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R.J. Burnside & Associates Limited
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Subject: Greenwood Aggregates Pit Violet Hill Licence Application
Response #2 to the Combined Level 1 / 2 Hydrogeological Assessment Peer Review

Attention: Dwight Smikle: Senior Hydrogeologist

Whitewater Hydrogeology Ltd. (Whitewater) is pleased to respond to R.J. Burnside & Associates Limited's (Burnside) second round of technical peer review comments completed on the Combined Level 1 and 2 Hydrogeological Assessment for Greenwood Aggregates proposed Violet Hill Pit.

Based on Burnside's memorandum dated February 8, 2018, it is felt that clarification is necessary on the technical requirement for a Category 3, Class "A" Pit Above Water, which is outlined in the Provincial Standards that support the Aggregate Resources Act (ARA). As noted in the Whitewater report (2016), the only hydrogeological requirement is to "*determine the elevation of the established groundwater table within the site or demonstrate that the final depth of extraction is at least 1.5 m above the water table*."

The stratigraphy encountered at the proposed Violet Hill Pit site has restricted the extraction depth. The detailed geological logs and aggregate testing show that the aggregate that can be extracted and processed into a marketable product is found above 415 masl, which is on average approximately 5 m above the established groundwater table. Therefore, Greenwood has proposed that extraction will not occur below 415 masl.

Under the ARA, compliance is governed by the set floor elevation on the Site Plans, which must be at least 1.5 m above the established water table. The proposed Violet Hill Pit application does not indicate that Greenwood must remain 5 m above the established water table to remain in compliance.

If you have any questions or concerns, please do not hesitate to call at any time.

Yours truly,

Tecia White, M.Sc. P.Geo.
Senior Hydrogeologist
Whitewater Hydrogeology Ltd.

**Groundwater Contour/Flow Map**

Groundwater watersheds are conceptually like surface water watersheds because groundwater flows from topographic highs (groundwater recharge areas) to topographic lows (groundwater discharge areas). The boundaries of surface water and groundwater watersheds do not always coincide exactly. Groundwater movement occurs in aquifer systems and is subject to hydraulic properties of the aquifer, input to (recharge) and outflow from (discharge) the aquifer system, and geological factors. Unconfined aquifers (the water table) mimic surface water watersheds but can vary slightly based on the conditions mentioned above. Whitewater has not stated that the two divides are equivalent / coincide, but that the flow directions are similar (primarily west and south, with a small easterly component).

Figure 8 from the Whitewater report (2016) has been revised to reflect the requested information (see Figure 1 appended), which includes the revised seasonal high-water levels, groundwater contours, and groundwater flow direction. The seasonal high-water levels which were used to create the groundwater flow map were measured on July 6, 2017. Selected representative domestic water well data have been used to assist in the mapping of the regional groundwater flow pattern. Domestic water level data was filtered based on geological descriptions, supply aquifer details, date of drilling, and pump test information to that the static water level could be used to aid in defining the regional groundwater flow conditions (regional high and low groundwater elevations).

The results show that the primary groundwater flow direction is east with a southerly component. A small portion of the site has groundwater flowing west toward the Violet Hill Wetland. The updated mapping further supports the groundwater flow interpretation presented in the Whitewater report (2016).

**Geological Cross Sections and Base of Excavation**

Burnside has relied on the cross sections presented in the 2016 report to compare the proposed pit floor elevation to the established water table. It is noted that discrepancies in the cross sections provide insufficient data to determine that the base pit floor elevation (415 masl) will provide a 5 m (*correct value is 1.5 m, not 5 m*) separation from the established water table elevation.

It has been requested that cross sections should be provided in greater detail and should incorporate the spatial variations in the groundwater table derived from the groundwater contour map (Figure 1). To obtain the vertical scale resolution requested (i.e., to distinguish true separation depths), the cross sections would require being constructed at a vertical exaggeration greater than 20x. Too much vertical exaggeration can distort terrain to the point of misrepresentation. Therefore, it is felt that an updated hydrograph, which compares water levels to the proposed pit floor elevation and the revised Figure 8 will provide a clearer understanding of the proposed operation and site conditions.

The updated water levels are provided in Figure 2. For visual purposes, the 1.5 m unsaturated buffer zone beneath the proposed pit floor (415 masl) has been included. All the wells, except for MW4 and MW9 have seasonally high-water levels that are well below the 1.5 m buffer. MW4 and MW9 are both located upgradient from the proposed extraction boundary (40 and 200 m, respectively) and as a result, will have water levels that are higher than the interpreted levels across the pit floor (Figure 1). Based on the groundwater flow contours, the water table elevation ranges between a high of approximately 413 masl (south-west of MW4) to a low of 403 masl (near MW6) beneath the proposed extraction area. Therefore, the pit floor will remain 1.5 m above the water table.

The highest water levels report across the site (413 masl) are found in Phase E of the operations plan, which is the final area of the proposed extraction plan. On-going monitoring will confirm that extraction remains at or above the 1.5 m separation distance from the established water table (seasonal high) to ensure compliance.

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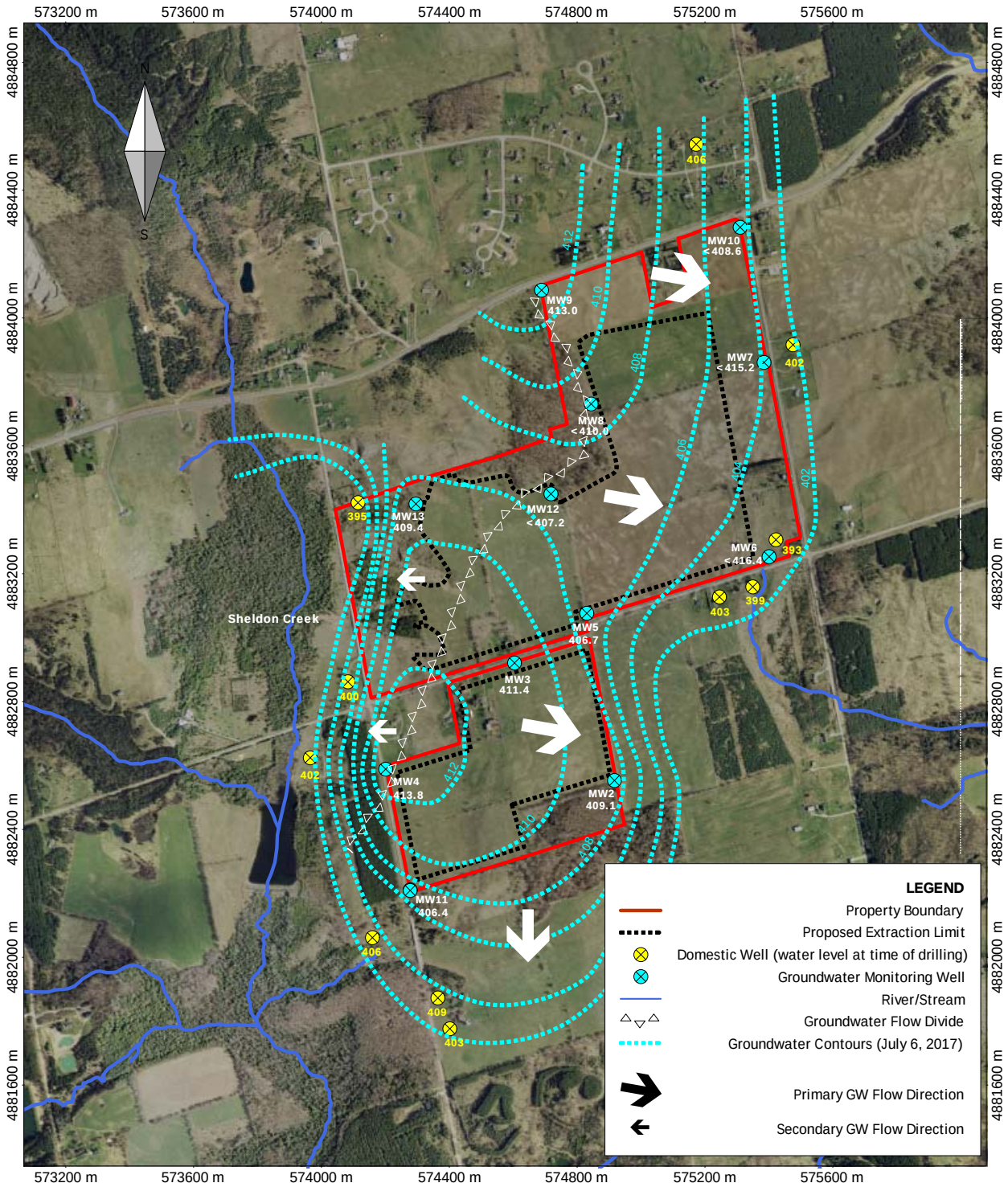


FIGURE 1: GROUNDWATER FLOW MAP

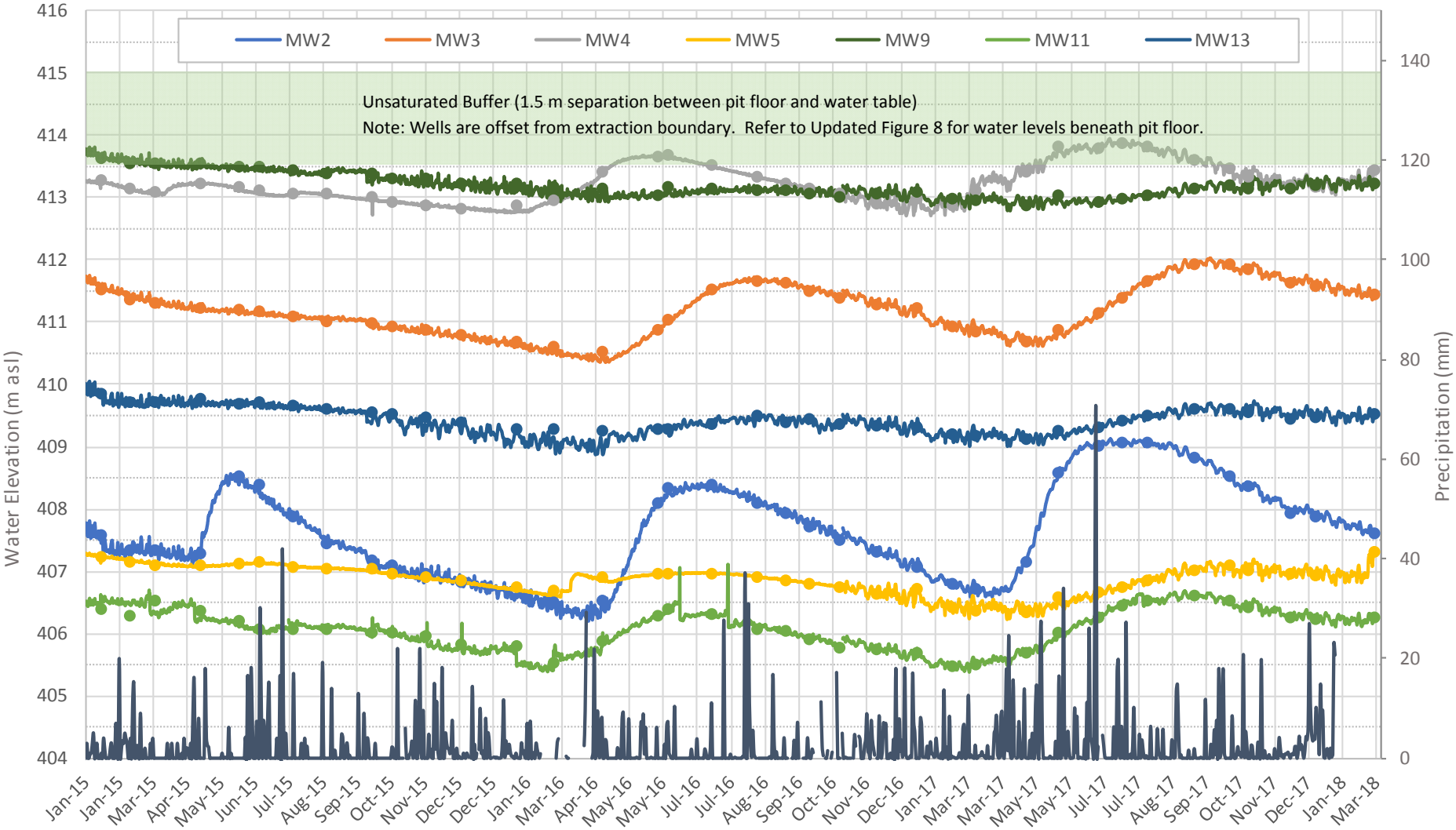


**FIGURE 2: UPDATED GW HYDROGRAPH**

**Note:**

Water levels presented on Figure 2 are those that were collected after well development, which was completed by Whitewater.

**Water Balance, Surface Water Catchments, and Impacts to Violet Hill Wetland**

Burnside raised the concern that the proposed extraction area extends into the Violet Hill Wetland watershed, which will result in the loss of overland flow to Sheldon Creek and the wetland. It is noted in the Whitewater report (2016) that runoff (overland flow) is limited based on the existing site characteristics (approximately 13% of the annual precipitation is available for runoff from areas that are not internally drained). Based on field observations, most of the water that is available for runoff infiltrates along the flow path before entering the Violet Hill Wetland.

Water balance analysis at a regional scale was required to address Burnside's concern on the proposed change in land use on the Violet Hill Wetland. As model scale increases, impacts associated with small land use changes are masked. Therefore, by increasing the water balance analysis from the local scale (site-specific analysis presented in the Whitewater report) to regional scale (watershed) as requested, influences from the proposed pit operations are lost.

The Manifold GIS Watershed Computation Tool was used to define two regional the watersheds so that the requested analysis be completed for areas east and west of the surface divide. These catchment areas are:

1. Basin A - the upper Sheldon Creek and Violet Hill Wetland; and
2. Basin B - an un-named watercourse immediately south-east of the site

A water balance analysis on a catchment by catchment basis (areas east and west of the divide) has been completed to provide a comparison between pre and post-development conditions (Table 1 and Table 2). The water balance results for pre-development scenario show that the Violet Hill property (extraction area and undisturbed lands) make up a very small percentage of the total catchment areas and as a result, a small percentage of the total runoff (0.7 and 3.3 %).

TABLE 1: PRE-DEVELOPMENT RUNOFF RATES

| Development Scenario | Drainage Area ($m^2$) | Runoff Rate (m/year) | Volume of Groundwater Runoff ($m^3$) | Runoff (% of total) |
|---|---|---|---|---|
| **Pre-Development Runoff** | | | | |
| Basin A | 23,198,125 | 0.117 | 2,714,181 | 96.7 |
| (Violet Hill Property) | 805,252 | 0.117 | 94,214 | 3.3 |
| **Total Basin A** | 24,003,377 | | 2,808,395 | 100 |
| Basin B | 8,792,928 | 0.117 | 1,028,773 | 99.3 |
| (Violet Hill Property) | 58,924 | 0.117 | 6,894 | 0.7 |
| **Total Basin B** | 8,851,852 | | 1,035,667 | 100 |

Notes:

1. The estimated infiltration factor (IF) based on the existing site characteristics is 0.7 and applies to the entire watershed based on topography and geology. See Whitewater report for water surplus calculations.
2. To complete the requested assessment, the internally drained areas previously assessed have been excluded.

The water balance for post-development scenario was modeled under the assumption that the proposed Violet Hill pit will reduce infiltration rates by 25%. The results indicate that the net change in the volume of runoff across the catchment areas from pre-development conditions would be less than 1% (unmeasurable). The proposed Violet Hill pit would have to include a paved area (impermeable surface) that covers a total of 4.5 ha (2.6 ha in Basin A and 1.9 ha in Basin B) in order to achieve these post-development runoff volumes. This modeled assumption overemphasizes any potential impact resulting from the proposed change in land use and addresses concerns regarding the compaction of material on pit floor and the construction of berms, internal roadways, and parking areas on Violet Hill property.

TABLE 2: POST-DEVELOPMENT RUNOFF RATES INCREASED BY 25%

| Development Scenario | Drainage Area ($m^2$) | Runoff Rate (m/year) | Volume of Groundwater Runoff ($m^3$) | Runoff (% of total) | Net Change (%) |
|---|---|---|---|---|---|
| **Pre-Development Runoff** | | | | | |
| Basin A | 23,198,125 | 0.117 | 2,714,181 | 96% | -0.7% |
| (Violet Hill Property) | 805,252 | 0.146 | 117,567 | 4% | +0.7% |
| **Total Basis A** | 24,003,377 | | 2,831,748 | 100% | |
| Basin B | 8,792,928 | 0.117 | 1,028,773 | 99% | -0.3% |
| (Violet Hill Property) | 58,924 | 0.146 | 8,603 | 1% | +0.3% |
| **Total Basis B** | 8,851,852 | | 1,037,376 | 100% | |