tonne^{-1}$	37
Method of Application:			Incorporated
Anticipated Weather			Cool/dry
Anticipated Volatilization (%)	within 1 day		15
Available Organic N (@ 20%)	Dried Basis	kg $Tonne^{-1}$	7.3
Ammonium nitrogen available	Dried Basis	kg $Tonne^{-2}$	1.10
Plant Available Nitrogen (PAN) (Year 1)	Dried Basis	kg $Tonne^{-1}$	8.4
PAN Year 2 (@12% mineralization)	Dried Basis	kg $Tonne^{-1}$	4.4
PAN Year 3 (@6% mineralization)	Dried Basis	kg $Tonne^{-1}$	2.2
Phosphorous	Dried Basis	kg $Tonne^{-1}$	17.8
$P_2O_{5\ equivalent}$	Dried Basis	kg $Tonne^{-1}$	40.9
Total Available P_2O_5	Dried Basis	kg $Tonne^{-1}$	10.2

Application Rate based on Nitrogen				**Land Area Required**
Nitrogen Based Application Rate	Dried Basis	tonnes ha^{-1}	18	**75** Ha
Amount of Available P2O5 applied	Dried Basis	kg ha^{-1}	183	186 Ac
P_2O_5 Application check		%	408	
Application Rate based on Phosphorous (1xCR)				**Land Area Required**
Total Phosphorus Based Application Rate	Dried Basis	tonnes ha^{-1}	6	**223** Ha
Amount of Nitrogen applied	Dried Basis	kg ha^{-1}	51	**552** Ac
		lb ac^{-1}	45	
Additional Nitrogen required		kg ha^{-1}	100	
		lb ac-1	89	
Application Rate based on Phosphorous (2xCR)				**Land Area Required**
Total Phosphorus Based Application Rate	Dried Basis	tonnes ha^{-1}	**12**	**112** Ha
Amount of Nitrogen applied	Dried Basis	kg ha^{-1}	102	**276** Ac
Additional Nitrogen required		kg ha^{-1}	49	
Application Rate based on Phosphorous (3xCR)				**Land Area Required**
Total Phosphorus Based Application Rate	Dried Basis	tonnes ha^{-1}	**18**	**74** Ha
Amount of Nitrogen applied	Dried Basis	kg ha^{-1}	153	**184** Ac
Additional Nitrogen required		kg ha^{-1}	- 2	

Selected Application rate based on:		**2x CR P**	
Selected Application Rate	Dried Basis	tonnes ha^{-1}	**12**
		tons ac^{-1}	**5**
	Wet Basis	tonnes ha^{-1}	48
		tons ac^{-1}	21
Estimated Biosolids Volume Applied	Wet	Tonnnes	3,041
Estimated Biosolids Volume Remaining	Wet	Tonnes	1,959

Notes

Available Ammonium N - Volatilization loss associated with different application methods (0% with Injection)

Organic N - TKN - Ammonium N

Available Organic N - Organic N x 0.20 year 1 (Ross and Racz, 2003)

Mineralization of Year 2 = 12%, Year 3 = 6%

Plant Available Nitrogen= (NO3-N)+Volatilization factor (NH4-N)+Organic N Mineralization

Estimated P2O5 Available based on 25% of total Phosphorus as directed by MSD.

Note: the biosolids are FeCl treated and fixes the majority of the total P.

Soil Phosphorous Olsen method.

* See Estimates of Ammonium-N Retained After Biosolids application

Table 3. Field Prescription Application Rate, SE31-08-01EPM

Sept. 20, 2017

Based on Total P as directed by MSD.

Field ID:	SE31-08-01EPM	
Land Area Available (ha):		25
2018 Crop	Canola	
2018 Target Yield:	55 bu/ac	
	lb/ac	kg/ha
Target Nitrogen total :	150	168
Fertilizer Phosphate (P2O5) total:	40	45
1 x P2O5 Crop Removal @ target Yield:	55	62
2 x P2O5 Crop Removal @ target Yield:	110	123
3 x P2O5 Crop Removal @ target Yield:	165	185
Sulfate-S target:	20	22

Plant Available Nutrients Soil Test Data			
	W0003	**W0003**	
Sample Depth	0-15 cm	15-60 cm	Total Available
Units	mg kg^{-1}		kg ha-1
Total Nitrogen	0.29	0.186	
Available Nitrate-N	02.0	2	16
Available Phosphate-P	09.0		18
Available Potassium	390		780
Available Sulfate-S			-
	W0004	**W0004**	
Sample Depth	0-15 cm	15-60 cm	Total Available
Units	mg kg^{-1}		kg ha-1
Total Nitrogen	0.333	0.202	
Available Nitrate-N	02.0	2	16
Available Phosphate-P	17.3		35
Available Potassium	430		860
Available Sulfate-S			-

City of Winnipeg Biosolids Characteristics and Analysis

Parameter Name	Parameter Description	Unit	Biosolid Analysis Pilot Project
Estimated Biosolid Volume	In-field	m^3	5,000
Specific Gravity	As Received	g cm^{-1}	1.00
Estimated Biosolids		tonnes	5,000
Dry tonnes biosolids available (=wet tonnes x %solids)	Dried Basis	tonnes	1,342
Moisture	As Received	**%**	73.1
Total Solids	As Received	**%**	26.8
Total Volatile Solids	Dry Basis	%	
Organic Matter	Dry Basis	%	-
Inorganic Content	Dry Basis	%	-
Total Organic Carbon	Dry Basis	%	29.70
N:P Ratio	Dry Basis	x:1	2.10
pH	Saturated Paste		6.15
Total N	Dried Basis	%	3.8
	Dried Basis	mg kg^{-1}	38,014
	Dried Basis	kg $Tonne^{-1}$	38.0
Ammonium - N (NH4-N)	wet	mg kg-1	4,795.0
	Dried Basis	mg kg^{-1}	1,290.4
	Dried Basis	kg $Tonne^{-1}$	1.3
Available Nitrate-N	Dried Basis	mg kg^{-1}	3.77
Available Nitrate-N		kg $Tonne^{-1}$	0.004
Total Phosphorous	Dried Basis	mg kg^{-1}	18,097
Phosphate-P (Modified Kelowna solution)	Dried Basis	mg kg-1	637
Total P:Phosphate-P ratio	Dried Basis	x:1	28
Percent Phosphate of Total		%	4

Amount of Biosolids Nutrient Available to Crop

Organic N (=TN-ammonium N)	Dried Basis	mg kg^{-1}	36,724
Organic N	Dried Basis	kg $Tonne^{-1}$	37
Method of Application:			Incorporated
Anticipated Weather			Cool/dry
Anticipated Volatilization (%)	within 1 day		15
Available Organic N (@ 20%)	Dried Basis	kg $Tonne^{-1}$	7.3
Ammonium nitrogen available	Dried Basis	kg $Tonne^{-2}$	1.10
Plant Available Nitrogen (PAN) (Year 1)	Dried Basis	kg $Tonne^{-1}$	8.4
PAN Year 2 (@12% mineralization)	Dried Basis	kg $Tonne^{-1}$	4.4
PAN Year 3 (@6% mineralization)	Dried Basis	kg $Tonne^{-1}$	2.2
Phosphorous	Dried Basis	kg $Tonne^{-1}$	18.1
$P_2O_{5\ equivalent}$	Dried Basis	kg $Tonne^{-1}$	41.6
Total Available P_2O_5	Dried Basis	kg $Tonne^{-1}$	10.4

Application Rate based on Nitrogen				Land Area Required
Nitrogen Based Application Rate	Dried Basis	tonnes ha^{-1}	20	**67** Ha
Amount of Available P2O5 applied	Dried Basis	kg ha^{-1}	207	167 Ac
P2O5 Application check		%	462	
Application Rate based on Phosphorous (1xCR)				**Land Area Required**
Total Phosphorus Based Application Rate	Dried Basis	tonnes ha^{-1}	6	**227** Ha
Amount of Nitrogen applied	Dried Basis	kg ha^{-1}	50	**560** Ac
		lb ac^{-1}	44	
Additional Nitrogen required		kg ha^{-1}	118	
		lb ac-1	105	
Application Rate based on Phosphorous (2xCR)				**Land Area Required**
Total Phosphorus Based Application Rate	Dried Basis	tonnes ha^{-1}	**12**	**113** Ha
Amount of Nitrogen applied	Dried Basis	kg ha^{-1}	100	**280** Ac
Additional Nitrogen required		kg ha^{-1}	68	
Application Rate based on Phosphorous (3xCR)				**Land Area Required**
Total Phosphorus Based Application Rate	Dried Basis	tonnes ha^{-1}	**18**	**76** Ha
Amount of Nitrogen applied	Dried Basis	kg ha^{-1}	150	**187** Ac
Additional Nitrogen required		kg ha^{-1}	18	

Selected Application rate based on:		Phosphorus	PAP Year 1
Selected Application Rate	Dried Basis	tonnes ha^{-1}	**12**
		tons ac^{-1}	**5**
	Wet Basis	tonnes ha^{-1}	47
		tons ac^{-1}	21
Estimated Biosolids Volume Applied	Wet	Tonnnes	1,170
Estimated Biosolids Volume Remaining	Wet	Tonnes	3,830

Notes

Available Ammonium N - Volatilization loss associated with different application methods (0% with Injection)

Organic N - TKN - Ammonium N

Available Organic N - Organic N x 0.25year 1

Mineralization of Year 2 = 12%, Year 3 = 6%

Plant Available Nitrogen= (NO3-N)+Volatilization factor (NH4-N)+Organic N Mineralization

Plant Available Phosphorus based on P2O5 (Modified Kelowna Analysis) as the biosolids are FeCl treated and fixes the majority of the total P.

Soil Phosphorous Olsen method.

* See Estimates of Ammonium-N Retained After Biosolids application

Table 4. City of Winnipeg Biosolid Trace Elements (Metal) Field Specific Soil Metal Concentrations and Cumulative Metal Concentrations

Trace Element	City of Wpg Average Concentration		NE31-8-1E (0-15cm) W001		NE31-8-1E (0-15cm) W002		Mean Soil Metal Concentration	Loading Rate 12 Tonnes / Ha (dry)	Cumulative Metal Concentration	Cumulative Weight Allowed by Guideline[2]
	mg kg^{-1}	kg $tonne^{-1}$	mg kg^{-1}	kg ha^{-1}	mg kg^{-1}	kg ha^{-1}	kg ha^{-1}	kg ha^{-1}	kg ha^{-1}	kg ha^{-1}
Arsenic (As)	4.34	0.00	8.99	0.009	9.06	0.009	0.01	0.052	0.06	21.6
Cadmium (Cd)	2.25	0.00	0.20	0.000	0.20	0.000	0.00	0.000	0.00	2.5
Chromium (Cr)	117.57	0.12	44.5	0.045	48.6	0.049	0.05	0.000	0.05	115.2
Copper (Cu)	590.93	0.59	32.2	0.032	30.6	0.031	0.03	0.000	0.03	113.4
Lead (Pb)	70.67	0.07	15.1	0.015	13.6	0.014	0.01	0.000	0.01	126
Mercury (Hg)	1.01	0.00	00.0	0.000	00.0	0.000	0.00	0.000	0.00	11.9
Nickel (Ni)	53.20	0.05	44.0	0.044	44.8	0.045	0.04	0.000	0.04	90
Zinc (Zn)	1412.31	1.41	092	0.092	93.0	0.093	0.09	0.000	0.09	360

Notes:

Max loading rate calculated

[1] = Soil concentrations less than detection

[2] = Cumulative Weight Allowed by Guideline includes the metals in soils.

Recommended Appliction Loading rate: 12 Tonnes/Ha (dry)

Table 5. City of Winnipeg Biosolid Trace Elements (Metal) Field Specific Soil Metal Concentrations and Cumulative Metal Concentrations

Trace Element	City of Wpg Average Concentration		SE31-8-1E (0-15cm) W003		SE31-8-1E (0-15cm) W004		Mean Soil Metal Concentration	Loading Rate 12 Tonnes / Ha (dry)	Cumulative Metal Concentration	Cumulative Weight Allowed by Guideline[2]
	mg kg^{-1}	kg $tonne^{-1}$	mg kg^{-1}	kg ha^{-1}	mg kg^{-1}	kg ha^{-1}	kg ha^{-1}	kg ha^{-1}	kg ha^{-1}	kg ha^{-1}
Arsenic (As)	4.34	0.00	9.23	0.009	9.34	0.009	0.01	0.051	0.06	21.6
Cadmium (Cd)	2.25	0.00	0.25	0.000	0.30	0.000	0.00	0.000	0.00	2.5
Chromium (Cr)	117.57	0.12	51.2	0.051	43.5	0.044	0.05	0.000	0.05	115.2
Copper (Cu)	590.93	0.59	32.9	0.033	31.8	0.032	0.03	0.000	0.03	113.4
Lead (Pb)	70.67	0.07	14.5	0.015	15.7	0.016	0.02	0.000	0.02	126
Mercury (Hg)	1.01	0.00	00.0	0.000	00.0	0.000	0.00	0.000	0.00	11.9
Nickel (Ni)	53.20	0.05	15.6	0.016	39.0	0.039	0.03	0.000	0.03	90
Zinc (Zn)	1412.31	1.41	101	0.101	90.0	0.090	0.10	0.000	0.10	360

Notes:
Max loading rate calculated
[1] = Soil concentrations less than detection
[2] = Cumulative Weight Allowed by Guideline includes the metals in soils.

Recommended Appliction Loading rate: 12 Tonnes/Ha (dry)

Table 6. Analytical Summary of City of Winnipeg Biosolids Analysis (2012 to Present)

Statistical Analysis Summary	Total Solids	Moisture	Total Organic Carbon (dry basis)	Total Kjendal Nitrogen	Total Nitrogen (Slu-ext)	pH	Conductivity	Aluminum	Arsnic	Cadmium	Colbolt	Chromium
	(%)			*(mg/kg N)*			*(µS/cm)*	*Total (mg/kg dry)*				
Min	21.5	68.9	23.2	23600.0	30900.0	5.8	5260.0	27.4	3.0	1.3	4.0	63.6
Max	34.1	79.8	34.8	39900.0	44200.0	7.3	20600.0	11600.0	6.3	9.8	24.9	345.0
Average	26.9	73.3	27.4	32627.6	37347.1	6.1	9459.9	6923.4	4.4	2.2	6.6	115.8
95th percentile	31.3	77.9	32.5	38100.0	42360.0	6.7	15330.0	9561.5	5.6	4.1	8.5	203.9
Standard Deviation	2.9	3.0	3.3	3491.1	3606.9	0.3	3341.4	1690.0	0.7	1.2	2.3	42.9
Count (n=)	114	100	90	101	17	59	55	108	108	108	104	108

Notes:
Data provided by City of Winnipeg

Table 6. Analytical Summary c

Statistical Analysis Summary	Copper	Iron	Mercury	Potassium	Molybdenum	Nickel	Phosphorus	Lead	Selenium	Zinc
	Total (mg/kg dry)									
Min	370.0	24700.0	0.6	705.0	7.7	16.7	13400.0	29.5	1.9	632.0
Max	954.0	68000.0	1.8	2810.0	30.6	121.0	26800.0	325.0	106.0	5080.0
Average	596.8	38517.6	1.0	1760.1	15.0	55.2	17905.0	72.7	5.3	1395.0
95th percentile	813.5	59725.0	1.4	2368.0	20.3	82.8	24695.0	120.3	5.5	2852.0
Standard Deviation	126.1	10481.9	0.2	338.1	3.8	16.2	4125.7	46.4	12.8	762.9
Count (n=)	108	108	95	105	107	106	108	106	108	110

Notes:
Data provided by City of Winni

Table 6. Analytical Summary c

Statistical Analysis Summary	Ammonium-N	Phosphate-P (mg/Kg)	Sulfate-S (mg/Kg)	Potassium (mg/Kg)	Nitrite-N (mg/Kg)	Nitrate-N (mg/Kg)	Nitrate + Nitrite-N (mg/Kg)	Loss On Ignition (%)	Inorganic Carbon as CaCO3	Total Carbon by combustion	Total Inorganic Carbon in Soil	Total Organic Carbon Calculation
	(mg/Kg) (wet)	*(mg/kg dry)*						*(%)*	*(%)*			
Min	3120.0	450.0	554.0	530.0	1.0	4.6	3.0	40.5	5.7	25.5	0.7	24.3
Max	6700.0	1380.0	2540.0	690.0	1.8	4.6	3.3	52.7	10.2	31.9	1.2	31.2
Average	4963.0	720.5	1994.4	625.3	1.4	4.6	3.2	47.0	7.8	28.9	0.9	28.0
95th percentile	5804.0	1188.0	2516.0	683.2	1.7	4.6	3.3	52.5	10.1	31.8	1.2	30.9
Standard Deviation	1076.7	255.3	544.9	53.8	0.2	0.0	0.1	3.8	1.3	1.8	0.2	1.9
Count (n=)	10	10	10	10	6	1	5	10	15	15	15	15

Notes:
Data provided by City of Winni

City of Winnipeg Biosolids Analysis

PHOSPHORUS

Since 2007, the City's wastewater treatment process has included chemical treatment with Ferric Chloride (FeCl3+) at the North End Sewage Treatment Plant (NEWPCC) to precipitate Total Phosphorus out. The reaction between phosphorus and metal salts is as follows:

$$FeCl_3 + PO_4^{3-} \rightarrow FePO_4 \text{ (precipitate)} + 3Cl^-$$

In 2002, the City completed a number of studies on the process of chemical treatment. In Section 13 of the Nitrification Study (Earth Tech Inc., 2002), the chemical phosphorous removal alternatives are reviewed. In this study it is reported that on the basis of reaction stoichiometry, 162.3g of FeCl3 will react with 95g of P04 to form 150.8g of FePO4, resulting in a weight ratio of 5.2:1 of FeCl3 to phosphorus. In general however, the chemicals required vary significantly depending upon the wastewater characteristics such as influent phosphorus concentrations, pH, alkalinity, quantity and nature of suspended solids, ionic constituents and the effluent phosphorus limit required. The NEWPCC feeds ferric chloride at the primary sludge feed influent to the digester (approximately 80L/hr set rate) and at the digested sludge feed effluent from the holding tanks (approximate feed rate 15L/hr, automatic flow adjusted ratio).

Laboratory analysis of the biosolids demonstrates (Table 6) Total Phosphorus is on average 17,905 mg/kg, dry and standard deviation of 4,125 mg/kg, dry (n=116). Further laboratory analysis between April 2017 and present establishes the average plant available Phosphate-P as 756 mg/kg, with a standard deviation of 266 mg/kg, dry (n=10) using the Modified Kelowna extraction (Table 6). The plant available Phosphate-P is approximately 4% of the Total Phosphorous (Table 2 and 3). This is far below the typical assumption that 50% of Total Phosphorous is made available in manure (Tri-Provincial Manure Application and User Guidelines), and non-chemically treated biosolids (USEPA, 1995).

Studies have demonstrated that biosolids treated with metal salts (Ferric Chloride or Alum) greatly reduce plant available Phosphate-P. Pastene (1981) as reported in O'Connor et al (2002) recommended the molar ratio of (Al + Fe) to phosphorus as an indicator of the P-supplying power of the biosolids. It was suggested that ratio values of <1 were characteristic of biosolids capable of supplying large quantities of soluble phosphorus, whereas ratio values of >1 indicate sources of poor phosphorus supply. O'Connor et al's (2002) work determined that significantly lower phosphorus availability was characterized by biosolids containing very high (>50g/kg) total Fe and Al concentrations and which have been processed by methods that result in dry materials (>60% solids). McCoy (1986) found that P uptake from sludges treated with FeCl3, averaged 4% of the uptake from monocalcium phosphate (MCP). The uptake from the sludge treated with Fe3 and Alum was 0% relative to MCP and plant uptake of phosphorus from FeCl3 treated sludge relative to triple superphosphate (TSP) was only 10%.

Based on the knowledge that the City's biosolids are treated with Ferric Chloride salt to achieve a reduction in the total Phosphorus concentration in the wastewater stream, the assumption is that the resulting biosolids (post Ferric Chloride treatment) provide a low percentage of plant available phosphorus to plants. As important to this assumption is that the receiving soils were

calcium based with an average soil pH of 7.5 where it is understood that the $FePO_4$ precipitate would remain in an insoluble form and continue to limit plant availability of phosphorus.

NITROGEN MINERALIZATION

The biosolids application rate to the agricultural land was based on the content and availability of the nitrogen present in the biosolids. Fitzgerald and Racz (1999) evaluated the effect of biosolids on crops, soil and environmental quality and in this work the nitrogen mineralization of nitrogen in the City of Winnipeg Biosolids is reported to be between 11% and 17%. A conservative approach to nitrogen mineralization rate for this program was estimated at 20%, less than the typical 25% mineralization applied in manure application programs, but more than the observed mineralization rate reported by Fitzgerald and Racz (1999).

2017 Biosolids Management Program

September				2017				
Date	Wet Cake Landfill (T)	Wet Cake Landuse (T)	% Total Solids	Dry Cake (T)	Loads to Landfill	Loads to Compost	Loads to Landuse	Loads Total
1	149.05	0.00	26.66	39.74	6	0	0	6
2				0.00				0
3				0.00				0
4				0.00				0
5	232.17	0.00	26.86	62.36	9	0	0	9
6	279.54	0.00	26.31	73.55	6	5	0	11
7	225.87	0.00	24.88	56.20	6	3	0	9
8	149.94	0.00	25.14	37.69	6	0	0	6
9				0.00				0
10				0.00				0
11	205.11	0.00	24.46	50.17	8	0	0	8
12	203.00	0.00	24.65	50.04	8	0	0	8
13	151.62	0.00	24.17	36.65	6	0	0	6
14	196.59	0.00	24.98	49.11	8	0	0	8
15	97.35	0.00	24.27	23.63	4	0	0	4
16				0.00				0
17				0.00				0
18	179.95	0.00	24.76	44.56	7	0	0	7
19	254.46	0.00	25.47	64.81	7	3	0	10
20	201.70	0.00	25.22	50.87	5	3	0	8
21	50.50	132.94	24.56	45.05	0	2	7	9
22	0.00	114.28	25.89	29.59	0	0	6	6
23				0.00				0
24				0.00				0
25	252.80	0.00	29.25	73.94	5	5	0	10
26	227.31	0.00	28.37	64.49	4	5	0	9
27	152.50	0.00	26.50	40.41	6	0	0	6
28	148.56	0.00	26.95	40.04	6	0	0	6
29	0.00	132.29	28.36	37.52	0	0	7	7
30				0.00				0
TOTAL	3358.02	379.51	25.89	970.40	107	26	20	153
NOTES:								

2017 Biosolids Management Program

October				2017				
Date	Wet Cake Landfill (T)	Wet Cake Landuse (T)	% Total Solids	Dry Cake (T)	Loads to Landfill	Loads to Compost	Loads to Landuse	Loads Total
1				0.00				0
2	0.00	94.98	28.87	27.42	0	0	5	5
3	0.00	209.46	27.89	58.42	0	0	11	11
4	0.00	133.37	28.33	37.78	0	0	7	7
5	0.00	114.12	27.78	31.70	0	0	6	6
6	0.00	57.08	29.45	16.81	0	0	3	3
7				0.00				0
8				0.00				0
9	0.00	38.05	29.29	11.14	0	0	2	2
10	100.09	0.00	29.12	29.15	0	4	0	4
11	49.98	0.00	33.40	16.69	0	2	0	2
12	0.00	259.28	25.49	66.09	0	0	13	13
13	0.00	206.05	24.84	51.18	0	0	10	10
14				0.00				0
15				0.00				0
16	0.00	335.43	23.87	80.07	0	0	13	13
17	0.00	206.13	23.47	48.38	0	0	8	8
18	0.00	178.62	23.27	41.56	0	0	7	7
19	0.00	154.60	24.48	37.85	0	0	6	6
20	0.00	150.90	25.69	38.77	0	0	6	6
21				0.00				0
22				0.00				0
23	100.05	104.12	23.06	47.08	0	4	4	8
24	205.08	0.00	25.26	51.80	8	0	0	8
25	200.23	0.00	24.21	48.48	4	4	0	8
26	150.46	0.00	23.06	34.70	2	4	0	6
27	102.41	0.00	24.45	25.04	4	0	0	4
28				0.00				0
29				0.00				0
30	201.37	0.00	24.19	48.71	8	0	0	8
31	201.42	0.00	23.39	47.11	8	0	0	8
TOTAL	1311.09	2242.19	26.04	895.94	34	18	101	153
NOTES:								

APPENDIX

E SOIL CERTIFICATE OF ANALYSIS

WSP Canada Group Limited
ATTN: BRIAN MOONS
1600 Buffalo Place
Winnipeg MB R3T 6B8

Date Received: 22-AUG-17
Report Date: 01-SEP-17 07:37 (MT)
Version: FINAL

Client Phone: 204-477-6650

Certificate of Analysis

Lab Work Order #: L1978983

Project P.O. #: NOT SUBMITTED
Job Reference: 17M-00008-01
C of C Numbers:
Legal Site Desc:

Hua Wo
Chemistry Laboratory Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	MU	Qualifier*	D.L.	Units	Bias	Extracted	Analyzed	Batch
L1978983-1 W001 0-15									
Sampled By: BM on 22-AUG-17 @ 09:00									
Matrix: SOIL									
Miscellaneous Parameters									
Available Phosphate-P	12.6	-		1.0	mg/kg	-	25-AUG-17	25-AUG-17	R3812043
Available Potassium	418	+/-52	DLHC	40	mg/kg	-11.8%	25-AUG-17	25-AUG-17	R3812127
Mercury (Hg)	0.0380	+/-0.010		0.0050	mg/kg	0	25-AUG-17	29-AUG-17	R3814622
Total Nitrogen by LECO	0.318	+/-0.056		0.020	%	0	29-AUG-17	29-AUG-17	R3814347
pH (1:2 soil:water)	6.52	+/-0.18		0.10	pH	0	31-AUG-17	31-AUG-17	R3816229
Nitrate, Nitrite and Nitrate+Nitrite-N									
Nitrite-N	<0.40	-		0.40	mg/kg	-	31-AUG-17	31-AUG-17	R3816380
Nitrate+Nitrite-N	2.6	+/-1.5		2.0	mg/kg	0	31-AUG-17	31-AUG-17	R3816380
Nitrate-N	2.6	-		2.0	mg/kg	-	31-AUG-17	31-AUG-17	R3816380
Metals									
Arsenic (As)	8.99	+/-1.1		0.10	mg/kg	0	25-AUG-17	28-AUG-17	R3813733
Cadmium (Cd)	0.196	+/-0.035		0.020	mg/kg	0	25-AUG-17	28-AUG-17	R3813733
Chromium (Cr)	44.5	+/-8.0		1.0	mg/kg	0	25-AUG-17	28-AUG-17	R3813733
Copper (Cu)	32.2	+/-4.8		1.0	mg/kg	0	25-AUG-17	28-AUG-17	R3813733
Lead (Pb)	15.1	+/-2.9		0.20	mg/kg	0	25-AUG-17	28-AUG-17	R3813733
Nickel (Ni)	44.0	+/-5.5		0.50	mg/kg	0	25-AUG-17	28-AUG-17	R3813733
Zinc (Zn)	92	+/-12		10	mg/kg	0	25-AUG-17	28-AUG-17	R3813733
L1978983-2 W001 15-60									
Sampled By: BM on 22-AUG-17 @ 09:00									
Matrix: SOIL									
Miscellaneous Parameters									
Total Nitrogen by LECO	0.202	+/-0.037		0.020	%	0	29-AUG-17	29-AUG-17	R3814347
Nitrate, Nitrite and Nitrate+Nitrite-N									
Nitrite-N	<0.40	-		0.40	mg/kg	-	31-AUG-17	31-AUG-17	R3816380
Nitrate+Nitrite-N	<2.0	-		2.0	mg/kg	-	31-AUG-17	31-AUG-17	R3816380
Nitrate-N	<2.0	-		2.0	mg/kg	-	31-AUG-17	31-AUG-17	R3816380
L1978983-3 W002 0-15									
Sampled By: BM on 22-AUG-17 @ 10:00									
Matrix: SOIL									
Miscellaneous Parameters									
Available Phosphate-P	7.0	-		1.0	mg/kg	-	25-AUG-17	25-AUG-17	R3812043
Available Potassium	309	+/-40		20	mg/kg	-11.8%	25-AUG-17	25-AUG-17	R3812127
Mercury (Hg)	0.0290	+/-0.0084		0.0050	mg/kg	0	25-AUG-17	29-AUG-17	R3814622
Total Nitrogen by LECO	0.238	+/-0.043		0.020	%	0	29-AUG-17	29-AUG-17	R3814347
pH (1:2 soil:water)	7.50	+/-0.18		0.10	pH	0	31-AUG-17	31-AUG-17	R3816229
Nitrate, Nitrite and Nitrate+Nitrite-N									
Nitrite-N	<0.40	-		0.40	mg/kg	-	31-AUG-17	31-AUG-17	R3816380
Nitrate+Nitrite-N	<2.0	-		2.0	mg/kg	-	31-AUG-17	31-AUG-17	R3816380
Nitrate-N	<2.0	-		2.0	mg/kg	-	31-AUG-17	31-AUG-17	R3816380
Metals									
Arsenic (As)	9.06	+/-1.2		0.10	mg/kg	0	25-AUG-17	28-AUG-17	R3813733
Cadmium (Cd)	0.204	+/-0.036		0.020	mg/kg	0	25-AUG-17	28-AUG-17	R3813733
Chromium (Cr)	48.6	+/-8.8		1.0	mg/kg	0	25-AUG-17	28-AUG-17	R3813733
Copper (Cu)	30.6	+/-4.6		1.0	mg/kg	0	25-AUG-17	28-AUG-17	R3813733
Lead (Pb)	13.6	+/-2.6		0.20	mg/kg	0	25-AUG-17	28-AUG-17	R3813733
Nickel (Ni)	44.8	+/-5.6		0.50	mg/kg	0	25-AUG-17	28-AUG-17	R3813733
Zinc (Zn)	93	+/-12		10	mg/kg	0	25-AUG-17	28-AUG-17	R3813733
L1978983-4 W002 15-60									
Sampled By: BM on 22-AUG-17 @ 10:00									
Matrix: SOIL									

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	MU	Qualifier*	D.L.	Units	Bias	Extracted	Analyzed	Batch
L1978983-4 W002 15-60									
Sampled By: BM on 22-AUG-17 @ 10:00									
Matrix: SOIL									
Miscellaneous Parameters									
Total Nitrogen by LECO	0.254	+/-0.046		0.020	%	0	29-AUG-17	29-AUG-17	R3814347
Nitrate, Nitrite and Nitrate+Nitrite-N									
Nitrite-N	<0.40	-		0.40	mg/kg	-	31-AUG-17	31-AUG-17	R3816380
Nitrate+Nitrite-N	<2.0	-		2.0	mg/kg	-	31-AUG-17	31-AUG-17	R3816380
Nitrate-N	<2.0	-		2.0	mg/kg	-	31-AUG-17	31-AUG-17	R3816380
L1978983-5 W003 0-15									
Sampled By: BM on 22-AUG-17 @ 10:20									
Matrix: SOIL									
Miscellaneous Parameters									
Available Phosphate-P	9.0	-		1.0	mg/kg	-	25-AUG-17	25-AUG-17	R3812043
Available Potassium	390	+/-49		20	mg/kg	-11.8%	25-AUG-17	25-AUG-17	R3812127
Mercury (Hg)	0.0310	+/-0.0088		0.0050	mg/kg	0	25-AUG-17	29-AUG-17	R3814622
Total Nitrogen by LECO	0.290	+/-0.052		0.020	%	0	29-AUG-17	29-AUG-17	R3814347
pH (1:2 soil:water)	6.98	+/-0.18		0.10	pH	0	31-AUG-17	31-AUG-17	R3816229
Nitrate, Nitrite and Nitrate+Nitrite-N									
Nitrite-N	<0.40	-		0.40	mg/kg	-	31-AUG-17	31-AUG-17	R3816380
Nitrate+Nitrite-N	<2.0	-		2.0	mg/kg	-	31-AUG-17	31-AUG-17	R3816380
Nitrate-N	<2.0	-		2.0	mg/kg	-	31-AUG-17	31-AUG-17	R3816380
Metals									
Arsenic (As)	9.23	+/-1.2		0.10	mg/kg	0	25-AUG-17	28-AUG-17	R3813733
Cadmium (Cd)	0.252	+/-0.045		0.020	mg/kg	0	25-AUG-17	28-AUG-17	R3813733
Chromium (Cr)	51.2	+/-9.3		1.0	mg/kg	0	25-AUG-17	28-AUG-17	R3813733
Copper (Cu)	32.9	+/-4.9		1.0	mg/kg	0	25-AUG-17	28-AUG-17	R3813733
Lead (Pb)	14.5	+/-2.8		0.20	mg/kg	0	25-AUG-17	28-AUG-17	R3813733
Nickel (Ni)	45.6	+/-5.7		0.50	mg/kg	0	25-AUG-17	28-AUG-17	R3813733
Zinc (Zn)	101	+/-13		10	mg/kg	0	25-AUG-17	28-AUG-17	R3813733
L1978983-6 W003 15-60									
Sampled By: BM on 22-AUG-17 @ 10:20									
Matrix: SOIL									
Miscellaneous Parameters									
Total Nitrogen by LECO	0.186	+/-0.035		0.020	%	0	29-AUG-17	29-AUG-17	R3814347
Nitrate, Nitrite and Nitrate+Nitrite-N									
Nitrite-N	<0.40	-		0.40	mg/kg	-	31-AUG-17	31-AUG-17	R3816380
Nitrate+Nitrite-N	<2.0	-		2.0	mg/kg	-	31-AUG-17	31-AUG-17	R3816380
Nitrate-N	<2.0	-		2.0	mg/kg	-	31-AUG-17	31-AUG-17	R3816380
L1978983-7 W004 0-15									
Sampled By: BM on 22-AUG-17 @ 10:45									
Matrix: SOIL									
Miscellaneous Parameters									
Available Phosphate-P	17.3	-		1.0	mg/kg	-	25-AUG-17	25-AUG-17	R3812043
Available Potassium	430	+/-54	DLHC	40	mg/kg	-11.8%	25-AUG-17	25-AUG-17	R3812127
Mercury (Hg)	0.0383	+/-0.010		0.0050	mg/kg	0	25-AUG-17	29-AUG-17	R3814622
Total Nitrogen by LECO	0.333	+/-0.059		0.020	%	0	29-AUG-17	29-AUG-17	R3814347
pH (1:2 soil:water)	6.63	+/-0.18		0.10	pH	0	31-AUG-17	31-AUG-17	R3816229
Nitrate, Nitrite and Nitrate+Nitrite-N									
Nitrite-N	<0.40	-		0.40	mg/kg	-	31-AUG-17	31-AUG-17	R3816380
Nitrate+Nitrite-N	<2.0	-		2.0	mg/kg	-	31-AUG-17	31-AUG-17	R3816380
Nitrate-N	<2.0	-		2.0	mg/kg	-	31-AUG-17	31-AUG-17	R3816380
Metals									

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample Details/Parameters	Result	MU	Qualifier*	D.L.	Units	Bias	Extracted	Analyzed	Batch
L1978983-7 W004 0-15									
Sampled By: BM on 22-AUG-17 @ 10:45									
Matrix: SOIL									
Metals									
Arsenic (As)	9.34	+/-1.2		0.10	mg/kg	0	25-AUG-17	28-AUG-17	R3813733
Cadmium (Cd)	0.295	+/-0.053		0.020	mg/kg	0	25-AUG-17	28-AUG-17	R3813733
Chromium (Cr)	43.5	+/-7.9		1.0	mg/kg	0	25-AUG-17	28-AUG-17	R3813733
Copper (Cu)	31.8	+/-4.8		1.0	mg/kg	0	25-AUG-17	28-AUG-17	R3813733
Lead (Pb)	15.7	+/-3.1		0.20	mg/kg	0	25-AUG-17	28-AUG-17	R3813733
Nickel (Ni)	39.0	+/-4.9		0.50	mg/kg	0	25-AUG-17	28-AUG-17	R3813733
Zinc (Zn)	90	+/-11		10	mg/kg	0	25-AUG-17	28-AUG-17	R3813733
L1978983-8 W004 15-60									
Sampled By: BM on 22-AUG-17 @ 10:45									
Matrix: SOIL									
Miscellaneous Parameters									
Total Nitrogen by LECO	0.202	+/-0.038		0.020	%	0	29-AUG-17	29-AUG-17	R3814347
Nitrate, Nitrite and Nitrate+Nitrite-N									
Nitrite-N	<0.40	-		0.40	mg/kg	-	31-AUG-17	31-AUG-17	R3816380
Nitrate+Nitrite-N	<2.0	-		2.0	mg/kg	-	31-AUG-17	31-AUG-17	R3816380
Nitrate-N	<2.0	-		2.0	mg/kg	-	31-AUG-17	31-AUG-17	R3816380

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

Sample Parameter Qualifier Key:

Qualifier	Description
DLHC	Detection Limit Raised: Dilution required due to high concentration of test analyte(s).

Test Method References:

ALS Test Code	Matrix	Test Description	Preparation Method Reference	Method Reference**
HG-200.2-CVAF-WP	Soil	Mercury in Soil by CVAFS		EPA 200.2/1631E (mod)
Soil samples are digested with nitric and hydrochloric acids, followed by analysis by CVAFS.				
K-AVAIL-SK	Soil	Available Potassium		Comm. Soil Sci. Plant, 25 (5&6)
Plant available potassium is extracted from the soil using Modified Kelowna solution. Potassium in the soil extract is determined by flame emission at 770 nm.				
MET-200.2-MS-WP	Soil	Metals		EPA 200.2/6020A
Samples for analysis are homogenized, dried at 60 degrees Celsius, sieved through a 2 mm (10 mesh) sieve, and a representative subsample of the dry material is weighed. The sample is then digested by block digester (EPA 200.2). Instrumental analysis is by inductively coupled plasma - mass spectrometry (EPA Method 6020A). Method Limitation: This method is not a total digestion technique. It is a very strong acid digestion that is intended to dissolve those metals that may become "environmentally available." By design, elements bound in silicate structures are not normally dissolved by this procedure as they are not usually mobile in the environment.				
N-TOT-LECO-SK	Soil	Total Nitrogen by combustion method		CSSS (2008) 22.4
The sample is ignited in a combustion analyzer where nitrogen in the reduced nitrous oxide gas is determined using a thermal conductivity detector.				
N2/N3-AVAIL-SK	Soil	Nitrate, Nitrite and Nitrate+Nitrite-N		APHA 4500 NO3F
Available Nitrate and Nitrite are extracted from the soil using a dilute calcium chloride solution. Nitrate plus Nitrite is quantitatively reduced to nitrite by passage of the sample through a copperized cadmium column. The nitrite (reduced nitrate plus original nitrite) is then determined by diazotizing with sulfanilamide followed by coupling with N-(1-naphthyl) ethylenediamine dihydrochloride. The resulting water soluble dye has a magenta color which is measured at colorimetrically at 520nm. Nitrite is determined on the same extract by following the same instrumental procedure without a cadmium column. Reference: Recommended Methods of Soil Analysis for Canadian Prairie Agricultural Soils. Alberta Agriculture (1988) p. 19 and 28				
PH-1:2-SK	Soil	pH (1:2 Soil:Water Extraction)		AB Ag (1988) p.7
1 part dry soil and 2 parts de-ionized water (by volume) is mixed. The slurry is allowed to stand with occasional stirring for 30 - 60 minutes. After equilibration, pH of the slurry is measured using a pH meter.				
PO4-AVAIL-OLSEN-SK	Soil	Available Phosphate-P by Olsen		CSSS (2008) 8.2
Plant available phosphorus is extracted from the sample with sodium bicarbonate. PO4-P in the filtered extract is determined colorimetrically at 880 nm.				

** The indicated Method Reference is the closest nationally or internationally recognized reference for the applicable ALS test method. ALS methods may incorporate modifications from the specified reference to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
SK	ALS ENVIRONMENTAL - SASKATOON, SASKATCHEWAN, CANADA
WP	ALS ENVIRONMENTAL - WINNIPEG, MANITOBA, CANADA

Chain of Custody Numbers:

Reference Information

GLOSSARY OF REPORT TERMS

Surr - Surrogates are compounds that are similar in behaviour to target analyte(s), but that do not normally occur in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery. In reports that display the D.L. column, laboratory objectives for surrogates are listed there.
mg/kg - milligrams per kilogram based on dry weight of sample
mg/kg wwt - milligrams per kilogram based on wet weight of sample
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight
mg/L - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.
MU: Measurement Uncertainty. The reported uncertainty is an expanded uncertainty calculated using a coverage factor of 2 which gives a level of confidence of approximately 95%.
Bias: The reported method bias is the average long term deviation from the target value for a long term reference or control sample, measured in percent. Zero values indicate no detectable method bias.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

Quality Control Report

Client: WSP Canada Group Limited
1600 Buffalo Place
Winnipeg MB R3T 6B8
Contact: BRIAN MOONS

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
HG-200.2-CVAF-WP	**Soil**							
Batch R3814622								
WG2604093-4 CRM		**PACS-3**						
Mercury (Hg)			107.1		%		70-130	29-AUG-17
WG2604093-5 DUP		**L1978983-7**						
Mercury (Hg)		0.0383	0.0370		mg/kg	3.5	40	29-AUG-17
WG2604093-2 LCS								
Mercury (Hg)			106.8		%		80-120	29-AUG-17
WG2604093-1 MB								
Mercury (Hg)			<0.0050		mg/kg		0.005	29-AUG-17
K-AVAIL-SK	**Soil**							
Batch R3812127								
WG2600851-1 DUP		**L1979030-3**						
Available Potassium		398	401		mg/kg	0.8	30	25-AUG-17
WG2600851-3 IRM		**FARM2005**						
Available Potassium			94.6		%		70-130	25-AUG-17
WG2600851-2 MB								
Available Potassium			<20		mg/kg		20	25-AUG-17
MET-200.2-MS-WP	**Soil**							
Batch R3813733								
WG2601712-4 CRM		**PACS-3**						
Arsenic (As)			99.2		%		70-130	28-AUG-17
Cadmium (Cd)			92.6		%		70-130	28-AUG-17
Chromium (Cr)			101.5		%		70-130	28-AUG-17
Copper (Cu)			102.8		%		70-130	28-AUG-17
Lead (Pb)			92.2		%		70-130	28-AUG-17
Nickel (Ni)			100.1		%		70-130	28-AUG-17
Zinc (Zn)			99.4		%		70-130	28-AUG-17
WG2601712-5 CRM		**CANMET TILL-1**						
Arsenic (As)			102.0		%		70-130	28-AUG-17
Cadmium (Cd)			101.9		%		70-130	28-AUG-17
Chromium (Cr)			99.0		%		70-130	28-AUG-17
Copper (Cu)			103.1		%		70-130	28-AUG-17
Lead (Pb)			104.4		%		70-130	28-AUG-17
Nickel (Ni)			101.0		%		70-130	28-AUG-17
Zinc (Zn)			98.9		%		70-130	28-AUG-17
WG2601712-7 DUP		**WG2601712-6**						
Arsenic (As)		9.34	9.45		mg/kg	1.1	30	28-AUG-17

Quality Control Report

Client: WSP Canada Group Limited
1600 Buffalo Place
Winnipeg MB R3T 6B8
Contact: BRIAN MOONS

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
MET-200.2-MS-WP	**Soil**							
Batch R3813733								
WG2601712-7 DUP		**WG2601712-6**						
Cadmium (Cd)		0.268	0.251		mg/kg	6.8	30	28-AUG-17
Chromium (Cr)		43.5	43.0		mg/kg	1.2	30	28-AUG-17
Copper (Cu)		31.8	30.7		mg/kg	3.6	30	28-AUG-17
Lead (Pb)		15.7	15.5		mg/kg	1.5	40	28-AUG-17
Nickel (Ni)		39.0	38.6		mg/kg	0.9	30	28-AUG-17
Zinc (Zn)		90	88		mg/kg	2.4	30	28-AUG-17
WG2601712-2 LCS								
Arsenic (As)			107.2		%		80-120	28-AUG-17
Cadmium (Cd)			98.9		%		80-120	28-AUG-17
Chromium (Cr)			106.0		%		80-120	28-AUG-17
Copper (Cu)			102.7		%		80-120	28-AUG-17
Lead (Pb)			102.0		%		80-120	28-AUG-17
Nickel (Ni)			103.6		%		80-120	28-AUG-17
Zinc (Zn)			103.3		%		80-120	28-AUG-17
WG2601712-1 MB								
Arsenic (As)			<0.10		mg/kg		0.1	28-AUG-17
Cadmium (Cd)			<0.020		mg/kg		0.02	28-AUG-17
Chromium (Cr)			<1.0		mg/kg		1	28-AUG-17
Copper (Cu)			<1.0		mg/kg		1	28-AUG-17
Lead (Pb)			<0.20		mg/kg		0.2	28-AUG-17
Nickel (Ni)			<0.50		mg/kg		0.5	28-AUG-17
Zinc (Zn)			<10		mg/kg		10	28-AUG-17
N-TOT-LECO-SK	**Soil**							
Batch R3814347								
WG2600661-1 DUP		**L1978697-3**						
Total Nitrogen by LECO		0.557	0.552		%	1.0	20	29-AUG-17
WG2600661-2 IRM		**08-109_SOIL**						
Total Nitrogen by LECO			0.115		%		0.085-0.135	29-AUG-17
WG2600661-4 MB								
Total Nitrogen by LECO			<0.020		%		0.02	29-AUG-17
N2/N3-AVAIL-SK	**Soil**							
Batch R3816380								
WG2604304-1 DUP		**L1978983-2**						
Nitrite-N		<0.40	<0.40	RPD-NA	mg/kg	N/A	50	31-AUG-17

Quality Control Report

Client: WSP Canada Group Limited
1600 Buffalo Place
Winnipeg MB R3T 6B8
Contact: BRIAN MOONS

Test	Matrix	Reference	Result	Qualifier	Units	RPD	Limit	Analyzed
N2/N3-AVAIL-SK	**Soil**							
Batch R3816380								
WG2604304-1 DUP		**L1978983-2**						
Nitrate+Nitrite-N		<2.0	<2.0	RPD-NA	mg/kg	N/A	30	31-AUG-17
WG2604304-3 IRM		**SAL814**						
Nitrate+Nitrite-N			114.1		%		70-130	31-AUG-17
WG2604304-2 MB								
Nitrite-N			<0.40		mg/kg		0.4	31-AUG-17
Nitrate+Nitrite-N			<2.0		mg/kg		2	31-AUG-17
PH-1:2-SK	**Soil**							
Batch R3816229								
WG2604311-2 IRM		**SAL814**						
pH (1:2 soil:water)			8.09		pH		7.65-8.25	31-AUG-17
PO4-AVAIL-OLSEN-SK	**Soil**							
Batch R3812043								
WG2599642-1 DUP		**L1978598-7**						
Available Phosphate-P		6.2	7.0		mg/kg	12	30	25-AUG-17
WG2599642-3 IRM		**FARM2005**						
Available Phosphate-P			103.4		%		80-120	25-AUG-17
WG2599642-2 MB								
Available Phosphate-P			<1.0		mg/kg		1	25-AUG-17

Quality Control Report

Workorder: L1978983 Report Date: 01-SEP-17

Client: WSP Canada Group Limited
1600 Buffalo Place
Winnipeg MB R3T 6B8
Contact: BRIAN MOONS

Legend:

Limit	ALS Control Limit (Data Quality Objectives)
DUP	Duplicate
RPD	Relative Percent Difference
N/A	Not Available
LCS	Laboratory Control Sample
SRM	Standard Reference Material
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ADE	Average Desorption Efficiency
MB	Method Blank
IRM	Internal Reference Material
CRM	Certified Reference Material
CCV	Continuing Calibration Verification
CVS	Calibration Verification Standard
LCSD	Laboratory Control Sample Duplicate

Sample Parameter Qualifier Definitions:

Qualifier	Description
RPD-NA	Relative Percent Difference Not Available due to result(s) being less than detection limit.

Quality Control Report

Workorder: L1978983 Report Date: 01-SEP-17

Client: WSP Canada Group Limited
1600 Buffalo Place
Winnipeg MB R3T 6B8
Contact: BRIAN MOONS

Hold Time Exceedances:

ALS Product Description	Sample ID	Sampling Date	Date Processed	Rec. HT	Actual HT	Units	Qualifier
Plant Available Nutrients							
Nitrate, Nitrite and Nitrate+Nitrite-N							
	1	22-AUG-17 09:00	31-AUG-17 16:38	3	9	days	EHT
	2	22-AUG-17 09:00	31-AUG-17 16:38	3	9	days	EHT
	3	22-AUG-17 10:00	31-AUG-17 16:38	3	9	days	EHT
	4	22-AUG-17 10:00	31-AUG-17 16:38	3	9	days	EHT
	5	22-AUG-17 10:20	31-AUG-17 16:38	3	9	days	EHT
	6	22-AUG-17 10:20	31-AUG-17 16:38	3	9	days	EHT
	7	22-AUG-17 10:45	31-AUG-17 16:38	3	9	days	EHT
	8	22-AUG-17 10:45	31-AUG-17 16:38	3	9	days	EHT

Legend & Qualifier Definitions:

EHTR-FM: Exceeded ALS recommended hold time prior to sample receipt. Field Measurement recommended.
EHTR: Exceeded ALS recommended hold time prior to sample receipt.
EHTL: Exceeded ALS recommended hold time prior to analysis. Sample was received less than 24 hours prior to expiry.
EHT: Exceeded ALS recommended hold time prior to analysis.
Rec. HT: ALS recommended hold time (see units).

Notes*:
Where actual sampling date is not provided to ALS, the date (& time) of receipt is used for calculation purposes.
Where actual sampling time is not provided to ALS, the earlier of 12 noon on the sampling date or the time (& date) of receipt is used for calculation purposes. Samples for L1978983 were received on 22-AUG-17 14:55.

ALS recommended hold times may vary by province. They are assigned to meet known provincial and/or federal government requirements. In the absence of regulatory hold times, ALS establishes recommendations based on guidelines published by the US EPA, APHA Standard Methods, or Environment Canada (where available). For more information, please contact ALS.

The ALS Quality Control Report is provided to ALS clients upon request. ALS includes comprehensive QC checks with every analysis to ensure our high standards of quality are met. Each QC result has a known or expected target value, which is compared against pre-determined data quality objectives to provide confidence in the accuracy of associated test results.

Please note that this report may contain QC results from anonymous Sample Duplicates and Matrix Spikes that do not originate from this Work Order.

Chain of Custody (COC) / Analytical Request Form

ALS Environmental

www.alsglobal.com

Canada Toll Free: 1 800 668 9878

L1978983-COFC

COC Number: 14 -

Page 1 of 1

L1978983

Report To		Report Format / Distribution		Select Service Level Below (Rush Turnaround Time (TAT) is not available for all tests)
Company:	WSP Group Canada Limited	Select Report Format: ☑ PDF ☑ EXCEL ☐ EDD (DIGITAL)		R ☑ Regular (Standard TAT if received by 3 pm - business days)
Contact:	Brian Moons	Quality Control (QC) Report with Report ☐ Yes ☑ No		P ☐ Priority (2-4 bus. days if received by 3pm) 50% surcharge - contact ALS to confirm TAT
Address:	1600 Buffalo Place	☐ Criteria on Report - provide details below if box checked		E ☐ Emergency (1-2 bus. days if received by 3pm) 100% surcharge - contact ALS to confirm TAT
		Select Distribution: ☑ EMAIL ☐ MAIL ☐ FAX		E2 ☐ Same day or weekend emergency - contact ALS to confirm TAT and surcharge
Phone:	204-477-6650	Email 1 or Fax brian.moons@wsp.com		Specify Date Required for E2,E or P:
		Email 2 darren.keam@wsp.com		

Invoice To	Same as Report To ☐ Yes ☑ No	Invoice Distribution	
	Copy of Invoice with Report ☐ Yes ☑ No	Select Invoice Distribution: ☑ EMAIL ☐ MAIL ☐ FAX	
Company:	WSP Group Canada Limited	Email 1 or Fax apwest@wsp.com	
Contact:	accounts payable	Email 2	
Project Information		**Oil and Gas Required Fields (client use)**	
ALS Quote #:	Q63821	Approver ID:	Cost Center:
Job #:	17M-00008-01	GL Account:	Routing Code:
PO / AFE:		Activity Code:	
LSD:		Location:	
ALS Lab Work Order # (lab use only)		**ALS Contact:** Judy D	**Sampler:** Brian Moons

Analysis Request

Indicate Filtered (F), Preserved (P) or Filtered and Preserved (F/P) below

ALS Sample # (lab use only)	Sample Identification and/or Coordinates (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Available Phosphate-P by Olsen	Total nitrogen by combustion	Nitrate, Nitrite and Nitrate+Nitrite-N	pH by 1:2 soil:water extraction	Available potassium	As, Cd, Cr, Cu, Ni, Pb, Zn	Hg by CVAFS						Number of Containers
	W001 0-15	22-Aug-17	9:00	Soil	R	R	R	R	R	R	R						2
	W001 15-60		9:00	Soil		R	R										1
	W002 0-15		10:07	Soil	R	R	R	R	R	R	R						2
	W002 15-60		10:00	Soil		R	R										1
	W003 0-15		10:20	Soil	R	R	R	R	R	R	R						2
	W003 15-60		10:20	Soil		R	R										1
	W004 0-15		10:45	Soil	R	R	R	R	R	R	R						2
	W004 15-60		10:45	Soil		R	R										1

Drinking Water (DW) Samples[1] (client use)	Special Instructions / Specify Criteria to add on report (client Use)
Are samples taken from a Regulated DW System? ☐ Yes ☐ No	
Are samples for human drinking water use? ☐ Yes ☐ No	

SAMPLE CONDITION AS RECEIVED (lab use only)

Frozen ☐ SIF Observations Yes ☐ No ☐

Ice packs Yes ☐ No ☐ Custody seal intact Yes ☐ No ☐

Cooling Initiated ☐

INITIAL COOLER TEMPERATURES °C			FINAL COOLER TEMPERATURES °C		
M29					

SHIPMENT RELEASE (client use)			INITIAL SHIPMENT RECEPTION (lab use only)			FINAL SHIPMENT RECEPTION (lab use only)		
Released by: Darren Moore	Date: 2017-08-22	Time: 14:55	Received by: AR	Date: AUG 22/17	Time: 2:55	Received by:	Date:	Time:

REFER TO BACK PAGE FOR ALS LOCATIONS AND SAMPLING INFORMATION

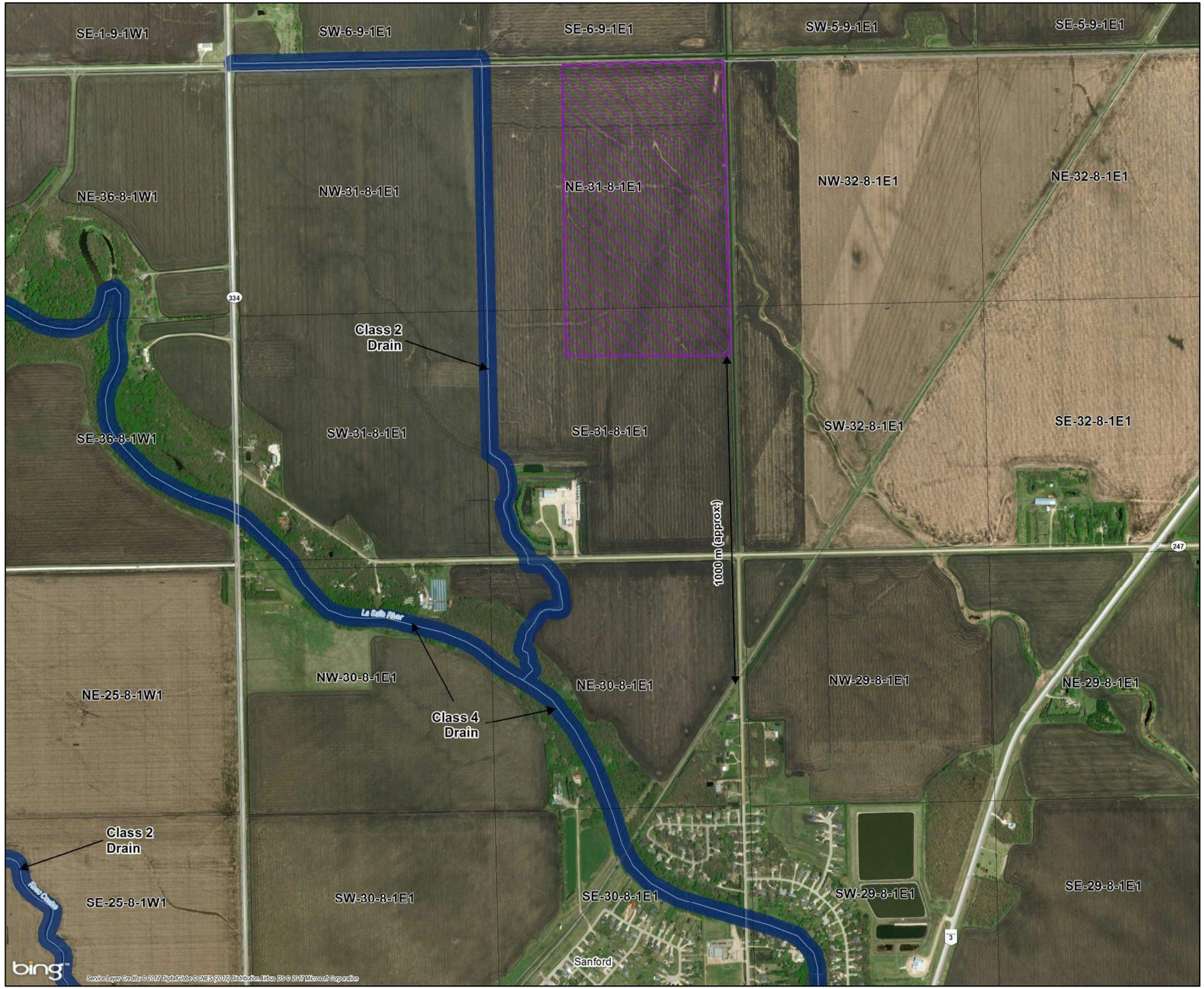
WHITE - LABORATORY COPY YELLOW - CLIENT COPY

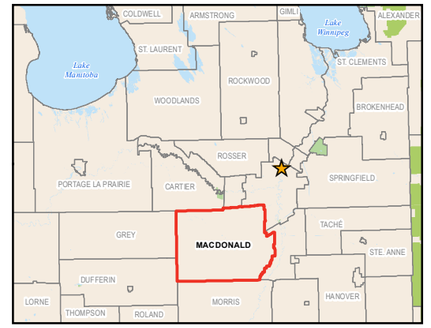
NA-FM-0328e v09 Front/04 January 2014

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY. By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the back page of the white - report copy.

APPENDIX

F FIGURES





CITY OF WINNIPEG BIOSOLIDS LAND APPLICATION PILOT PROGRAM

Legend

- North End Sewage Treatment Plant (NEWPCC)
- Land Applied Area (134 Acres)
- Quarter Section Grid
- Drainage Network 30m buffer
- Drain Feature
- Provincial Trunk Highway
- Provincial Road
- Railway Line

DRAFT: For Discussion Purposes Only

Coordinate System: NAD 83, UTM Zone 14 N
Data Source: MLI, WSP, NRCan, Bing
Date Created: August 01, 2017
Revision Date: November 09, 2017

N

0 50 100 200 Metres
0 0.05 0.1 0.2 0.3 Miles

FIGURE 3

2017 Biosolids Land Applied Area for the Pilot Program

wsp

U:\Projects\PROJECTS_2017\17M-00008-00_CityWinnipegBiosolids\Phase_II\MXD\FIG3_2017BiosolidsLandAppliedAreaPilotProgram_20171109.mxd

RGE 1

SW-6-9-1E1

SE-6-9-1E1

SW-5-9-1E1

NW-31-8-1E1

NE-31-8-1E1

4

NW-32-8-1E1

(RIV$_7$ - OBO$_3$)

(MYT$_5$ - SCY$_5$)

W002

W003

W004

SW-31-8-1E1

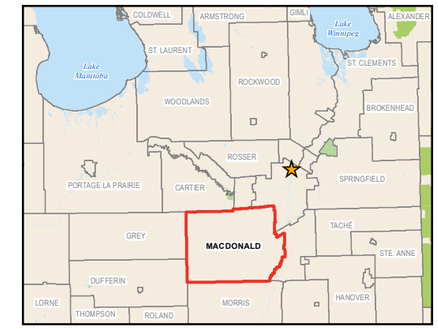
SE-31-8-1E1

SW-32-8-1E1

bing

RGE 1

U:\Projects\PROJECTS_2017\17M-00008-00_CityWinnipegBiosolidsPhase_II\MXD\FIG1_SITE4_BiosolidsLandApplicationField_AgCap_20170911.mxd



CITY OF WINNIPEG
BIOSOLIDS LAND APPLICATION
17M-00008

Legend

- North End Sewage Treatment Plant (NEWPCC)
- Soil Sample Location

Farm Producer Name

- Land Application Area

Agricultural Capability

- Class 1
- Class 2
- Class 3
- Class 4
- Quarter Section Grid
- Waterbody
- Provincial Trunk Highway
- Provincial Road
- Railway Line

Coordinate System: NAD 83, UTM Zone 14 N
Data Source: MLI, WSP, NRCan, Bing
Date Created: August 01, 2017
Revision Date: September 11, 2017

N

0 50 100 200 Metres

0 0.03 0.06 0.12 0.18 Miles

FIGURE 1
E 1/2 31-08-01 EPM
Biosolids Land Application Field (2017)
Agricultural Capability

wsp

APPENDIX

G STANDARD LIMITATIONS

STANDARD LIMITATIONS
ENVIRONMENTAL INVESTIGATIONS and CHARACTERIZATION PROGRAMS

These Standard Limitations form part of the Report to which they are appended and any use of the Report is subject to them.

1. Exclusive Use By Client

This Report was prepared for the exclusive use of the client identified as the intended recipient. Any use of the Report by any other party without the written consent of WSP Canada Group Limited is the sole responsibility of such party. WSP Canada Group Limited accepts no responsibility for damages that may be suffered by any third party as a result of decisions made or actions taken based on the Report.

2. Scope, Terms and Conditions of Contract

The observations and investigations (hereinafter referred to as the "Work") upon which this Report is based were carried out in accordance with the scope, terms and conditions of the contract or the proposal pursuant to which the Work was commissioned. The conclusions presented in the Report are based solely upon the scope of services described in the contract or the proposal and governed by the time and budgetary constraints imposed by them.

3. Standard of Care

The principles, procedures and standards relevant to the nature of the services performed are not universally the same. The Work has been carried out in accordance with generally accepted environmental study and/or professional practices, industry standards and environmental regulations, where applicable. No other warranties are either expressed or implied with respect to the professional services provided under the terms of the contract or the proposal and represented in this Report.

4. Scope of the Work

This Report may be based in part on information obtained at discrete sampling and/or monitoring locations. The conditions reported herein were those encountered at the subject property at the time the Work was performed and as present at the discrete sampling/monitoring locations, if any. Conditions between sampling/monitoring locations may be different than those encountered at the sampling/monitoring locations and WSP Canada Group Limited is not responsible for such differences.

5. Reasonable Conclusions

The conclusions contained in this Report are based on the Work and may also consider a review of information from other sources as identified in the Report. The accuracy of information from other sources was not verified unless specifically noted in the Report, nor was it determined if the reviewed information constituted all information that exists and pertains to the subject property.

The conclusions made are based on reasonable and professional interpretation of the information considered. If additional information concerning conditions of relevance to this Report is obtained during future work at the subject property, WSP Canada Group Limited should be notified in order that we may determine if modifications to the conclusions presented in this Report are necessary.

6. Report as a Complete Document

This Report must be read as a whole and sections taken out of context may be misleading. If discrepancies occur between the preliminary (draft) and final versions of the Report, the final version of the report shall take precedence.

7. Limits of Liability

WSP Canada Group Limited's liability with respect to the Work is limited to re-performing, without cost, any part of the Work that is unacceptable solely as a result of failure to comply with industry standards. WSP Canada Group Limited's maximum liability is limited in accordance with terms in the original contract, provided that notice of claim is made within regulated timelines as of the date of delivery of the Report.