February 13, 2016 *0PP-10-826*

Crain's Construction
1800 Maberly Elphin Road
Maberly, Ontario
K0H 2B0

Re: Surface Water and Groundwater Impacts of the Proposed Fernbank Quarry on Huntley Wetland

This letter report has been prepared in support of the Hydrogeology Study prepared by McIntosh Perry Consulting Engineers Ltd. (McIntosh Perry), dated March 2015, for the proposed Crain's Construction Quarry (the Site). The proposed quarry is to be located at 7731 Fernbank Road in the former Township of Goulbourn, Ottawa, Ontario. The legal description of the property is Lot 11, Concession 10, Geographic Township of Goulbourn, now in the City of Ottawa. This letter report has been prepared to discuss the potential surface water and groundwater impacts of the proposed quarry on the nearby Provincially Significant Huntley Wetland. As noted in the Hydrogeology Study, the Huntley wetland is located approximately 200m from the proposed quarry at its closest point. The hydrogeologic modelling of the proposed quarry location has suggested that the cumulative impacts of the development on the Huntley wetland are negligible from a groundwater perspective. This report seeks to confirm this statement, and includes both surface water and groundwater analyses.

Areal Analysis

McIntosh Perry staff began with an areal analysis of the site impacts using geographic data from the Ontario Ministry of Natural Resources and Forestry (MNRF, 2015) for the Huntley wetland and its catchment boundary. It should be noted that the Huntley Wetland spans both the Rideau and Mississippi watersheds, however as the vast majority of the wetland is within the jurisdiction of the Rideau Valley Conservation Authority (RVCA) as opposed to Mississippi Valley Conservation (MVC), this review is limited to the Rideau River catchment area. As a result, the analysis can be considered a conservative review, as the percentage impact of the proposed quarry would decrease with an increased catchment area of the wetland (i.e. if the catchment portion within the MVC jurisdiction was incorporated). From here on, all references to the Huntley wetland catchment boundary and the Huntley wetland area refer only to the data within the RVCA boundary.

Based on the catchment data from MNRF for the Huntley wetland, the wetland has a total catchment area of approximately 2,488 ha. The Site encompasses approximately 57 ha of this catchment area. Based on these values, the Site accounts for ~2.28% of the total catchment area.

Hydrological Analysis

As a secondary analysis, McIntosh Perry staff conducted a water balance / water budget assessment of the Site. As the analysis was limited to the impacts of the Site on the Huntley Wetland, the site review consisted of runoff and infiltration delineation within the Jenkinson Drainage Area (Figure 3 of the Hydrogeology Study), and did not include a review of the Hobbs Drainage Area. To maintain a conservative approach, the entire portion of the Site that lies within the Jenkinson Drainage Area was treated as the proposed extraction area (i.e. setbacks were not considered), thus the total contributing area is estimated at approximately 48 ha. Pre-development and post-development scenarios were developed for comparative purposes at the Site.

The Site was analysed as per the Thornthwaite and Mather (1957) water balance method where water surplus is estimated based on the relation between evapotranspiration, runoff, and infiltration. Infiltration was estimated through the application of the infiltration factors provided by the Mississippi Source Protection Region (MSPR). The MSRP developed infiltration factors based on the Ministry of the Environment and Energy and customized them for the Mississippi Rideau Region. These factors refer to topography, soil, and ground cover. Surplus was estimated based on precipitation minus evapotranspiration. Finally, the remainder of the surplus is considered as runoff.

Analysis of Proposed Crain's Quarry Site

To begin, data from Environment Canada for the Ottawa International Airport (1981-2000), was used to calculate the surplus:

Table 1: Surplus Calculation per Environment Canada data for Ottawa International Airport (1981 - 2000)

Month	Temp	Heat Index	PET	Daylight Correction Value	Adjusted PET	Total Precipitation	Surplus	Deficit
January	-10.3	0	0.00	0.81	0.00	65.4	65.4	0.0
February	-8.1	0	0.00	0.81	0.00	54.3	54.3	0.0
March	-2.3	0	0.00	1.02	0.00	64.4	64.4	0.0
April	6.3	1.4	31.59	1.12	35.38	74.5	39.1	0.0
May	13.3	4.4	78.56	1.27	99.77	80.3	0.0	19.5
June	18.5	7.2	111.58	1.29	143.94	92.8	0.0	51.1
July	21	8.8	132.78	1.30	172.62	91.9	0.0	80.7
August	19.8	8.0	114.21	1.20	137.05	85.5	0.0	51.5
September	15	5.3	72.96	1.04	75.88	90.1	14.2	0.0
October	8	2.0	33.72	0.95	32.03	86.1	54.1	0.0
November	1.5	0.2	4.96	0.80	3.97	81.9	77.9	0.0
December	-6.2	0	0.00	0.74	0.00	76.4	76.4	0.0
		37.4	580.36		700.63	943.6	445.8	202.9

Monthly T from Environment Canada:

Heat Index (i) = 37.4
a: 1.06

Total Surplus = Surplus (445.8) – Deficit (202.9) = 243.0

Next, the infiltration factors were chosen based on the following data:

Table 2: Infiltration Factors from the "Tier 1 Water Budget and Water Quantity Stress Assessment" prepared by the Mississippi-Rideau Source Protection Region, August 2009

Description of Area / Development Site	Value of Infiltration Factor
Topography	
Flat Land (<1.5 slope range)	0.172
Rolling land (1.5 – 3% slope range)	0.120
Hilly land (>3% slope range)	0.073
Soil	
Low (clay, silt)	0.10
Low-Medium (till, sand-silt)	0.15
Medium (till, silty sand)	0.20
Medium-High (sands)	0.30
High (gravel, sands, organic deposits)	0.40
Variable (till)	0.20
Variable (fill)	0.40
Variable (sand)	0.35
Variable (bedrock)	
Precambrian Bedrock	0.20
Paleozoic Bedrock	0.05
Land Cover	
Low Infiltration – urban, aggregate	0.05
Medium Infiltration – agriculture, pasture, abandoned fields, wetland	0.10
High Infiltration – forest and plantation	0.20

For pre-development, the site has slopes generally between 1.5 and 3% slope, and as such was assigned a topographic infiltration rate of 0.12. The soil classification was generally noted as till, and was considered variable. As such, the site was assigned a soil infiltration rate of 0.20. Finally, a value of 0.10 was used to classify the land cover as it is generally agricultural/open fields. Based on these infiltration factors, the site was generally assumed to have an infiltration factor of 0.42 and a runoff coefficient of 0.58 under pre-development conditions, resulting in an estimated total annual infiltration of 49,139 m^3/year and an estimated total runoff of 67,859 m^3/year. A breakdown of pre-development calculations has been provided in Table 3, below.

For the post-development analysis, it was assumed that the entire extraction area has been disturbed. Given the disturbance to the lands, the topography of the fully disturbed site has been considered as "hilly" and assigned a value of 0.073. The soils have been assigned an infiltration factor of 0.05 (while the site will generally consist of exposed bedrock during and after extraction, there will still be a minor amount of infiltration, and so a value of 0.00 would be overly conservative). Finally, a value of 0.0 has been assigned to the land cover, as the site will not have any ground cover during or following the extraction (prior to rehabilitation). A breakdown of post-development calculations has been provided in Table 4, below.

Table 3: Pre-Development Water Balance Calculations

	Vegetated	Total
Area (m^2)	481541	481541
Pervious Area (m^2)	481541	481541
Impervious Area (m^2)	0	0
Infiltration Factors		
Topographic Infiltration Factor	0.12	
Soil Infiltration Factor	0.20	
Land Cover Infiltration Factor	0.10	
MOE infiltration Factor	0.42	
Actual Infiltration Factor	0.42	
Run-off Coefficient	0.58	
Inputs (per Unit Area)		
Precipitation (mm/year)	944	944
Run-on (mm/year)	0	0
Other Inputs (mm/year)	0	0
Total Inputs (mm/year)	944	944
Outputs (per Unit Area)		
Precipitation Surplus (mm/year)	243	243
Net Surplus (mm/year)	243	243
Evapotranspiration (mm/year)	701	701
Infiltration (mm/year)	102	102
Rooftop Infiltration (mm/year)	0	0
Total Infiltration (mm/year)	102	102
Runoff Pervious Areas	141	141
Runoff Impervious Areas	0	0
Total Runoff (mm/year)	141	141
Total Outputs (mm/year)	944	944
Difference (Inputs - Outputs)	0	0
Inputs (Volume)		
Precipitation (m^3/year)	454382	454382
Run-on (m^3/year)	0	0
Total Inputs (m^3/year)	454382	454382
Outputs (Volume)		
Precipitation Surplus (m^3/year)	116999	116999
Net Surplus (m^3/year)	116999	116999
Evapotranspiration (m^3/year)	337384	337384
Infiltration (m^3/year)	49139	49139
Rooftop infiltration (m^3/year)	0	0
Total Infiltration (m^3/year)	49139	49139
Runoff Pervious Areas (m^3/year)	67859	67859
Runoff Impervious Areas (m^3/year)	0	0
Total Runoff (m^3/year)	67859	67859
Total Outputs (m^3/year)	454382	454382
Difference (Inputs - Outputs)	0	0

Table 4: Post-Development Water Balance Calculations

	Quarry	Total
Area (m^2)	481541	481541
Pervious Area (m^2)	0	0
Impervious Area (m^2)	481541	481541
Infiltration Factors		
Topographic Infiltration Factor	0.073	
Soil Infiltration Factor	0.05	
Land Cover Infiltration Factor	0.00	
MOE infiltration Factor	0.123	
Actual Infiltration Factor	0.123	
Run-off Coefficient	0.877	
Inputs (per Unit Area)		
Precipitation (mm/year)	944	944
Run-on (mm/year)	0	0
Other Inputs (mm/year)	0	0
Total Inputs (mm/year)	944	944
Outputs (per Unit Area)		
Precipitation Surplus (mm/year)	243	243
Net Surplus (mm/year)	243	243
Evapotranspiration (mm/year)	701	701
Infiltration (mm/year)	30	30
Rooftop Infiltration (mm/year)	0	0
Total Infiltration (mm/year)	30	30
Runoff Pervious Areas	0	0
Runoff Impervious Areas	213	213
Total Runoff (mm/year)	213	213
Total Outputs (mm/year)	944	944
Difference (Inputs - Outputs)	0	0
Inputs (Volume)		
Precipitation (m^3/year)	454382	454382
Run-on (m^3/year)	0	0
Total Inputs (m^3/year)	454382	454382
Outputs (Volume)		
Precipitation Surplus (m^3/year)	116999	116999
Net Surplus (m^3/year)	116999	116999
Evapotranspiration (m^3/year)	337384	337384
Infiltration (m^3/year)	14391	14391
Rooftop infiltration (m^3/year)	0	0
Total Infiltration (m^3/year)	14391	14391
Runoff Pervious Areas (m^3/year)	0	0
Runoff Impervious Areas (m^3/year)	102608	102608
Total Runoff (m^3/year)	102608	102608
Total Outputs (m^3/year)	454382	454382
Difference (Inputs - Outputs)	0	0

Table 5, below, summarizes the key results from Tables 3 and 4.

Table 5: Pre- and Post-Development Results Summary

Characteristic	Pre-Development	Post-Development	Change (Pre- to Post)
Inputs (Volumes)			
Precipitation (m^3/year)	454382	454382	0%
Run-on (m^3/year)	0	0	0%
Other Inputs m^3/year)	0	0	0%
Total Inputs (m^3/year)	454382	454382	0%
Outputs (Volumes)			
Precipitation Surplus (m^3/year)	116999	116999	0%
Net Surplus (m^3/year)	116999	116999	0%
Evapotranspiration (m^3/year)	337384	337384	0%
Infiltration (m^3/year)	49139	14391	-71%
Rooftop infiltration (m^3/year)	0	0	0%
Total Infiltration (m^3/year)	49139	14391	-71%
Runoff Pervious Areas (m^3/year)	67859	0	-100%
Runoff Impervious Areas (m^3/year)	0	102608	0%
Total Runoff (m^3/year)	67859	102608	51%
Total Outputs (m^3/year)	454382	454382	0%

Analysis of Huntley Wetland

As part of the preparation of this report, McIntosh Perry staff reviewed a similar study completed by Palmer Environmental Consulting Group Inc. (Palmer, 2014) for a neighbouring quarry developed by Taggart. As part of their analysis, they completed water budget calculations for the "Southern Provincially Significant Wetland (PSW)". The Southern PSW is located approximately 1.5 km southeast of the proposed Crain's quarry. Based on the Southern PSW's proximity to the Site, field observations made by McIntosh Perry personnel, and a desktop comparison of overburden, it is reasonable to assume that the Southern PSW possesses similar surface and subsurface characteristics to the Huntley Wetland.

The catchment area for the Southern PSW encompasses approximately 84.2 ha, as noted in the Feature Specific Water Budget Assessment and Wetland Hydrogeology Study completed by Palmer (2014). As previously noted, the catchment area for the Huntley wetland is approximately 2,488.4 ha. Using these data, the results of Palmer's analysis of the Southern PSW were scaled to determine approximate equivalent values for the Huntley wetland – Table 6, below, summarizes the key data that were used.

Table 6: Southern PSW Data - from Palmer Report

Southern PSW – Post-Development – Palmer Report	
Catchment Size (ha)	84.1680
Runoff Total (m^3/yr)	179,485
Infiltration Total (m^3/yr)	154,384

Table 7: Huntley PSW Data – Scaled based on MNRF Data and Palmer Report

Huntley PSW – Post-Development – MNRF Data	
Catchment Size (ha)	2488
Runoff Total (m^3/yr)	See Calculation Below
Infiltration Total (m^3/yr)	See Calculation Below

The approximate scaled equivalent runoff total was calculated as follows:

$$\frac{84.1680\ ha}{24880.40\ ha} = \frac{179{,}485.280\ m^3/yr}{R}$$

Therefore, R = 5,306,424 (m^3/yr), where R is the total estimated runoff for the Huntley Wetland, as scaled based on the calculations from the Palmer report for the Southern PSW.

Similarly, the approximate scaled equivalent infiltration total was calculated as follows:

$$\frac{84.1680\ ha}{24880.40\ ha} = \frac{154{,}384.024\ m^3/yr}{I}$$

Therefore I = 4,564,314 (m^3/yr), where I is the total estimated infiltration for the Huntley Wetland, as scaled based on the calculations from the Palmer report for the Southern PSW.

Based on the data presented in Table 5, the total net change to surface flows for the site is estimated at 102,608 m^3/yr – 67,859 m^3/yr for a total increase of 34,749 m^3/yr. This increase in surface water flow (runoff) is considered a loss due to the conservative nature of this memo; although runoff is increasing in a post-development scenario, this calculation assumes that a large portion of the off-site runoff will not be (directly) returned to the Huntley PSW.

Based on the analysis prepared by Geofirma Engineering Ltd. in McIntosh Perry's Hydrogeological Investigation for the Site, the proposed quarry is anticipated to reduce the net groundwater inflow beneath the wetland by 32,800 m^3/yr.

Impact Analysis

Using the data above, the anticipated hydrological impact (surface water and groundwater) of the proposed quarry on the Huntley wetland was calculated as follows:

$$\frac{Site\ Runoff\ Loss^{*} + Groundwater\ Loss}{Huntley\ PSW\ Total\ Runoff + Total\ Infiltration} = \%\ Impact$$

$$\frac{34{,}749 m^3/yr + 32{,}800 m^3/yr}{5{,}306{,}424.90 m^3/yr + 4{,}564{,}314.29 m^3/yr} = 0.6\%$$

*Refer to previous for clarification on runoff differential being considered loss vs. increase.

Based on the above analysis, it was estimated that the quarry development would cause a hydrologic impact amounting to no greater than 0.6% of the total Huntley Wetland water budget.

The above hydrological analysis relies on a number of assumptions. As previously noted above, it has been assumed that given the close proximity of the Southern PSW to the Huntley Wetland, it was assumed that the two wetland catchments have similar geological characteristics, which allows a scaled estimate of key data based on the model prepared in the Palmer report. The above analysis also assumes that groundwater from the site contributes to the base flow of the Huntley Wetland, including deep base flows.

The following items contribute to the conservative nature of this analysis:

- Runoff calculations: it has been assumed that the entire Site, as it lies within the Jenkinson catchment, contributes to the Huntley Wetland.
- Runoff calculations: reduction in runoff factors assumes that no pumping works will be performed. However, as pooled water will be treated and pumped back into the Huntley wetland, actual reductions in runoff will be significantly less than calculated.
- Groundwater connectivity: given the relatively continuous layer of clay matrix till currently present under the Huntley wetland, the expected loss of wetland baseflow due to a reduction in groundwater infiltration to the wetland is significantly exaggerated.
- Infiltrated water that could be considered interflow was not considered to re-contribute to the surface water flow in this analysis. However, it should be noted that the proposed quarry consists of a simple 'taking and return' system, where groundwater and surface water is pumped, treated, and returned to a natural watercourse.

Conclusion

Given the above areal and hydrological analysis, McIntosh Perry believes that the proposed quarry will have negligible impacts on the neighbouring Huntley Wetland, from both a surface water and groundwater perspective. Both methods of analysis conclude a less than 3% impact to the wetland. Furthermore, given the noted assumptions, it is expected that the actual impacts are even less. Given the relatively continuous clay matrix till layer underlying the wetland, it is unlikely that the Site currently contributes significantly to the Wetland through infiltration. As such, given that the Site's primary contribution is via overland surface flow, and provided the proposed quarry will pump pooled water back into the catchment area to ensure work areas remains dry, the surface flows will continue to reach the Huntley Wetland as per pre-development conditions.

We trust that this information is satisfactory for your present requirements. Should you have any questions or require additional information, please do not hesitate to contact the undersigned.

Respectfully submitted,

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