Stormwater Management Plan

Mountain Ash Limited Partnership Summit Pit

SLR Project No: 212.06650.00006

April 2021

Stormwater Management Plan for Summit Pit

Rocky View County, Alberta

SLR Project No: 212.06650.00006

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1.0 INTRODUCTION

Mountain Ash Limited Partnership (Mountain Ash) is planning to develop the Summit Pit (the Project) along Highway 567 within NW and SW 31-026-03 W5M, northeast of the Town of Cochrane, in Rocky View County (RVC), Alberta (Drawing 1). The Project will encompass approximately 208 acres (84 ha) excluding existing road rights-of-way. Mountain Ash is applying for Phase 1 of a six-phase mining plan. This land is currently owned by 1410266 Alberta Ltd. (a general partner of Mountain Ash). Summit Pit received land use and a master site development plan (MSDP) approval on March 2, 2021 (Land Use Bylaw C-8051-2020).

A conceptual Stormwater Management Plan (SWMP) was developed for the Project in 2016 (SLR 2016). The SWMP is required to ensure sustainable and effective management of surface water quality to protect existing local water users and the natural environment, which includes neighboring domestic wells and the Big Hill Springs Provincial Park. The conceptual SWMP has been revisited to consider the new phase mine plan developed in 2019. The water management strategy previously proposed, which is discussed in this report, has been maintained for the updated SWMP.

1.1 Hydrogeology

A hydrogeological assessment (SLR 2020) was undertaken as part of the MSDP application to assess the potential for groundwater impacts from the Project operations in relation to nearby groundwater users. A Groundwater Monitoring Plan (GMP) was subsequently prepared in relation to the operation of the Summit Pit. The objective of the GMP is to ensure the effects of site operations on groundwater resources in the vicinity of the site are monitored and negative impacts prevented wherever possible.

A total of 10 groundwater monitoring points were installed at the site and have been subject to periodic groundwater elevation monitoring between October 2014 and September 2019 (as detailed in the Hydrogeological Assessment, SLR 2020). A summary of the analysis related to the Storm Water Management Plan is presented below:

- The highest groundwater elevations are recorded in the sand and gravel at 1,274.87 masl (16.21 m below ground surface [bgs]) on November 20, 2014. Groundwater levels have been declining since, and in July 2019 had reached a low of 1273.65 masl (17.43 m bgs) at the same monitoring point.
- Minimal fluctuation in the groundwater levels within the sand and gravel indicates very little or no influence from pumping within residential wells completed in the bedrock in the area.

The base of the settlement ponds will be approximately 3 m bgs in the glacial till, and consequently a minimum of 10 m above the sand and gravel groundwater table. Groundwater monitoring will be ongoing to ensure that the base of the pit (and the infiltration areas) will be kept a minimum of 1.0 m above the maximum groundwater table. The drainage features will be designed to prevent direct interaction with the groundwater system.

1.2 Hydrology

1.2.1 Overview

The site is located approximately 1 km upslope of the Big Hill Springs Provincial Park and is located within the surface water catchment of an Unnamed Watercourse which forms a tributary to the larger Bighill

Creek. No surface water bodies (streams or lakes) have been identified within the site area itself; however, there are two wetlands in the northwest corner considered as Class III (seasonal) wetlands which are to be retained on the landscape. The small wetlands scattered across the property where aggregate extraction will take place are not going to be retained. Mountain Ash will consider upgrading or replacing wetlands however possible at the time of reclamation.

The wetlands located in the northwest corner of the site (see wetland area on Drawing 2), which do not have a surface discharge outlet, are fed by rainfall and snowmelt from the local catchment and from a portion of the catchment to the north of Highway 567 (via a culvert located beneath the highway). These wetlands will be retained on the landscape and this small area will not be developed for aggregate extraction with exception of construction of settlement Pond C (Drawing 2). The Hydrogeological Assessment (SLR 2020) also confirms that these wetlands are not groundwater fed.

Giving the impermeable nature of the surficial soils at surface, infiltration of precipitation (snow or rainfall) landing on the existing site would be limited; therefore, the predominant hydrological regime would be characterized by stormwater runoff.

1.2.2 Rainfall Data

Intensity Duration Frequency (IDF) rainfall data has been obtained from the Environment and Climate Change Canada Website for the rainfall gauge located at Calgary International Airport some 30 km southeast of the site (ID 3031094). The period of record used to derive the IDF statistics is from 1947 through 2015. The IDF graph represents rainfall storm duration against rainfall intensity for varying rainfall return periods and is used to inform the outline hydraulic design / sizing of stormwater management features.

1.3 Proposed Development

As shown on Drawing 2, the northwest quarter of Section 31 (Drawing 1) covers a total area of approximately 65 ha (160 acres), whereas the southwest quarter covers approximately 70 ha (173 acres). The ultimate excavation footprint covering a continuous parcel overlapping both quarter sections will be approximately 84 ha (208 acres). A screening earth berm will be built along the outer perimeter of the extraction area to act as a noise/visual barrier (Drawings 3A to 3F). Surface runoff from the perimeter berm will have to be collected and sediment control will be provided. Once permitted, the property will be operated in six phases of uneven size (depending upon setbacks), each lasting about six years. Each phase will be worked via individual cells with a maximum of approximately four cells 'open' at any given time. A summary of the individual phases is provided below (see Drawing 2):

- Phase 1 comprises about 13.90 ha and includes working cells 1 to 15.
- Phase 2 is immediately to the north comprising of about 15.20 ha and will be worked over cells 16 to 31.
- Phase 3 consists of approximately 15.21 ha and includes working cells 32 to 47.
- Phase 4 comprises 11.70 ha and will be worked via cells 48 to 61. The two wetlands in the northwest corner will be retained and Phase 4 will be developed on the lands south and east of them.
- Phase 5 comprises 15.96 ha and will be worked via cells 62 to 76, and 78.
- Phase 6 comprises 8.424 ha and will be worked via cells 79 to 87.

Based on drilling investigations at the site, there is 4 m to 6 m of glacial till overburden overlying the sand and gravels. The till soils will be stripped and stockpiled around the perimeter of the relevant extraction phases for screening purposes and ultimately for future use in the site restoration.

The sand and gravel are the target deposit for extraction and lies immediately above the underlying bedrock. Groundwater in assessment boreholes were noted between 20 m and 24 m bgs and generally lies above the bedrock. It is anticipated that the site will be worked to 1.0 m above the maximum recorded groundwater level within the gravel deposit and will therefore be worked dry, with no requirement for operational or permanent dewatering. Actual depths will be determined with progressive investigation of water levels as the site is developed.

1.4 Objectives

The objectives of this SWMP are to demonstrate that stormwater water runoff within the site confines will be effectively and sustainably managed using City of Calgary[1], Rocky View County[2], and Province of Alberta[3] stormwater management techniques and best practice guidance (where applicable).

The underlying principles of this assessment are:

1) To ensure that storm water generated by incident rainfall on the site (and its immediate surrounds) is managed to prevent a potential increase in flood risk downstream in the catchment and maintain 'dry' working areas.

2) To provide suitable stormwater quality treatment to prevent potential pollution of the underlying aquifer and surface water bodies within the catchment.

3) To provide a passive or, gravity stormwater management system that does not require routine pumping.

4) To achieve separation of 'clean' (i.e., stormwater runoff from unworked land) and potentially 'dirty' (i.e., runoff from overburden tips) stormwater runoff where practically possible.

5) To provide stormwater management measures, which can be incorporated into the site development to prevent operational areas being impacted by stormwater runoff.

[1] The City of Calgary Water Resources (2011) Stormwater Management & Design Manual, September 2011.

[2] Rocky View County (2013). County Servicing Standards, Section 700, May 2013.

[3] Alberta Environmental Protection (1999). Stormwater Management Guidelines for the Province of Alberta, January 1999.

2.0 STORMWATER MANAGEMENT PLAN

2.1 Strategy Overview

The stormwater management strategy will be implemented over six Surface Water Management Phases and the proposed strategy for each phase is presented on Drawings 3A to 3F. Generally, the surface water management measures for each phase are similar and entail the following where applicable:

- Install perimeter (grassed / lightly vegetated) ditches (swales) at the outer foot of the screening berms / overburden stockpiles to route 'dirty' runoff (initial treatment) from the mounds to appropriately sized settlement / attenuation ponds (secondary treatment). Shallower longitudinal gradients in the swales would encourage longer residence times, lower velocities and thus improve treatment effectiveness. The perimeter ditches are identified with blue dashed lines and the ponds as blue rectangles on Drawing 2 and Drawings 3A to 3F.
- A locally created sump excavated into the underlying sands and gravels accepts the 'treated' outflow from the pond where the runoff will locally form groundwater recharge (via infiltration through the sands and gravels thus providing a tertiary level of surface water treatment) and reduction in surface water volumes. Sumps are to be connected to the outer settlement ponds by a culvert/pipe beneath the perimeter berm. The infiltration sumps are identified as magenta squares on Drawing 2 and Drawings 3A to 3F.
- Interception ditches are proposed upslope of the Surface Water Management Phases to prevent stormwater runoff from the up-gradient catchment entering the extraction areas. This water is considered 'clean' and therefore does not require treatment; instead, it is routed around the Surface Water Management Phases via diversion ditches and allowed to disperse overland (via a series of shallow excavated diffusion channels). This provides hydrological continuity between the upslope and downslope of the relevant Surface Water Management Phases. The diversion ditches are identified with orange dashed lines on Drawings 3A to 3F.
- A temporary locally created sump excavated within the extraction area to collect clean runoff upslope of the Surface Water Management Phases during the development of Phases 2, 3 and 4 (see orange square on Drawings 3B to 3D). The temporary sump will also collect water from Pond C during the Phase 3 extraction operation (Drawing 3C). The temporary sump is to be located in a low topographic spot within the extraction area and is required due to topographic constraints that impede gravity flow of clean water away from the extraction area (see direction of diversion ditches discharging to the temporary sump). Water collected in the temporary sump will either infiltrate or be pumped to the temporary diversion ditch located west of Phase 1, which conveys clean water to the perimeter of the extraction area for direct release to the environment (Drawings 3B to 3D).

2.2 Design Criteria

All stormwater management features (i.e., swales, settlement ponds and discharge sumps) are sized to the 1:100 year storm event as required by Provincial / County guidance. The stormwater management elements are sized using the rainfall intensities for varying storm durations taken from the IDF Graph

With regards to swale design the application of the recommended 'Unit Area Release Rate Method' enables the peak runoff to be determined by incorporation of a conservative unit release rate = 90 l/s/ha (City of Calgary Stormwater Management & Design Manual). Freeboard allowances are incorporated into the outline design to provide snowmelt offsetting.

For the attenuation / settlement pond design, to achieve acceptable sedimentation the target velocity and particle size range for wet ponds is 2.8 x 10^{-4} m/s and 20 – 50 ųm, respectively (City of Calgary Stormwater Management & Design Manual). The outflow rate (m^3/s) and surface area (m^2) are determined from application of this minimum settlement velocity. The pond volume is determined by accommodating the stormwater runoff volume from its receiving catchment for the 1:100 year 24-hour storm event and is designed to maintain a 300 mm freeboard above this design storm event. The pond catchment areas are shown on Drawing 2.

The sump(s) within the sands / gravel horizon are also sized to accommodate a 1:100 year 24-hour outflow hydrograph from the associated settlement pond (i.e. the design storm event) plus incident rainfall onto the extraction area. A proposed 300 mm freeboard is also recommended for the outline sump design. The hydraulic conductivity of the sands and gravels governs the rate of infiltration rate (i.e. discharge rate) into the sand and gravels and the lower in-situ permeability of 1 x 10^{-4} m/s is applied to adopt a conservative approach.

With respect to snowmelt contributions to stormwater runoff, this is inherently difficult to accurately quantify as recognized by the Alberta Stormwater Management Guidelines (Section 4.4.5 of the guidelines). Furthermore, review of the City of Calgary Stormwater Management & Design Manual and Rocky View Servicing Standards confirms that the design criteria for storage features is a 1:100 year (24 hour) storm (no detailed quantitative assessment of snowmelt appears to be required). Notwithstanding, a minimum freeboard allowance of 0.1 m on top of the 1:100 year 24-hour event have been incorporated into the outline design of the stormwater management features to provide additional conveyance capacity as a contingency for potential snowmelt contributions to site runoff.

Snow accumulations must be appropriately managed by site operatives to ensure the operational efficiency of the proposed SWMP is maintained where possible. This includes avoiding localized large snow piles along draining to only one ditch rather than making use of the network of ditches, and timely removal of snow and/or ice accumulation in the ditches as required to maintain conveyance capacity.

All stormwater management features are to be unlined as it is anticipated that the surficial till (clay) has sufficient stability and cohesive properties to facilitate the excavations. However, if liners are deemed to be necessary for particular features / reasons, this can be incorporated at the discretion of the developer. In any case, all features are to be grassed to enable filtration, reduce sediment transfer and enhance stability. The appropriate stormwater management elements will be constructed prior to commencement of the relevant excavations to enable establishment of the grass and their construction specifications verified before accepting the design flows.

2.3 Surface Water Quality

To account for the sensitive nature of the surrounding water environment, the proposed SWMP offers three stages of surface water quality treatment for stormwater runoff shed from overburden areas:

Stage 1	Filtration / aeration / biological interaction through conveyance of water in proposed surface water ditches.
Stage 2	Suspended solid settlement and further biological interaction within settlement / attenuation ponds. Residence time within the pond encourages settlement and is provided via appropriate hydraulic design (to achieve minimum settlement velocities).
Stage 3	Infiltration through the sands and gravels before entering the groundwater.

Plant areas located within the site should be developed with appropriate cross-falls to allow immediate positive drainage to proposed ditches. Surface water drainage from the site plant areas will be passed through an oil interceptor before discharging into receiving ditches.

2.4 Surface Water Runoff

2.4.1 Outside Extraction Areas

Surface water runoff from the overburden storage and screening areas (and the local up-gradient catchment where applicable) will be attenuated via settlement ponds designed to achieve appropriate sedimentation with a target velocity of 2.8 x 10^{-4} m/s taken from the City of Calgary Stormwater Management & Design Manual.

2.4.2 Within Sand and Gravel Extraction Areas

Each cell will be excavated first through the glacial till, which will be stockpiled, and then into the target sand and gravel. Incident rainfall onto the extraction areas within the glacial till horizon would need to be locally managed (due to limited permeability / infiltration capacity of the till) via integrating an appropriate cross fall within the base of the working area (i.e. 1% to 2%) to convey rainfall to a dedicated sump with proposed minimum dimensions of [5 m (W) x 5 m (L) x 1 m (D)] = 25 m^3. Each quadrant will be worked via individual cells with a maximum of approximately four cells 'open' at any given time. Outline modelling (for the design 1:100 year 24-hour storm event) confirms limited accumulation of runoff within the extraction areas (maximum of 4 x cells = 40,000 m^2) of <10 m^3 which spread over the extraction base area is equivalent to <0.001 m of water depth during the storm event. It is also noted that the exposure of the till during excavations will be temporary until the underlying sands and gravels are reached.

Once the excavation enters the sand and gravel, incident rainfall (for the design 1:100 year 24-hour storm event) is readily infiltrated thus no management of precipitation within the extraction areas is required.

The aggregate extraction is dry i.e., groundwater will not be encountered. Taking the above into consideration, no regular requirement for dewatering the extraction areas via pumping is anticipated. However, in the event that groundwater is unexpectedly encountered it is recommended that extraction be limited in that area and the floor of the excavation area be raised for subsequent extraction. Given the flexible extent of the extraction area, no emergency pumping is deemed necessary.

2.5 Outline Design of Stormwater Management Features

The following subsections outline the hydraulic design for the proposed stormwater management elements.

2.5.1 Swales

A standard swale size is proposed for the development and has been determined by analyzing the swale with the largest contributing catchment area and shallowest longitudinal gradients.

Using the design criteria outlined in Section 2.2 the rate of runoff is determined by the Unit Area Release Rate Method:

$$Q = UARR\ x\ A$$

Where: *Q* = Peak Runoff Rate (l/s)

UARR = Unit Area Release Rate (l/s/ha)

A = Catchment Area (ha)

Adoption of a higher UARR (i.e., 90 l/s/ha for this assessment) ensures a conservative approach to the swale hydraulic design. Table 1 summarizes the peak flow calculation for the swale with the largest catchment (corresponds to the Phase 2 north diversion ditch shown on Drawing 3B).

Table 1 Swale Peak Flow Calculations

Parameter	ID	Unit	Value	Notes
Unit Area Release Rate	UARR	l/s/ha	90	The top end figure within the 'higher release rate' category as defined in the City of Calgary Stormwater Management & Design Manual for areas of moderate slopes where surface ponding storage is limited
Catchment Area	A	ha	27.33	Measured from AutoCAD development plans for the Phase 2 north diversion ditch shown on Drawing 3B
Calculated Peak Flow	Q	m^3/s	2.46	Standard swale design is sized to accommodate this peak flow (plus freeboard allowances to provide offsetting of snowmelt contributions)

The channel geometry required to convey the anticipated peak flow has been determined through application of Manning's Equation. The Manning's 'n' coefficient of the swales, established from experience and referenced to respected literature[4], has been estimated to be 0.033. The proposed geometry is as follows:

Base Width	=	0.750 m
Base to Top of Bank	=	0.750 m
Side Slopes	=	1 vertical to 2 horizontal
Minimum Longitudinal Gradient	=	1%
Total Swale Top Width	=	3.75 m

The proposed standardized swale design has sufficient capacity for all proposed swales within the stormwater management plan and review of the site contour data (2 m LiDAR) confirms that all ditches have an average longitudinal gradient >1% (thus the design capacity of the swales in practice will be >2.82 m^3/s given the proposed swale depth of 0.750 m).

[4] Chow, V.T. (1959). Open Channel Hydraulics

The following construction and maintenance measures should be included in the design of the swales:

- Swales should be grassed to promote filtration and treatment of intercepted runoff whilst also providing stability integrity.
- Where acute bends within the alignment of swales are required, erosion protection measures (i.e., rip-rap or gravel) should be provided to prevent erosion of the swale.
- Erosion protection (i.e., rip-rap or gravel) should be provided for point discharges into / from swales to prevent erosion.
- Routine / inspection to ensure optimum operation efficiency – a potential maintenance strategy is outlined in Section 3.3.

2.5.2 Settlement Ponds

A total of three settlement / attenuation ponds will be constructed, Ponds A, B and C as depicted on Drawings 3A to 3F. The exact positions of these will be determined by site management; however, the general location should be maintained as they are dictated by the surrounding topography and remove any requirement for pumping (i.e., ponds are located at low topographic points to allow for gravity drainage).

2.5.2.1 Storm Event Management

Using the design criteria specified in Section 2.2, the ponds are designed to accommodate a 1:100 year 24-hour storm event (as required by City of Calgary and Rocky View County Guidance) whilst also maintaining sufficient surface areas to facilitate sedimentation. The runoff generated from the storm event has been calculated using industry recognized SWMM software developed by the United States Environmental Protection Agency (Version 5.1, U.S. EPA, 2015). The City of Calgary Stormwater Management & Design Manual recommends using EPA SWMM in the design of dual (minor and major) drainage systems. Minor systems are typically flow conveyance structures such as ditches, whereas major systems are typically storage facilities such as ponds. A Chicago temporal distribution[5] has been applied to formulate the synthetic design storm as per the City of Calgary Stormwater Management & Design Manual. The runoff volumes and peak flows obtained from the modelling are summarized in Table 2. Peak inflow rates range from 0.07 m^3/s to 0.18 m^3/s. Pond storage required to retain the runoff resulting from the 1:100 year 24-hour storm event range from 1,201 m^3 to 2,957 m^3.

Table 2 also shows peak flows for the 1:5 year 24-hour storm event, required to evaluate pond geometry requirements for solids settling.

Table 2 Design Runoff Volumes for Selected 24-hour Rainfall Events

Parameter	Unit	Pond A	Pond B	Pond C
Catchment Area	ha	3.9	4.1	9.3
Width of Overland Flow Path	m	150	150	300
Average Catchment Surface Slope	%	1	1	1
Percentage of Impervious Area	%	5	5	5
1:5-year 24-hour Storm Event				
Total Rainfall	mm	52.8		
Total Runoff	mm	3.2	3.2	3.3
Peak Flow	m3/s	0.03	0.03	0.07
1:100-year 24-hour Storm Event				
Total Rainfall	mm	94.1		
Total Runoff	mm	30.8	30.6	31.8
Peak Flow	m3/s	0.07	0.07	0.18
Total Runoff Volume	m3	1,201	1,255	2,957

2.5.2.2 Storm Event Management

The ponds are designed to provide a minimum 85% removal of Total Suspended Solids (TSS) for particle sizes greater than, or equal to 50 µm (City of Calgary Stormwater Management & Design Manual). The settling velocity corresponding to a particle size of 50 µm for sediment removal is 2.8 x 10^{-4} m/s.

The distance required to settle out a certain size of sediment particle is determined by the settling length equation:

$$\text{Length} = [r\, Q_p / V_s]^{0.5}$$

Where: Length = horizontal settlement length (m)

r = length to width ratio of pond (using 3 for all the three ponds)

Q_p = peak flow rate corresponding to a 1:5-year event (m^3/s)

V_s = settling velocity (dependent on the desired particle size to settle)

Side slopes 3H:1V have been used to determine the pond dimensions. A summary of the settlement ponds hydraulic analysis and pond sizing is provided in Table 3.

Table 3 Summary of Settlement Ponds Hydraulic Analysis

Category	Parameter	Unit	Pond A	Pond B	Pond C	Notes
Pond Depth, Width and Length	Active Pond Depth	m	1	1	1	Active depth and vertical distance between pipe outlet invert and 1:100-year design water level
	Proposed Minimum Permanent Depth	m	2	2	2	A minimum depth from the pond bottom to pipe outlet invert (normal water level) must be 2.0 m.
	Freeboard Above HWL	m	0.35	0.35	0.35	A minimum freeboard of 0.30 m is required.
	Proposed Total Water Depth	m	3	3	3	Permanent pond depth plus active pond depth from the pond bottom to the design water level
	Pond Dimensions (L x W)	m	66 x 22	70 x 23	104 x 34	A Minimum Length (L) to Width (W) ratio 3:1, providing maximum settlement length
	Pond Surface Area	m3	1,452	1,615	3,543	Assuming pond with rectangle shape, pond top surface area is Length (L) by Width (W)
	Modelled Water Depths	m	0.92	0.92	0.93	1:100 Year modelled stormwater depth above pipe outlet invert (normal water level)
	Pond Side Slopes	-	3H:1V			Assumed slope for pond sizing purposes
Volume	Total Permanent Pond Volume	m^3	1,924	2,020	5,242	Extracted from pond hydraulic calculation
	Total Available Pond Treatment Volume	m^3	1,312	1,384	3,197	

Category	Parameter	Unit	Pond A	Pond B	Pond C	Notes
	Modelled Required Volume of Stormwater Attenuation	m^3	1,201	1,255	2,957	Total runoff volume of 1:100-year 24-hour storm event
Settlement Removal	Active Storage Detention Time	hr	24			Acceptable design criteria as per City of Calgary Stormwater Management & Design Manual (2011)
	85% Removal of Particle Size	µm	20 – 50			
	Settling Velocity	m/s	2.83×10^{-4}			
	1:5-year Peak Flow	m^3/s	0.03	0.03	0.07	Extracted result from model simulations
	Required Settling Length	m	17.8	18.0	27.5	Settling Calculations as per equation of City of Calgary Stormwater Management & Design Manual (2011)
Outflow Pipe (for discharge to infiltration sump)	Outflow Pipe Diameter	mm	450	450	600	Minimum Slope versus Pipe Size as per City of Calgary Stormwater Management & Design Manual (2011)
	Modelled Pipe Outflow	m^3/s	0.37	0.39	0.44	Extracted results from model simulations
	Modelled Pipe Outflow Velocity	m/s	1.07	1.08	1.34	

The required settlement lengths (i.e., 17.8 m to 27.5 m in Table 3) are much shorter than the proposed pond lengths (i.e., 66 m to 104 m in Table 3), which are required to meet the storage volumes needed to contain the runoff resulting from the 1:100 year 24-hour storm event.

It is worth noting that the excavated material resulting from the pond excavations can be integrated into the perimeter screening berms. Appropriate stormwater pond signage must be erected as described in Section 709 of the Rocky View County Servicing Standards Guidelines.

Pond inflow and outflow pipes will be fitted with a manual penstock valve to facilitate maintenance and to manually manage conveyance of water in the SWMP if required. The pond inlet and outlets are located at opposite ends to ensure maximum settlement potential. In order to maintain optimum pond efficiency, it is imperative that periodic / regular maintenance is undertaken as described in Section 3.4.

2.5.3 Groundwater Recharge / Discharge Sumps

Discharge sumps (Sump A, B and C) are required to discharge treated surface water runoff to unsaturated deposits of sand and gravel.

Drawings 3A to 3F indicate the locations of the sumps; however, the exact positioning of these will be determined by site management. Nonetheless, the general siting location will be maintained as they are dictated by the location of the settlement ponds and perimeter swales.

As with the settlement ponds, the sumps will remain operational for the duration of the entire development (from commissioning as per the appropriate Surface Water Management Phases). Pond and sumps will be located within the perimeter screening area and thus the relevant standoff distances will be maintained.

Like the first two stages of the stormwater management plan, which have been sized to accommodate the 1:100-year storm event, the sump design has adopted the same standard to ensure collected surface water is adequately controlled. The hydrological inputs to the sumps are the outflow hydrographs from the respective settlement / attenuation ponds and incident rainfall landing within the sump footprint.

The maximum infiltration rate from the sump into sands and gravels will be controlled by the in-situ hydraulic conductivity of 1×10^{-4} m/s (lower end of the measured range of hydraulic conductivity was selected – see Section 1.3.2). The time taken for the inflow hydrograph from the design rainfall event into the sump to half drain is less than 24 hours. Therefore, the system has half drained within a day and thus provides some residual capacity in case there is another rainfall event the next day.

A standard sump outline design has been derived for all three sumps and a summary of the proposed sump dimensions is presented in Table 4.

It is recommended that the following design considerations are taken into account:

- A minimum 0.5 m depth earth berm (and appropriate fencing) around the sump opening for safety precautions and to prevent direct (potentially dirty) runoff entering the sump.
- Appropriate signage must be erected as described in Section 709 of the Rocky View Servicing Standards Guidelines and tailored accordingly for the sump.
- Any other safety considerations to be implemented as required by site management / Health & Safety legislation.
- Grass seeding of the sump embankment to improve stability, reduce siltation of the sand and gravel layer and provide filtration of resulting from runoff from the sump slopes.
- Suitable erosion protection (i.e. erosion control blanket / rip-rap) to be provided down the sump slope from culvert outfall to base in order to prevent scour and erosion into the sump embankment.
- Suitable side slopes from a stability perspective must be defined by a qualified geotechnical engineer for detailed design of the sumps.
- A 5 m standoff to swales / perimeter berm and other any other constraining features to provide access for maintenance or for raising berm heights should future weather conditions indicate a need for more freeboard.
- Regular / periodic maintenance should be undertaken to maintain optimum sump efficiency (typical maintenance requirements are outlined in Section 3.4).

Table 4 Summary of Sumps Sizing

Parameter	Unit	Sump A	Sump B	Sump C	Notes
Base Dimensions	m	8.0 x 9.0	8.0 x 9.0	8.0 x 9.0	Proposed (potential) standardized sump design
Minimum Base Area	m^2	72	72	72	
Assumed Side Slopes	1 in X	2	2	2	
Surface Area Footprint	m^2	1,056	1,056	1,056	
Total Sump Depth	m	6.0	6.0	6.0	
Total Available Sump Volume	m^3	3,384	3,384	3,384	
Maximum Water Depth	m	3.8	3.9	5.7	Pond outflow hydrograph retained within sump volume
Freeboard Depth	m	2.204	2.125	0.332	300 mm freeboard provided
Maximum Volume of Water Storage in Sump	m^3	1,201	1,255	2,957	Confirms freeboard capacity is available to provide offsetting of snowmelt contributions

3.0 MAINTENANCE AND OPERATIONAL REQUIREMENTS

3.1 Overview

All stormwater drainage features associated with the development will remain under private ownership and will be maintained and operated by Mountain Ash.

The following sections outline recommended maintenance requirement for the various aspects of the surface water management system. If necessary and once the site is in operation, these outlined maintenance and management proposals will be refined by the operators to suit specific conditions / requirements.

3.2 Pipe Systems / Culverts

The anticipated maintenance and management plan for culverts / pipes within the SWMP is outlined in Table 5.

Table 5 Typical Pipe/ Culvert Maintenance Requirements

Maintenance Schedule	Required Action	Minimum Frequency
Regular Maintenance	Ensure pipe intakes / outlets are clear of debris/silt.	Monthly (or as required)
	Jet wash any sediment accumulations in manholes (within the site 'plant' area) and remove any debris.	Monthly (or as required)
Intermittent maintenance	CCTV survey of inaccessible culverts / pipes to identify any defects/signs of performance degradation such as: Cracked/deteriorating pipe; Leaking joints/seals at manholes; Pipe settling and potential structural failure; High water lines showing regular high stage in pipes (sign of lack of capacity or downstream constraint); and Suspected infiltration or exfiltration.	Every 2 – 5 years
Seasonal Maintenance	During winter months pipes / culverts should be kept clear of ice / snow accumulations via appropriate methods (such as steaming).	Winter
Remedial actions	Repair defects using suitable methods. Effective temporary repairs may be sufficient in short term until scheduled improvements can be made.	As required
Monitoring	Record areas of surface ponding and manhole / culvert surcharging (photos, inundated areas, depths) during extreme storm events and investigate the reasoning for this post-storm.	As required

3.3 Swales

The proposed surface water management scheme uses linear swales to convey intercepted stormwater to settlement ponds. A potential maintenance and management plan for these features is outlined in Table 6.

Table 6 Typical Swale Operation and Maintenance Requirements

Maintenance Schedule	Required Action	Minimum Frequency
Regular Maintenance	Litter, debris, and leaf removal.	Every 2 Months (or as required)
	Grass cutting - to maintain sward to desired height for conveyance / treatment and landscape / ecological benefit.	Every 2 Months (during growing season, or as required)
	Manage other vegetation and remove nuisance plants.	Every 6 Months (at start, or as required)
	Remove silt accumulations within erosion protection rip-rap and inspect/maintain structural integrity.	Every 2 Months (or as required)
Occasional Maintenance	Check for poor vegetation growth due to lack of sunlight or dropping of leaf litter and cut back adjacent vegetation where possible.	Annually
	Re-seed area of poor vegetation growth. Alter plant types to better suit conditions, if required.	Annually, or if bare soil is exposed over 10% or more of the swale treatment area
Remedial Actions	Repair of erosion or other damage by re-turning or re-seeding and providing subsequent erosion protection measures (such as stone rip-rap) if problems persist.	As required
	Re-level uneven surfaces and reinstate design levels.	As required
	Scarify and spike topsoil layer to improve infiltration performance, break up silt deposits and prevent compaction of soil surface.	As required
Monitoring	Inspect erosion protection measures (grass/rip-rap) and record/establish remediation frequencies and requirements (de-silting, structural integrity, etc.)	Every 2 Months
	Inspect infiltration surfaces for ponding, compaction, silt accumulation. Records areas where water is ponding for more than 48 hours.	Every 2 Months (or as required)
	Inspect silt accumulation rates and establish appropriate removal frequencies.	Every 6 Months

3.4 Settlement Ponds / Sumps

The proposed surface water management scheme utilizes stormwater settlement / attenuation ponds and sumps whose operational efficiency is critical in the management of stormwater associated with the development.

Therefore, anticipated maintenance requirements and management for the settlement ponds / sumps and their hydraulic control features is outlined in Table 7.

Table 7 Typical Attenuation Pond / Sump Maintenance Requirements

Maintenance Schedule	Required Action	Minimum Frequency
Regular Maintenance	Litter and debris removal.	Monthly (or as required)
	Grass cutting to maintain sward to desired height for conveyance/treatment and landscape/ecological benefit.	Monthly during growing season or as required
	Manage other vegetation and remove nuisance plants.	Monthly (or as required)
	De-silting of exposed sands and gravel layer at base of sump.	Monthly (or as required)
Occasional Maintenance	Manage submerged and emergent planting.	Annually
	Remove 25% of bank vegetation from water's edge to the pond crest.	Annually
	Tidy all dead growth before start of growing season.	Annually
Intermittent Maintenance	Remove sediment from one quadrant of the main body of the ponds.	2 – 10 years
	Remove sediment from the main body of the ponds when pool volume is reduced by 20%.	2 – 5 years (or as required)
Remedial Actions	Repair of erosion or other damage.	As required
	Aerate pond when signs of eutrophication are detected.	As required
	Realignment of rip-rap or other damage.	As required
	Repair/rehabilitation of hydraulic inlets and outlets.	As required
Monitoring	Inspect hydraulic structures for evidence of poor operation.	Monthly/after large storms

Maintenance Schedule	Required Action	Minimum Frequency
	Inspect banksides, structures, pipework, etc. for evidence of physical damage.	Monthly/after large storms
	Inspect water body for signs of eutrophication.	Monthly during warm seasons
	Inspect silt accumulation rates and establish appropriate removal frequencies.	Monthly

4.0 CONCLUSIONS

The conclusions of the assessment are as follows:

- The stormwater management assessment herein has been developed to sustainably manage surface water intercepted by or shed from the proposed development.
- Appropriate City, County and Provincial guidance documents relating to stormwater management have been referenced (where appropriate) to inform the assessment.
- A particular emphasis has been placed on surface water quality owing to the potentially 'sensitive' nature of the local water environment. As such, three stages of surface water treatment are proposed before surface water is ultimately discharged to groundwater.
- Excavations and workings are to take place at least 1.0 m above the groundwater table, therefore no dewatering of the sand and gravel unit is proposed.
- All elements of the surface water system have been sized to accommodate the design 1:100 year rainfall storm event. An overall conservative approach has been undertaken by providing freeboard allowances and modelling 'worst case' scenarios.
- Potential maintenance schedules for the stormwater management features have been outlined and their implementation is fundamental to ensure the efficacy of the surface water management system.
- The overall assessment confirms that the proposals to manage stormwater runoff are feasible, sustainable and practical and are appropriate for the duration of the development.

5.0 REFERENCES

Alberta Geological Survey, 1999. *Geological Map of Alberta, 1:1,000,000 scale.*

Downing, D.J. and Pettapiece, W.W., 2006. *Natural Regions and Subregions of Alberta*. Natural Regions Committee.

Shetsen, I. 1987. Quaternary Geology, Southern Alberta. 1:500,000 scale map. Alberta Research Council

SLR Consulting 2020. Hydrogeological Risk Assessment. Report Reference: 212.06650.00003.

Rocky View County (2013). County Servicing Standards

Alberta Environmental Protection (1999). Stormwater Management Guidelines for the Province of Alberta. Environmental Sciences Division

The City of Calgary (2011). Stormwater Management & Design Manual. The City of Calgary Water Resources

6.0 STATEMENT OF LIMITATIONS

This report has been prepared and the work referred to in this report has been undertaken by SLR for Mountain Ash Limited Partnership., hereafter referred to as the “Client”. The report has been prepared in accordance with the Scope of Work and agreement between SLR and the Client. It is intended for the sole and exclusive use of the Client. Other than by the Client and as set out herein, copying or distribution of this report or use of or reliance on the information contained herein, in whole or in part, is not permitted without the express written permission of SLR.

This report has been prepared for specific application to this site and site conditions existing at the time work for the report was completed. Any conclusions or recommendations made in this report reflect SLR’s professional opinion.

Information contained within this report may have been provided to SLR from third party sources. This information may not have been verified by a third party and/or updated since the date of issuance of the external report and cannot be warranted by SLR. SLR is entitled to rely on the accuracy and completeness of the information provided from third party sources and no obligation to update such information.

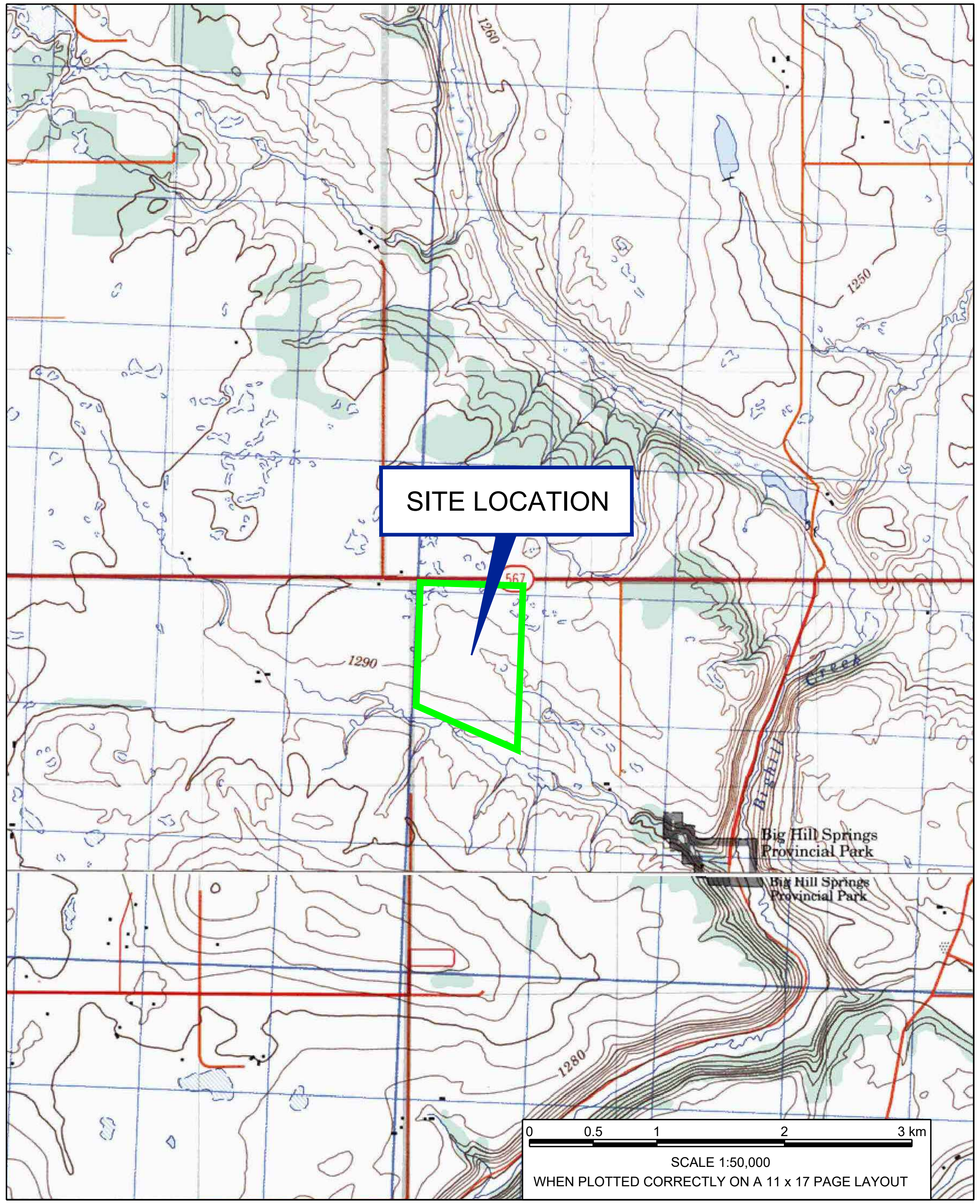
Nothing in this report is intended to constitute or provide a legal opinion. SLR makes no representation as to the requirements of compliance with environmental laws, rules, regulations, or policies established by federal, provincial, or local government bodies. Revisions to the regulatory standards referred to in this report may be expected over time. As a result, modifications to the findings, conclusions, and recommendations in this report may be necessary.

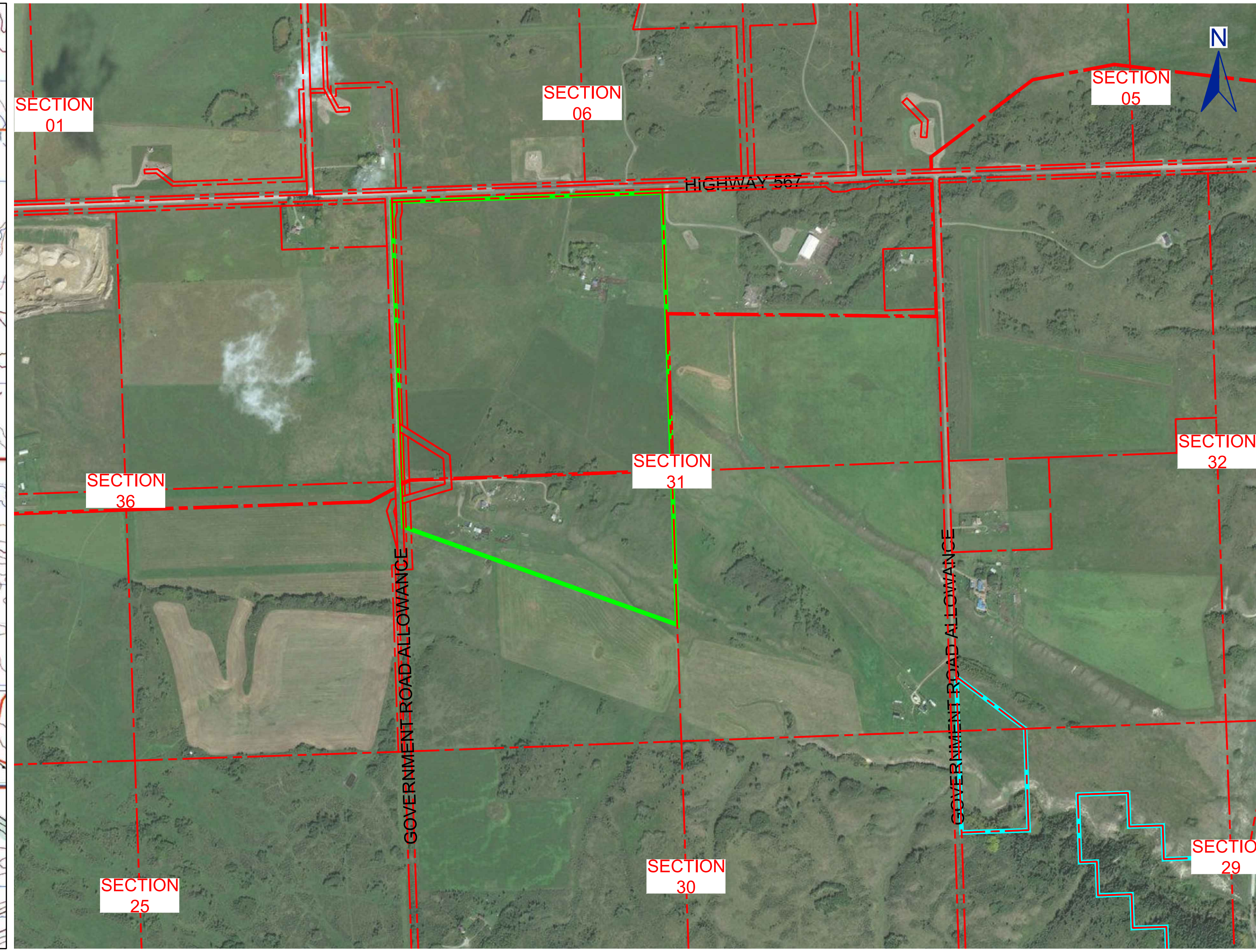
Drawings

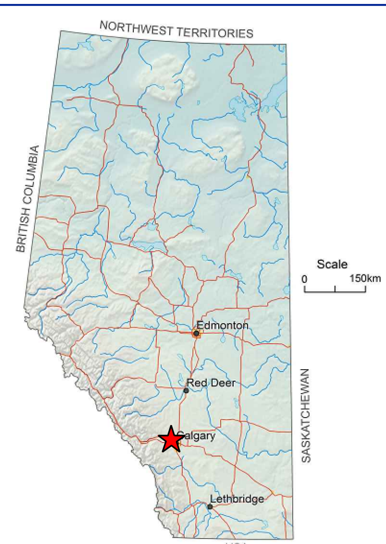
Stormwater Management Plan

Mountain Ash Limited Partnership Summit Pit

SLR Project No.: 212.06650.00006







NOTES:
DRAWING COMPILED FROM LIDAR DATA, PROPERTY LINE DATA AND AIR PHOTOS AS PROVIDED BY THE CLIENT, NTS MAP 82 O/01 TITLED "CALGARY" AND 82 O/08 TITLED "CROSSFIELD" AND SITE RECONNAISSANCE INFORMATION.

LEGAL DESCRIPTION:
W 1/2 SEC 31 TWP 026 RGE 03 W5M
ROCKY VIEW COUNTY, ALBERTA

IMAGERY SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY. IMAGERY DATE: SEPTEMBER 9, 2016.

LEGEND:
- PROPERTY BOUNDARY
- SUBJECT BOUNDARY
- BIG HILL SPRINGS PROVINCIAL PARK

0 0.25 0.5 1.0 km
SCALE 1:15,000
WHEN PLOTTED CORRECTLY ON A 11 x 17 PAGE LAYOUT
NAD 1983 UTM ZONE 11N

THIS DRAWING IS FOR CONCEPTUAL PURPOSES ONLY. ACTUAL LOCATIONS MAY VARY AND NOT ALL STRUCTURES ARE SHOWN.

MOUNTAIN ASH LIMITED PARTNERSHIP
SUMMIT PIT
NW & SW 31-26-03 W5M
ROCKY VIEW COUNTY, ALBERTA

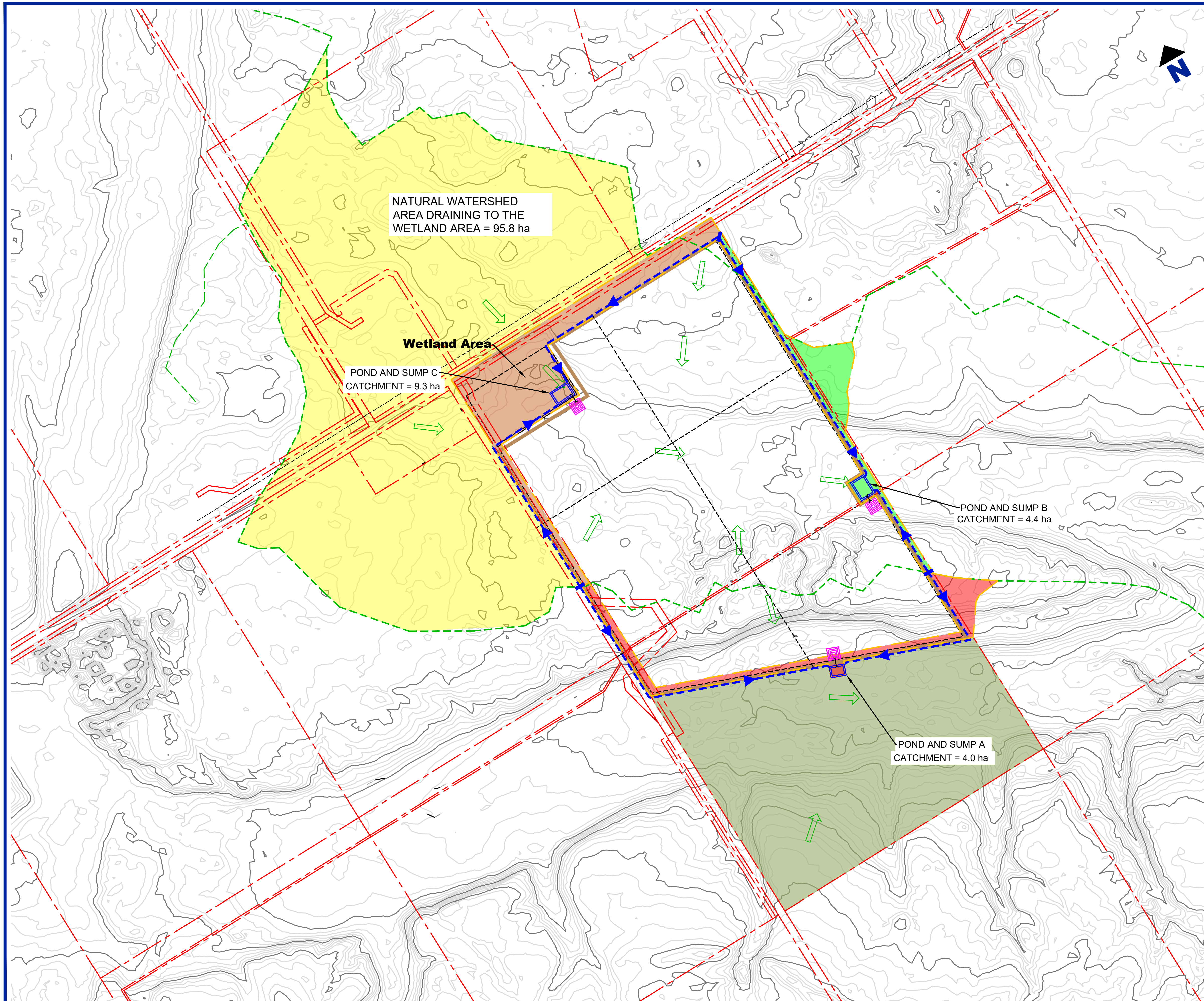
STORMWATER MANAGEMENT PLAN

SITE LOCATION & STUDY AREA

Date:	April 23, 2021	Drawing No. 1
Project No.	212.06650.00006	

SLR

Cadfile name: S_212-06650-00006-A7.dwg



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W 1/2 SEC 31 TWP 026 RGE 03 W5M
ROCKY VIEW COUNTY, ALBERTA

WATER MANAGEMENT FEATURES ILLUSTRATED ARE CONCEPTUAL ONLY, FINAL LOCATION AND SIZING TO BE DETERMINED IN DETAILED DESIGN.

LEGEND:
- MAJOR CONTOURS - GROUND SURFACE 5 m INTERVALS FROM LIDAR DATA
- MINOR CONTOURS - GROUND SURFACE 1 m INTERVALS FROM LIDAR DATA
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- OVERBURDEN PERIMETER BERM
- PROPOSED DRAINAGE DITCH
- PROPOSED ATTENUATION/SETTLEMENT POND
- PROPOSED INFILTRATION SUMP (INDICATIVE)
- PROPOSED CULVERT/PIPE
- EXISTING WATERSHED DIVIDE
- POND DESIGN CATCHMENT AREAS
- DIRECTION OF EXISTING SURFACE RUNOFF
- POND A DESIGN CATCHMENT AREA
- POND B DESIGN CATCHMENT AREA
- POND C DESIGN CATCHMENT AREA
- NATURAL WATERSHED AREA UPSTREAM OF PROJECT FOOTPRINT
- NATURAL AREA WITHIN PROPERTY BOUNDARIES BUT OUTSIDE PROJECT FOOTPRINT

0 100 200 400 600 m

SCALE 1:10,000
WHEN PLOTTED CORRECTLY ON A 11 x 17 PAGE LAYOUT
NAD 1983 UTM ZONE 11N

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SUMMIT PIT
NW & SW 31-26-03 W5M
ROCKY VIEW COUNTY, ALBERTA

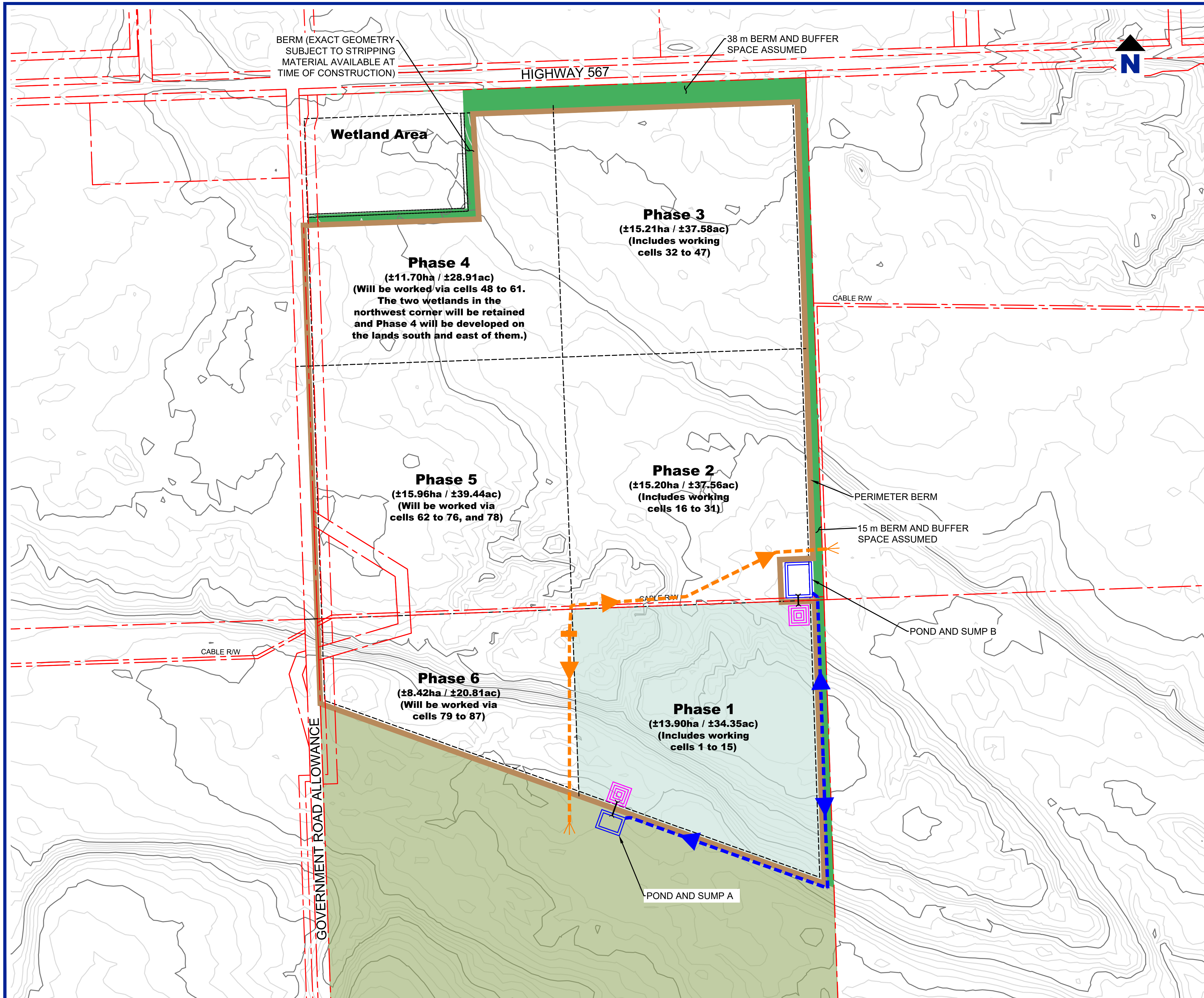
STORMWATER MANAGEMENT PLAN

WATERSHED DIVIDES AND POND CATCHMENT AREAS

Date: April 23, 2021		Drawing No.
Project No. 212.06650.00006		2

SLR

Cadfile name: S_212-06650-00006-A7.dwg



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0 50 100 200 300 m

SCALE 1:6,000
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NAD 1983 UTM ZONE 11N

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MOUNTAIN ASH LIMITED PARTNERSHIP
SUMMIT PIT
NW & SW 31-26-03 W5M
ROCKY VIEW COUNTY, ALBERTA

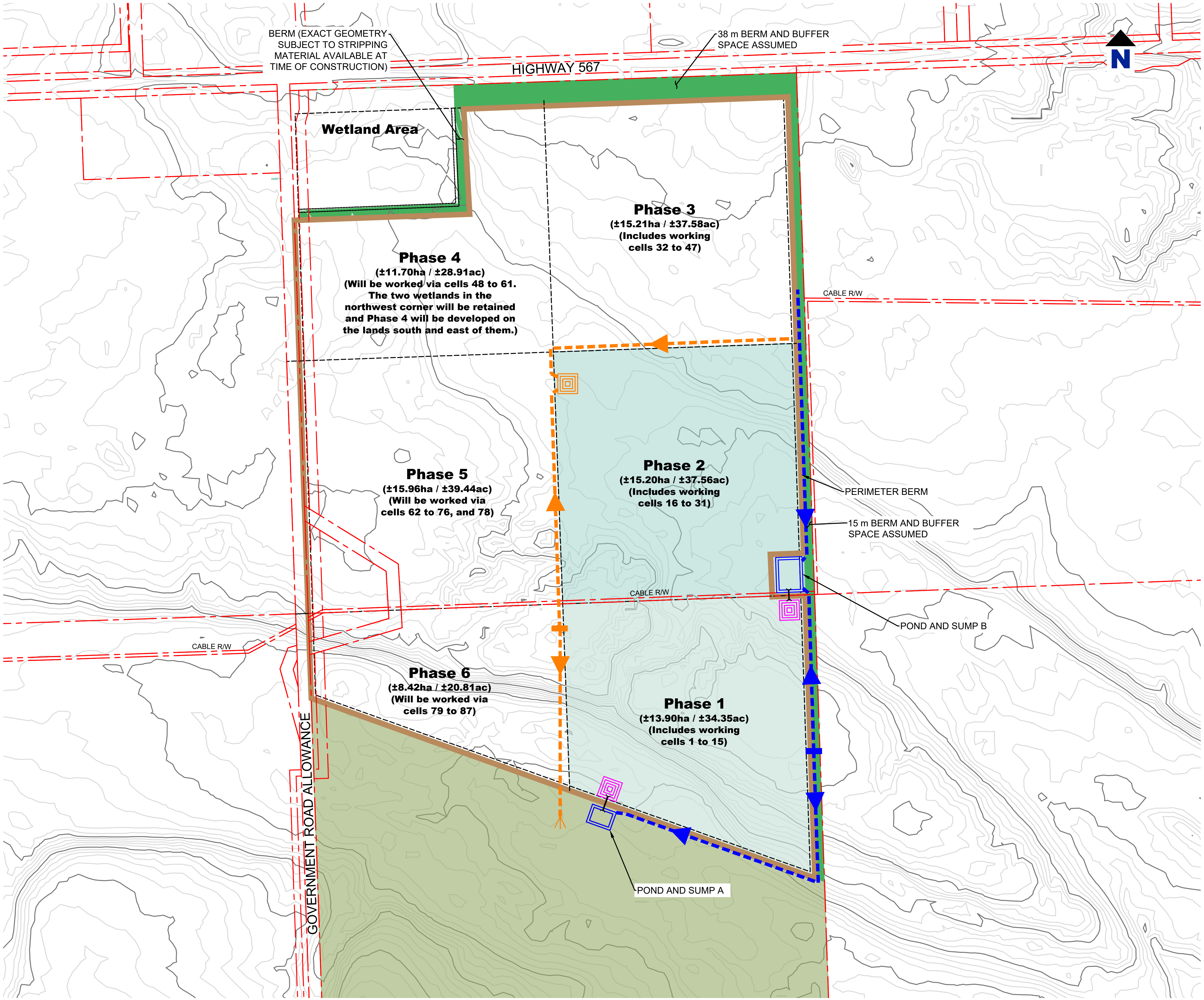
STORMWATER MANAGEMENT PLAN

PHASE 1 - EXTERNAL CONTACT WATER MANAGEMENT

Date: April 23, 2021		Drawing No.
Project No. 212.06650.00006		3A

SLR

Cadfile name: S_212-06650-00006-A7.dwg



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MOUNTAIN ASH LIMITED PARTNERSHIP
SUMMIT PIT
NW & SW 31-26-03 W5M
ROCKY VIEW COUNTY, ALBERTA

STORMWATER MANAGEMENT PLAN

PHASE 2 - EXTERNAL CONTACT WATER MANAGEMENT

Date: April 23, 2021	Drawing No. 3B
Project No. 212.06650.00006	

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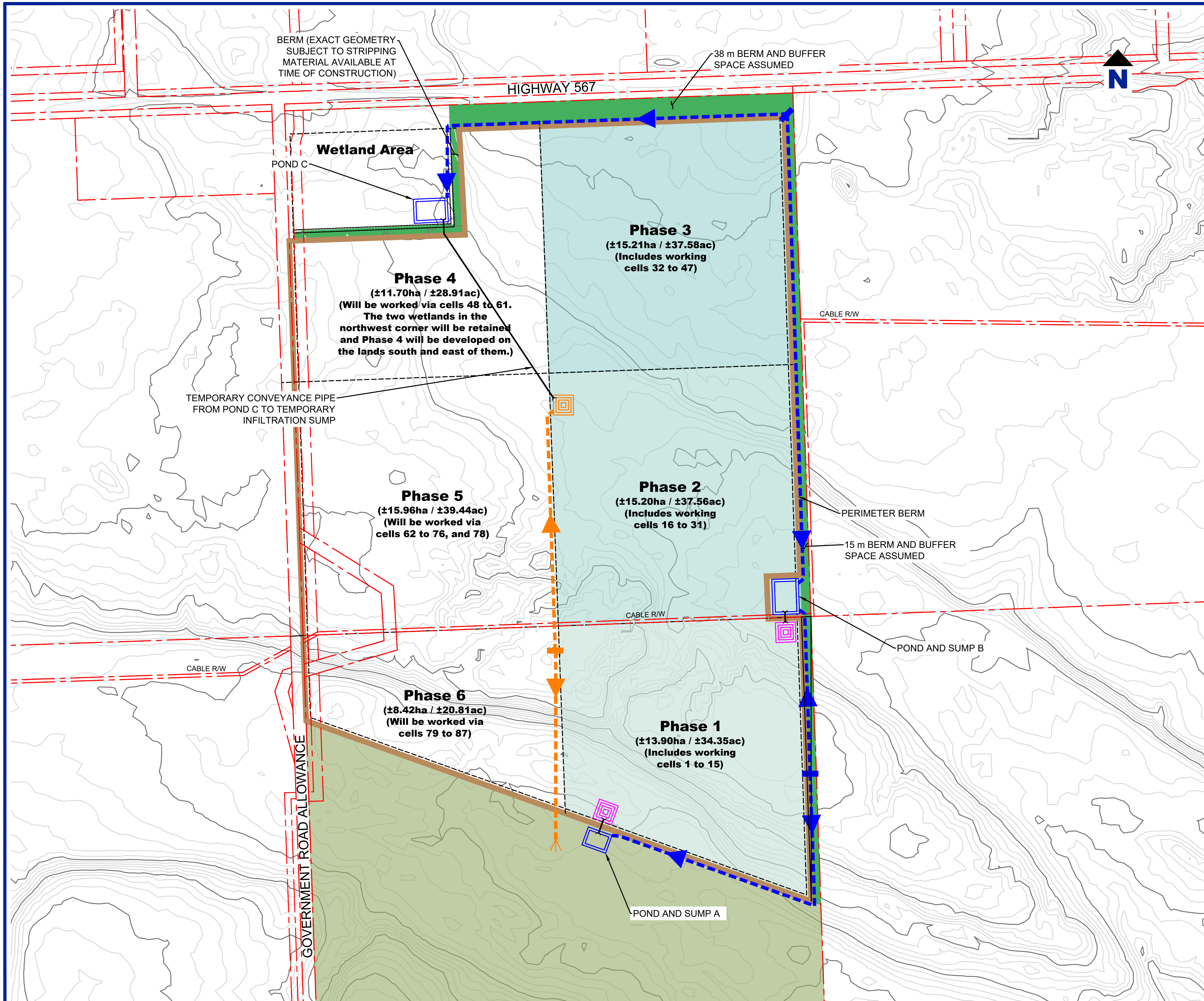

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NAD 1983 UTM ZONE 11N

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MOUNTAIN ASH LIMITED PARTNERSHIP
SUMMIT PIT
NW & SW 31-26-03 W5M
ROCKY VIEW COUNTY, ALBERTA

STORMWATER MANAGEMENT PLAN

PHASE 3 - EXTERNAL CONTACT WATER MANAGEMENT

Date: April 23, 2021	Drawing No. 3C
Project No. 212.06650.00006	

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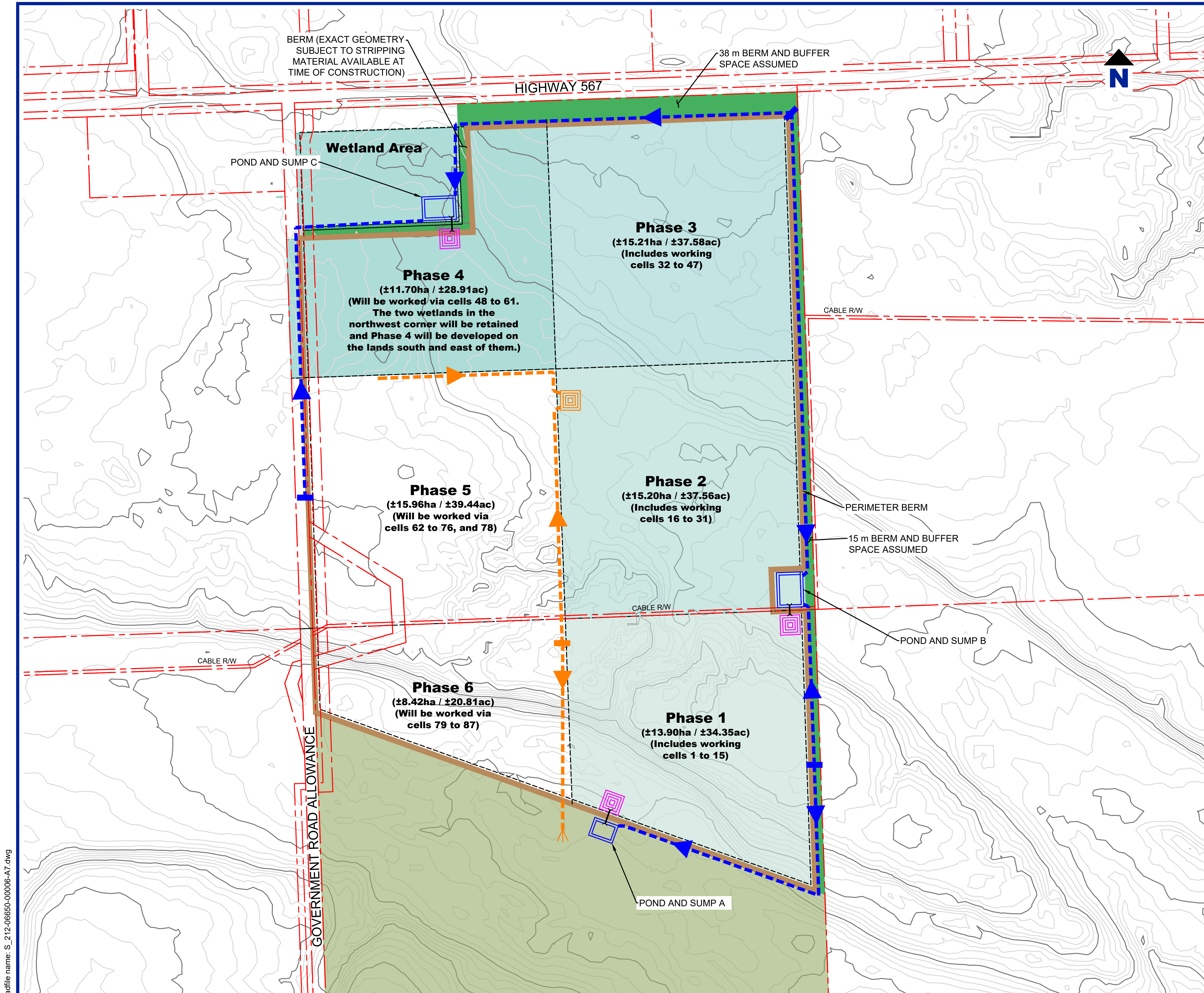

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ROCKY VIEW COUNTY, ALBERTA

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0 50 100 200 300 m

SCALE 1:6,000
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NAD 1983 UTM ZONE 11N

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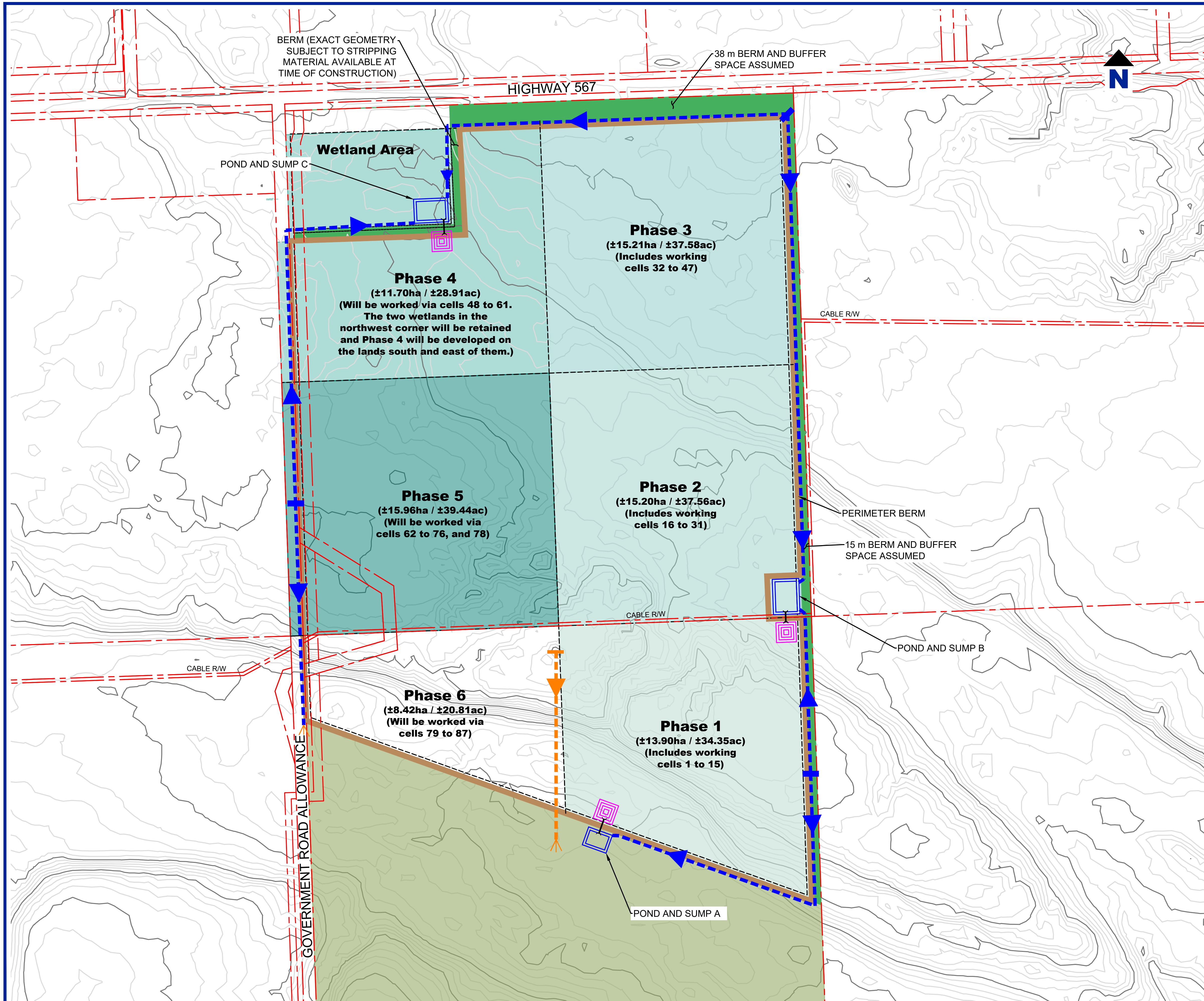
MOUNTAIN ASH LIMITED PARTNERSHIP
SUMMIT PIT
NW & SW 31-26-03 W5M
ROCKY VIEW COUNTY, ALBERTA

STORMWATER MANAGEMENT PLAN

PHASE 4 - EXTERNAL CONTACT WATER MANAGEMENT

Date: April 23, 2021
Project No. 212.06650.00006
Drawing No. 3D

SLR



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MOUNTAIN ASH LIMITED PARTNERSHIP
SUMMIT PIT
NW & SW 31-26-03 W5M
ROCKY VIEW COUNTY, ALBERTA

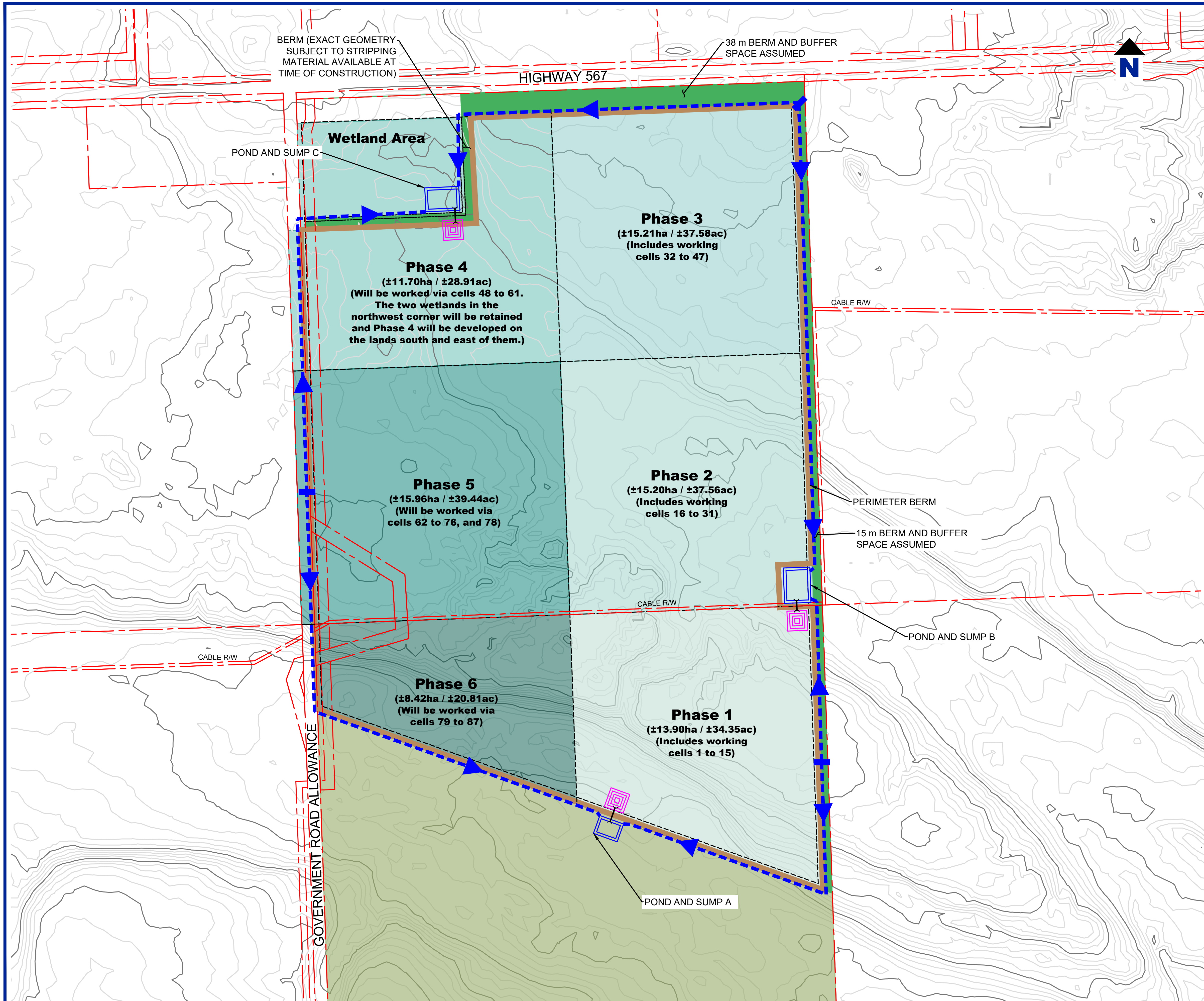
STORMWATER MANAGEMENT PLAN

PHASE 5 - EXTERNAL CONTACT WATER MANAGEMENT

Date: April 23, 2021	Drawing No. 3E
Project No. 212.06650.00006	

SLR

Cadfile name: S_212-06650-00006-A7.dwg



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LEGAL DESCRIPTION:
W 1/2 SEC 31 TWP 026 RGE 03 W5M
ROCKY VIEW COUNTY, ALBERTA

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0 50 100 200 300 m

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MOUNTAIN ASH LIMITED PARTNERSHIP
SUMMIT PIT
NW & SW 31-26-03 W5M
ROCKY VIEW COUNTY, ALBERTA

STORMWATER MANAGEMENT PLAN

PHASE 6 - EXTERNAL CONTACT WATER MANAGEMENT

Date: April 23, 2021	Drawing No.
Project No. 212.06650.00006	3F

SLR

Cadfile name: S_212-06650-00006-A7.dwg

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