Belmont Quarry Development – Part B

Substantive Application
Appendix B.6 – Hydrological Assessment
Winstone Aggregates

16 August 2026

Belmont Quarry

Hydrological analysis of proposed OBDA

Prepared by

Landscape Dynamics Ltd.

30 July 2026

Revision: 5.0

Revision Record

Revision	Date	Prepared By	Authorised By
5.0	30 July 2026	Jack McConchie	[redacted]

Basis of Report

This report has been prepared by Landscape Dynamics with all reasonable skill, care, and diligence, and taking account of the timescale and resources allocated to it by agreement with Winstone Aggregates (the client). Information reported herein is based on the interpretation of data collected, which has been accepted in good faith as being accurate and valid.

The report has been prepared on the instructions of our client in accordance with the agreed scope of work. If it is intended to support an application under the Fast-track Approvals Act 2024, it may be relied upon by the Expert Panel and relevant administering agencies for the purposes of assessing the application.

No warranties or guarantees are expressed or should be inferred by any third parties. This report may not be relied upon by other parties without written consent from Landscape Dynamics.

Landscape Dynamics disclaims any responsibility to the client and others in respect of any matters outside the agreed scope of the work.

I confirm in my capacity as author of this report, that I have read and agree to abide by the Environment Court of New Zealand's Code of Conduct for Expert Witnesses Practice Note 2023.

Executive Summary

The proposed 'OBDA' will be approximately 15.7ha and lie within a 23.86ha area located on the interfluve (catchment divide) between five small headwater gullies. The OBDA will be established and constructed across 10 stages, over 40-years. Only four of these stages (Stages 1, 2, 4 & 5), however, have any potential to affect the hydrology and flow regime of the small watercourses which drain the area.

There are few hydrological metrics describing the baseline environment; however, the principal driver of the hydrological processes is rainfall, which will not be affected by the development of the OBDA. Winstone Aggregates have maintained a rain gauge and climate station above the Belmont Quarry since 2009. Consequently, there are over 15-years of excellent, high-resolution data that can be used to characterise the rainfall, temperature and wind conditions affecting the site. These climate data provide the context when considering any potential effects of the OBDA on hydrological processes.

Despite there being few hydrological metrics for the area, this is not considered a major constraint when assessing the potential effects of the OBDA on hydrology. There are several reasons supporting this conclusion, including:

- The small footprint of the proposed OBDA (~15.7ha).
- The OBDA being located largely on the interfluve between five small headwater gullies. These gullies are typical of the many hundreds of gullies found in the western Hutt hills and draining the Wellington Fault scarp.
- The relatively simple, and largely predictable, hydrological processes operating in the area. The hydrological processes can be inferred from widely understood and agreed principles.
- Limited surface runoff in the area, except possibly during intense or prolonged rainfall over highly modified surfaces.
- The distance and area between the footprint of the OBDA and Belmont Regional Park (over 8.2ha). This will act as a buffer that will moderate and attenuate any small effects of the OBDA on hydrology and hydrological processes, should they occur.
- The small percentage of each sub-catchment potentially affected by the OBDA.
- The staged development of the OBDA, with each stage affecting only small discrete sub-catchments i.e., the stage boundaries are coincident with sub-catchment boundaries.
- The lack of any cumulative effects since each stage will be rehabilitated, from a hydrological perspective, prior to work on the next stage commencing.
- Progressive development of the OBDA over 40-years.
- Experience with the current Cottles OBDA which provides a real-world analogue for how runoff from the site can be managed to avoid any adverse hydrological effects.

By adopting the principles outlined in the Geotechnical and Erosion and Sediment Control (ESC) assessments for this project, it will be possible to maintain both surface and subsurface flow, and the existing flow regime and water quality following respective stages. The design and construction of the new OBDA in the manner proposed, and by implementing the principles and methodologies suggested, will ensure that the existing hydrological processes are maintained. Current discharges into each of the various drainage lines beyond the OBDA will continue.

Since the existing hydrological processes will be maintained within the OBDA, including both surface and subsurface flow, and discharge into each of the various drainage lines within the OBDA will continue, the hydrology of any wetlands downstream of the OBDA will likely be unchanged. The only wetland that will be affected adversely by the development of the OBDA, from a hydrological perspective, is that located within the footprint of the OBDA.

A significant distance is proposed between the footprint of the OBDA and the boundary with Belmont Regional Park. It is my opinion that, once the principles within the Geotechnical and ESC assessments are implemented, any effects of development of the OBDA on hydrology will be negligible. There will be no measurable adverse effects on hydrology or hydrological processes beyond the OBDA boundary. Any effects can therefore be considered 'less than minor'. This will be confirmed by monitoring water levels within the first wetland in each drainage line downgradient of the OBDA.

In my expert opinion, the final draft conditions of consent recognise and reflect the recommendations from this technical report appropriately. The implementation of these conditions will confirm that any effects of the development of the OBDA on hydrological processes are 'less than minor'.

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1.0 Background

Winstone Aggregates is seeking approval under the Fast-track Approvals Act 2024 to establish a new Overburden Disposal Area (OBDA) on the northern boundary of Belmont Quarry.

Belmont Quarry, operated by Winstone Aggregates (a division of Fletcher Concrete and Infrastructure Limited), is a principal source of aggregate for the Wellington region. The quarry is essential for meeting ongoing demand for roading, housing, and other development materials. Continued access to the aggregate resource requires the controlled removal and placement of overburden.

As development of Belmont Quarry has progressed, space within the current Overburden Disposal Areas (OBDA) has reached capacity. The Cottle Block has been the primary OBDA since consent was granted in 2007, but opportunities to store fill in this area are now exhausted; although it is still used for the disposal of fines. Without a new overburden disposal solution in place, the quarry will reach a critical constraint that will prevent further aggregate extraction. This will effectively halt operation of the quarry, impacting the region's construction supply chain.

To ensure a long-term solution for overburden management, it is proposed to develop a new OBDA adjacent to the existing quarry footprint (***Figure 1.1***). The selected OBDA is currently within Belmont Regional Park, adjacent to the existing operational area, on land which is the subject of an application for land exchange. This location has been identified as the most suitable because of its operational, environmental, and logistical advantages. Because it is adjacent to the existing quarry operation, it allows a direct haul route, minimising transport distances, fuel use and emissions, while also avoiding complex land tenure issues that would be associated with a more remote overburden disposal option.

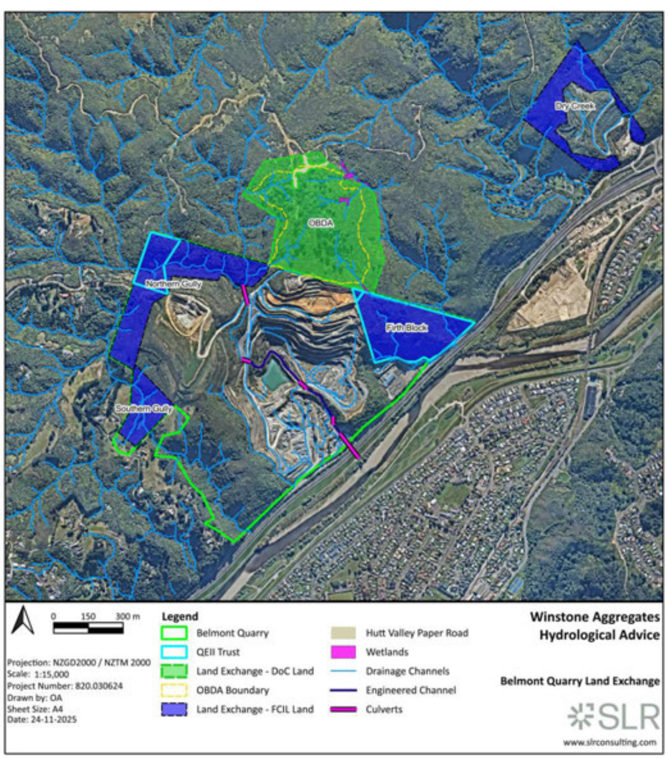

Figure 1.1: The proposed OBDA is adjacent to the Belmont Quarry, on land that is subject of an application for the land exchange.

Enabling the development of the OBDA requires a land exchange between Winstone Aggregates and the Department of Conservation. A Land Exchange application was lodged with Department of Conservation in December 2025. That application included a report by Landscape Dynamics Ltd on hydrological issues relevant to the exchange, which focused on conservation values.

The proposed OBDA will accommodate approximately 2.8 million cubic metres of overburden, including topsoil, subsoil, weathered greywacke, and process & pond fines over a 40-year operational period. The OBDA has been designed to function as a permanent engineered landform. It will be established and constructed across 10 stages, with supporting haul infrastructure, drainage, fines containment, and progressive rehabilitation.

This report considers the hydrological characteristics and processes operating within the proposed OBDA and how the development of the OBDA will interact with and effect these processes.

There are few hydrological data or metrics relating to the baseline environment within the proposed OBDA. Consequently, this hydrological assessment is underpinned by clear and unambiguous hydrological principles and processes, which are widely understood and agreed. The location of the proposed OBDA, and its manner of development and operation, mean that these principles provide a robust framework for assessing the potential effects of the OBDA on hydrology, hydrological processes, and hydrological effects.

2.0 Catchment Setting

2.1 Wider hydrological setting

The streams and watercourses in the wider vicinity of the proposed OBDA drain either the uplifted block or the steep scarp to the west of the Wellington Fault. The OBDA will be located largely on a ridge that separates several small headwater catchments. Runoff from the OBDA therefore drains either west into the Waikoropupu catchment; or east into two small adjacent catchments to the north. All these sub-catchments discharge into the Hutt River (***Figure 2.1***).

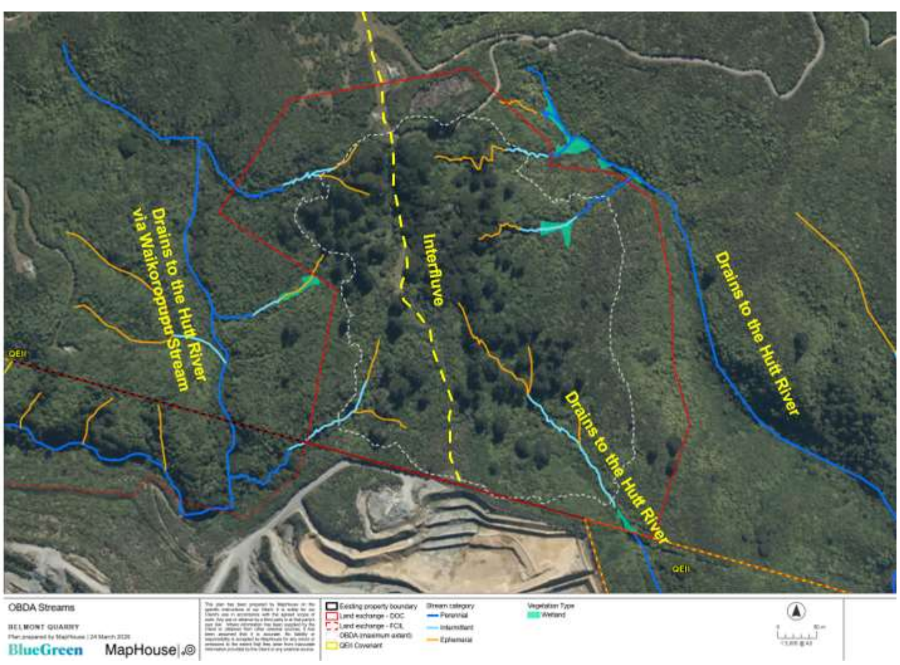

Figure 2.1: Location of the interfluve and direction of drainage away from the OBDA.

Prior to the establishment of the Belmont Quarry, the Waikoropupu catchment would have been typical of the many other small streams draining the Western Hutt hills and the scarp of the Wellington Fault (***Figure 2.2***). The 1.7km² catchment would have had a dendritic drainage network and been covered largely with regenerating native bush and scrub, with areas of pasture towards the catchment divide. The area has now been quarried for over a century, and the landforms and associated watercourses/drainage network have been modified by that activity.

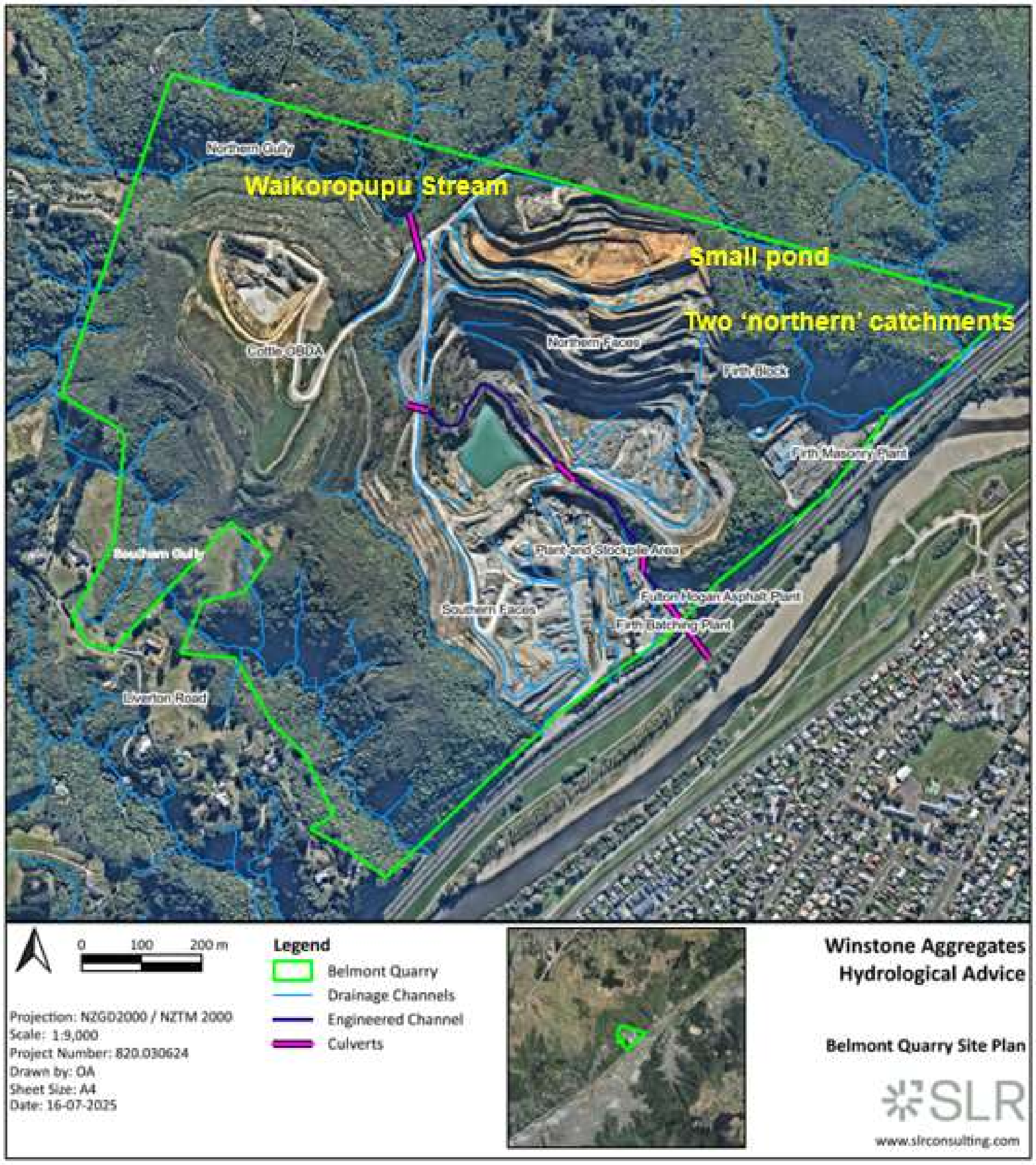

Figure 2.2: Belmont Quarry drainage and imagery.

The two smaller catchments to the north of Waikoropupu Stream have been unaffected by the quarry. These catchments retain their characteristic dendritic drainage network and are covered largely with regenerating native bush and scrub. There is a small 'pond' that follows the general alignment of the tributary on the boundary between the Firth Block and Belmont Regional Park. This 'pond' is surrounded by a small wetland. It is likely that this pond was caused by a landslide blocking the original channel and, because of the small catchment upstream, flows have so far been unable to erode a new channel through the landslide deposit.

2.2 Nature of streamflow

Belmont Quarry and the proposed OBDA are located on the uplifted block immediately west of the Wellington Fault. The relatively flat slopes on the ridges contrast with the steeply incised small watercourses, and numerous headwater gullies, eroded into the uplifted block. The small catchments, particularly of the headwater gullies, mean that surface flow is highly variable, both in space and over time. While the lower reaches of the larger streams have perennial flow, the continuity of surface flow decreases moving upslope, becoming first intermittent and then largely ephemeral (***Figure 2.3***). It should be noted, however, that the boundaries between these different 'theoretical' flow regimes will vary over time for the reasons discussed below. Providing a robust definition of the exact nature of the flow regime at a particular location is therefore problematic, even when applying current guidance.[1]

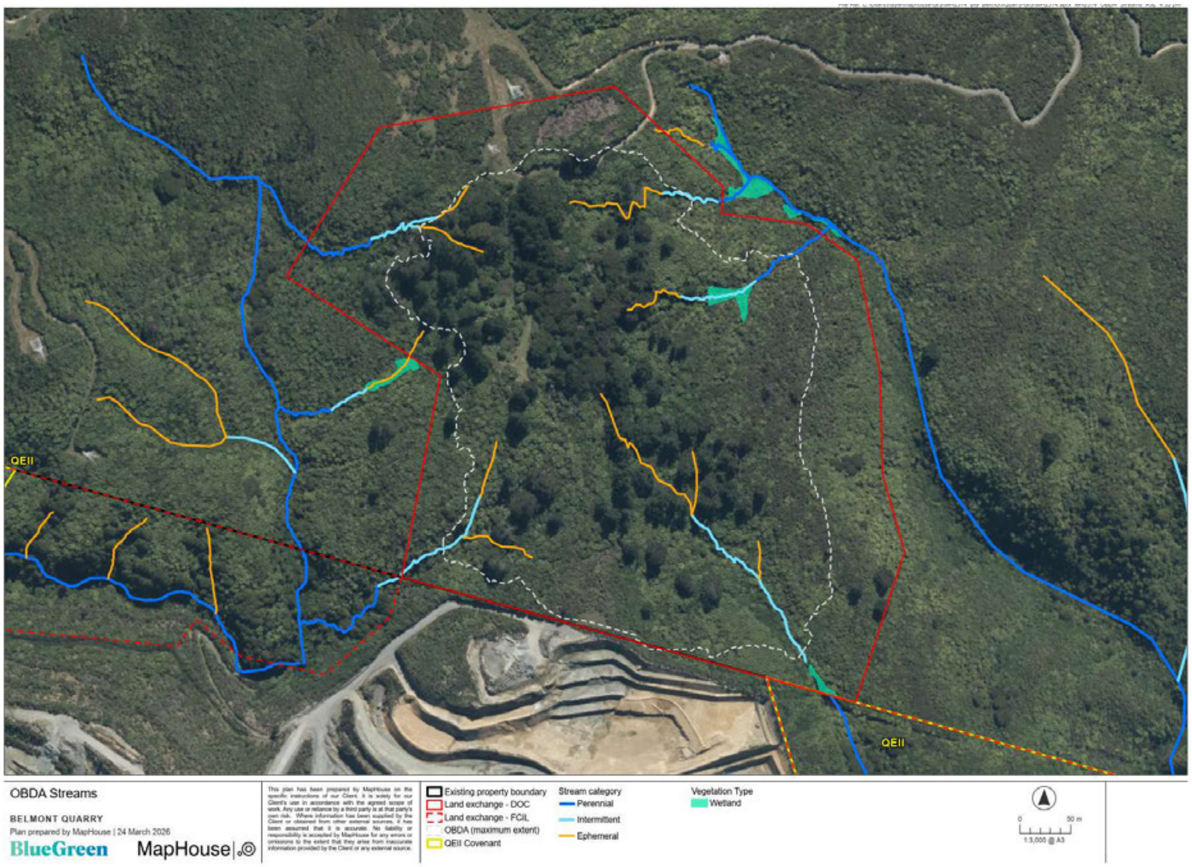

Figure 2.3: Characterisation of the likely flow regimes of larger watercourses in the vicinity of the OBDA.

Despite some uncertainty regarding the exact nature of the flow regimes of the watercourses draining the proposed OBDA currently, following rehabilitation of the site, the reinstated surface and subsurface flow paths will be similar in hydrological character to what exists within the baseline environment. This will be confirmed by the results from the monitoring proposed later in this report.

Excess precipitation, that is, precipitation greater than evapotranspiration and surface storage requirements, can move as either surface or subsurface flow depending on antecedent conditions,

[1] Watercourse categorisation guidance document, GWRC, May 2021.

the properties of the regolith, catchment size, and the intensity and duration of rainfall. A key hydrological characteristic of the drainage lines within the proposed OBDA is therefore whether there is continuous surface flow. Hydrologically, the more significant drainage lines are those with perennial flow. The hydrological values of watercourses with intermittent or ephemeral flow will vary with conditions (as discussed above).

While there are guidance documents, the assessment of the type of flow regime is often subjective, particularly in small gully heads. This is because the amount of water on the slope depends on rainfall, antecedent conditions, and the volume and characteristics of the regolith[2] ('sponge') which can hold, and then release, excess rainfall.

During any rainfall event, the regolith absorbs water. When the regolith is saturated, from either direct rainfall or subsurface percolation and throughflow, water will flow over the ground surface. If the regolith is not saturated, any flow will be subsurface until either the regolith thins (so it saturates), there is additional rainfall, or there is inflow of water from other areas which saturates the regolith and surface flow commences.

Headwater gullies are characterised by highly variable flow, both surface and subsurface, and the higher in the catchment the more variable the flow. Surface flow therefore varies both temporally and spatially. For example, with high antecedent moisture and higher rainfall, surface flow will be greater and more extensive. During periods with little or no rainfall, surface flow may cease, although subsurface flow may continue. It is also possible that, depending on the nature of the regolith, topography, and moisture conditions that surface flow will be intermittent down a drainage line, with water flowing over the surface in some reaches while being entirely subsurface in adjacent reaches. Short lengths of isolated and disconnected surface flow do not mean that flow in a drainage line should be considered perennial.

2.3 Drainage identification

A high-resolution DTM that provides the elevation of each 1m cell allows the topographic relationship between the various cells to be analysed. From this, the potential overland flow paths (e.g., potential streams, watercourses, and other drainage lines) can be inferred (***Figure 2.4***).

The potential overland flow paths i.e., watercourses, derived from analysis of the DTM are a function solely of the topography. There is no consideration of any rainfall-runoff relationship, and it is assumed that the ground surface is both bare of vegetation and impermeable. Consequently, the actual rainfall-runoff processes operating within the catchment are simplified greatly.

It is assumed that water moves from cells at higher elevation into cells at lower elevation. Flow accumulates downslope, as cells receive more flow from upslope, until some threshold is reached when it is assumed that surface flow commences i.e., streamflow begins.

The threshold for determining when surface flow might become apparent i.e., the potential flow lines shown on ***Figure 2.4***, may be defined using the Strahler stream order (i.e., a measure of the number of connected drainage lines upstream). Under the Strahler classification, an order two stream starts below the confluence of two first order streams, and a third order stream below the confluence of

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2 The unconsolidated, generally more porous and permeable material, overlying the bedrock.

two second order streams etc. Consequently, the higher the Strahler number, the greater the number of upstream tributaries, and potentially the larger and more stable the flow regime.

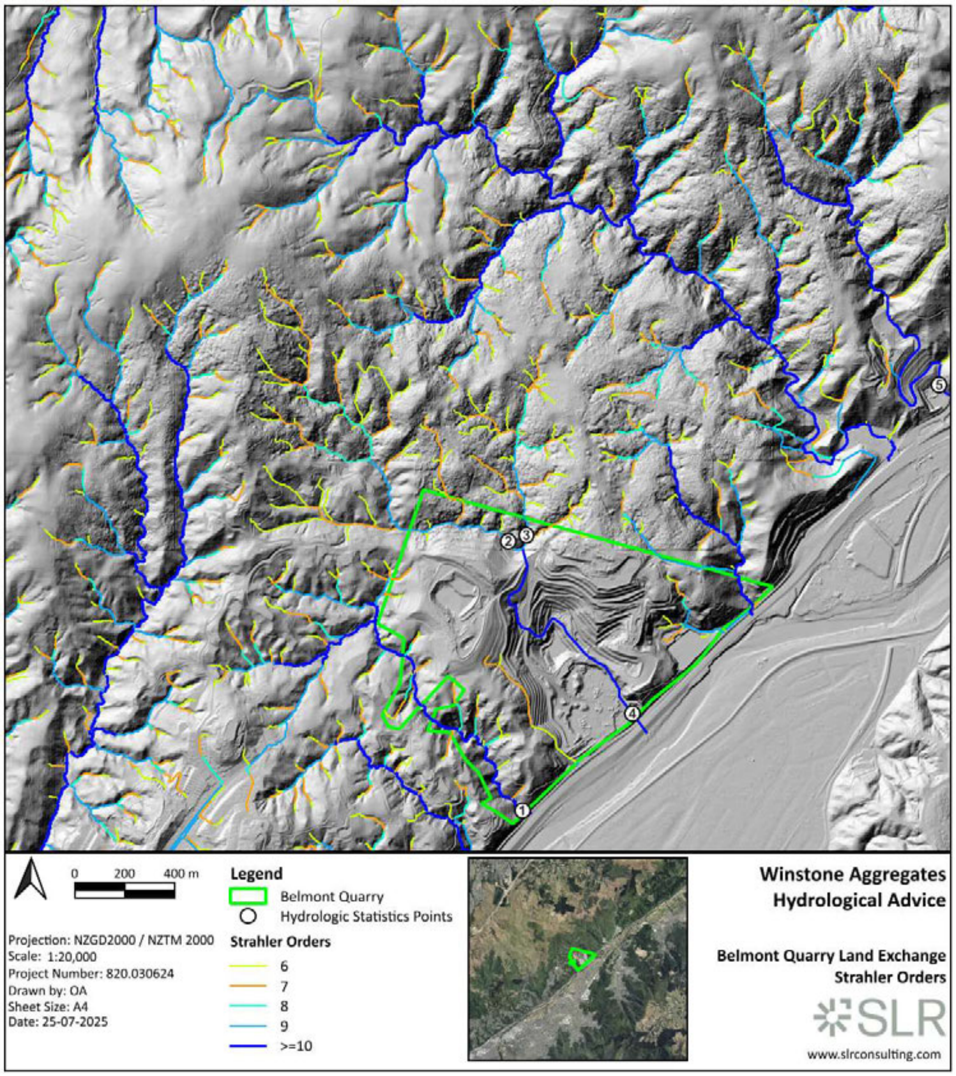

Figure 2.4: Inferred drainage lines in the proposed OBDA and surrounding area.

It should be noted, however, that the Strahler system was developed for actual stream networks and not assumed flow when analysing DTMs. In DTMs, the digital ‘streams’ often commence much nearer the interfluve or catchment divide than shown on paper maps. Therefore, the Strahler stream orders derived from a DTM are higher than would be found in the field. For example, for streams draining the Wellington Fault, it appears that a ‘stream’ with a Strahler order ten from the DTM is necessary for it to be shown on LINZ topographic maps. For comparison, the small tributary streams shown on a LINZ map would have a Strahler order one if determined from the map.

The potential drainage lines shown on the various images in this report commence at a Strahler stream order six, with the Strahler order then increasing downstream. Subsequent inspection in the field during various site visits showed that the hydrological modelling was realistic in terms of drainage lines. However, in headwater gullies, the assumption of overland flow from the DTM is conservative i.e., surface flow is shown higher up the slope than observed in the field. This, and its implications, are discussed in more detail later in this report. Even within the footprint of the quarry, (subject to extensive earthworks and landscape change), the potential drainage lines derived from the DTM are still consistent with what is observed in the field.

The surficial geology of the proposed OBDA consists of relatively thin regolith[3], formed from both *in situ* and colluvially-derived weathered bedrock, overlying generally impermeable greywacke bedrock. The geology and stratigraphy do not provide the conditions necessary for the formation of aquifers or any significant groundwater resource. Any groundwater is likely to only exist within the regolith in the heads of gullies, and other concave depressions, following either intense or prolonged rainfall. Consequently, there is no groundwater resource or any bores within the area proposed for the OBDA.

2.4 OBDA

The proposed OBDA will be approximately 15.7ha and lie within the 23.86ha land exchange area located on the interfluve (catchment divide) between five small headwater gullies (***Figure 2.5***). The various sub-catchments, and their relationship to the tributaries and small streams in the area, are shown in ***Figure 2.6***. OBDA-1 and OBDA-3 are two small headwater gullies that drain into NG-2, the northern tributary of Waikoropupu Stream. This tributary meets NG-1, the other main tributary of Waikoropupu Stream, just upstream of the culvert under the haul road to the Cottles OBDA. OBDA-2, OBDA-5 and OBDA-4 are all small headwater tributaries of FB-4.

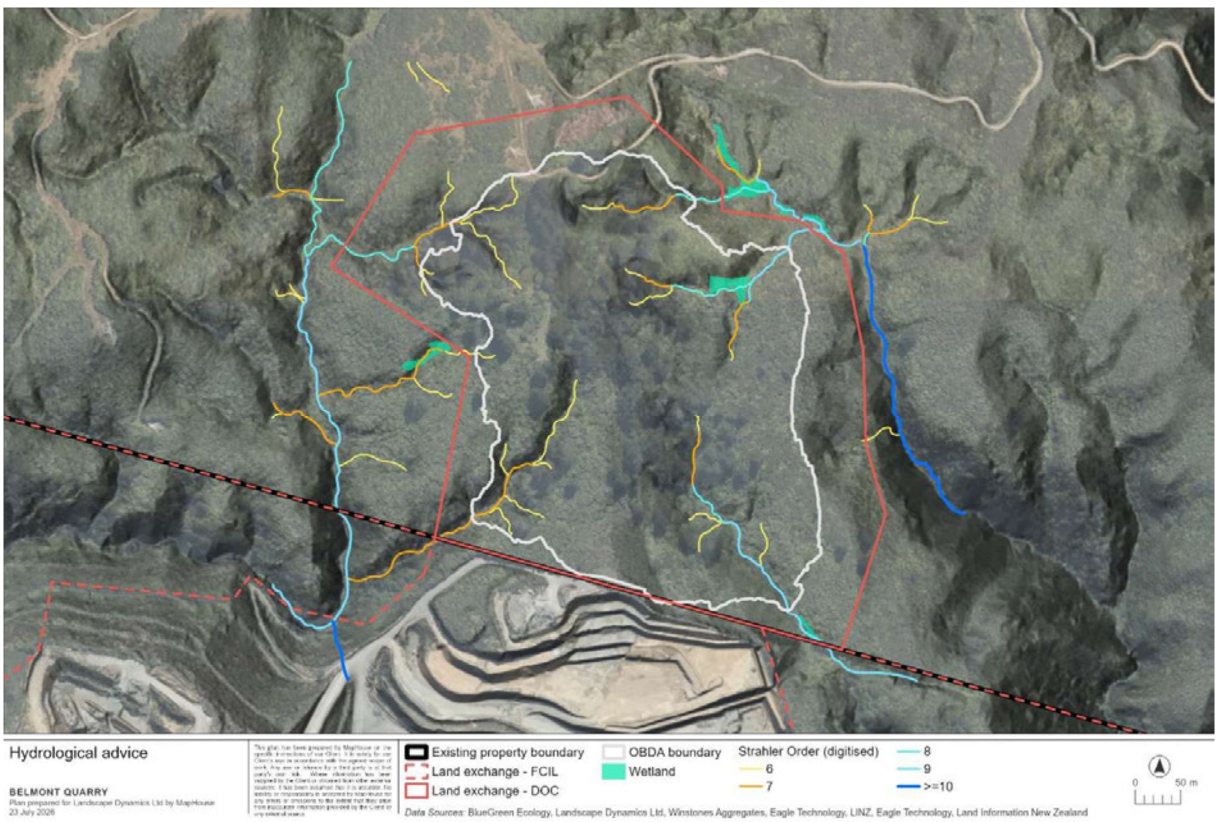

Figure 2.5: The proposed OBDA, inferred drainage network, and mapped wetlands.

3 Regolith is the unconsolidated material that overlies the bedrock.

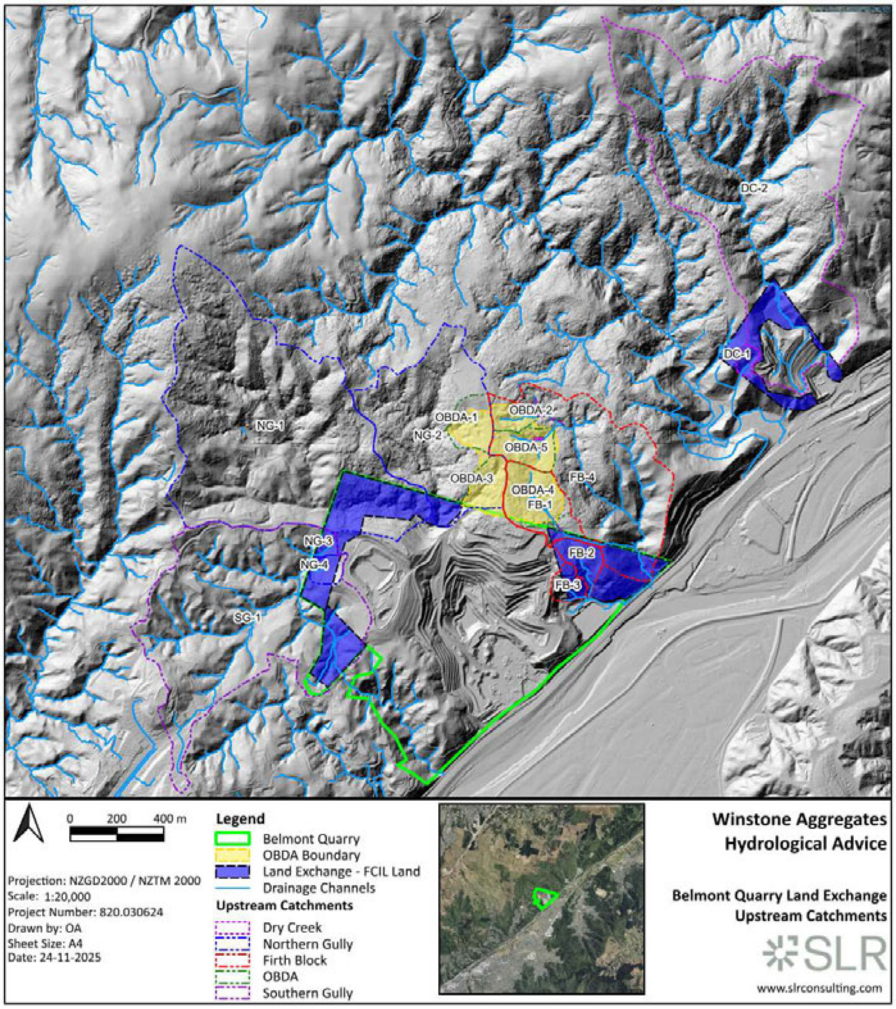

***Figure 2.6:** **Sub-catchments in the proposed OBDA and wider area.** Note the watercourses through the quarry are not shown. Sub-catchments NG-3, NG-4, FB-2, FB-3 and DC-1 are not affected by the development of the OBDA but are shown for completeness.*

The total area of the two catchments of which the five small headwater gullies are tributaries is 213ha (i.e., Waikoropupu Stream and the adjacent unnamed stream discharging to the Hutt River slightly further upstream). The sub-catchments within the proposed OBDA therefore represent only about 8% of their wider catchments. Those gullies that drain to the west have relatively low Strahler stream orders, indicating simple drainage lines which are unlikely to support perennial flow. These gullies discharge into the upper reaches of NG-2, a headwater tributary of Waikoropupu Stream.

The gullies that drain to the east, discharge into a small catchment eroded into the Wellington Fault scarp to north of Belmont Quarry and Waikoropupu Stream. This stream also discharges into the Hutt River. The lower reaches of this stream have relatively high Strahler orders because of the large number of small gullies that form the upper catchment.

The potential overland flow paths within the proposed OBDA exchange area are exaggerated in ***Figure 2.5*** & ***Figure 2.6*** because of the assumed threshold of surface flow adopted, and the assumptions regarding the generation of surface flow when analysing the DTM. Flow in the upper reaches of these potential drainage lines is subsurface, with water flowing on the concave bedrock interface rather than on the ground surface. Surface flow in the headwaters of these gullies under current conditions is likely only following either intense or prolonged rainfall.

The various gullies and headwater tributaries in the proposed OBDA have a combined length of 1855m, with the longest drainage line being 265m. Approximately 48% of the gullies have the Strahler order less than seven. This indicates damp gully heads, rather than perennial watercourses. While there are 223m of watercourse with a Strahler order of at least nine, these are generally located just inside the boundary of the exchange area and not within the footprint of the OBDA. This analysis therefore indicates that the OBDA is comprised mainly of smaller watercourses and damp gully heads, with only short lengths of streams likely to have perennial flow. Any reaches with perennial flow generally exist between the proposed OBDA footprint and the property boundary with Belmont Regional Park. Consequently, the hydrology of these streams is unlikely to be affected by the development of the OBDA.

Vegetation surveys have identified a small wetland at the confluence of two gullies above the small stream that drains the eastern side of the OBDA exchange area. Given the location of the wetland, and its morphological characteristics, it was likely formed by impeded drainage caused by a landslide blocking the original flow path. The Wellington Fault scarp and Western Hutt hills were affected by thousands of landslides during intense rainfall on 20 December 1976. This wetland may have formed after that event. Since the development of the OBDA will maintain the existing drainage pattern and runoff regime, and since this wetland lies outside of the footprint of OBDA, the hydrology of this wetland will be unchanged. This will be confirmed by the results from the monitoring proposed later in this report.

3.0 Hydrological Processes

The characteristics of any drainage lines and their flow regimes within the proposed OBDA are directly related to the passage of water from the point that rainfall lands on the ground, to its runoff into any stream (***Figure 3.1***).

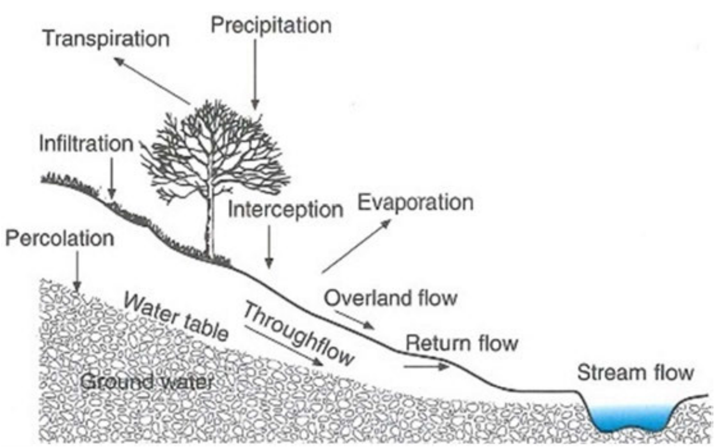

Figure 3.1: Various pathways and storages within a hillslope (McConchie, 2001).

There are few hydrological metrics describing the baseline environment; however, the principal driver of the hydrological processes is rainfall, which will not be affected by the development of the OBDA. Winstone Aggregates have maintained a rain gauge and climate station above the Belmont Quarry since 2009. Consequently, there are over 15-years of excellent, high-resolution data that can be used to characterise the rainfall, temperature and wind conditions affecting the site. These climate data provide the context when considering any potential effects of the OBDA on hydrological processes.

The lack of baseline hydrological metrics is not a major constraint when assessing the potential effects of the OBDA on hydrology. This is because the hydrological processes are relatively simple, largely predictable, and these processes can be inferred from widely understood and agreed principles.

Because of their proximity, and similar elevation, relative relief, and orientation to prevailing westerly conditions, all drainage lines within the OBDA are likely to experience the same rainfall patterns and characteristics. The similar geology, slope form, and general vegetation cover, also mean that the same rainfall-runoff relationships are likely to exist in each of the gullies or headwater tributaries. Any variation in the flow regimes is largely related to the size of the upstream catchment and the distance of the gully or stream from the interfluve. These same principles can be applied when managing runoff from the OBDA. This will ensure that the flow regimes of any watercourses downstream of the OBDA footprint will be largely unaffected by the proposed development.

Since many of the slopes in the proposed OBDA are short, steep, and planar, there is only a rudimentary channel network. Under 'natural' conditions, and with good vegetation cover, there is unlikely to be any surface runoff from most of the proposed OBDA area during most rainfall events. Surface runoff only commences once the regolith overlying the bedrock becomes saturated, or should the rainfall intensity exceed the infiltration rate. This later process is unlikely under 'natural' conditions. Therefore, surface runoff is most likely to occur only in concave depressions such as gullies. The position at which surface flow commences depends on the upstream catchment area (as summarised by the Strahler order), antecedent moisture conditions, and the intensity and duration of rainfall. As a result, the start of surface flow is likely to migrate up and down the headwater gullies depending on these conditions. During winter, and following either intense or prolonged rainfall, surface runoff will commence higher up the slope than at the end of autumn, or after a prolonged dry spell.

The total volume and timing of runoff, and ultimately the characteristics of any flow in the gullies and headwater tributaries in the OBDA, therefore involves three interacting mechanisms (***Figure 3.2****):*

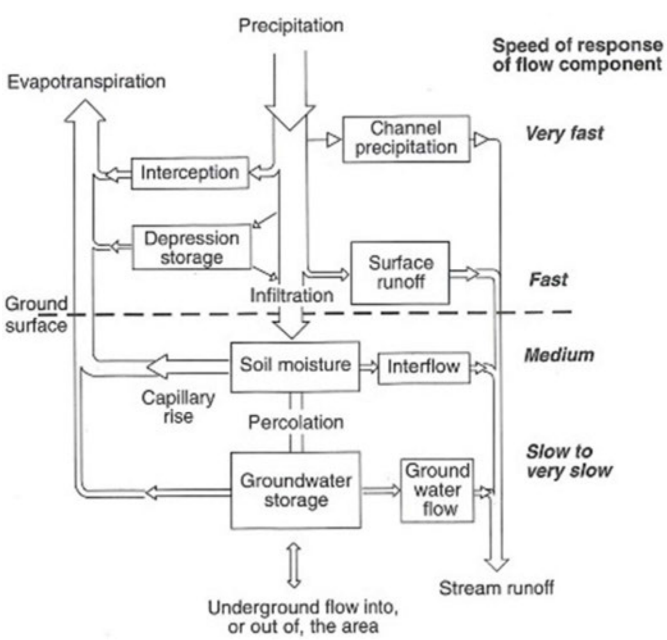

Figure 3.2: Processes by which moisture moves across and through a slope and generates runoff (McConchie, 2001).

- Overland flow (water flowing across the land surface, which as explained is negligible under current conditions);
- Throughflow (water flowing through the soil or unsaturated zone); and
- Groundwater flow (water flowing through the groundwater or saturated zone).

The relative importance of each of these mechanisms to runoff generation and streamflow depends on the nature of the catchment and rainfall characteristics (i.e., duration, intensity and depth). As described above, these are relatively uniform across the OBDA. Consequently, the principal control on any differences in the runoff regimes of the various gully heads is catchment area.

3.1 Groundwater

Given the relatively impermeable nature of the bedrock underlying the proposed OBDA, there is unlikely to be any groundwater resource or aquifers. The only groundwater that may exist will be when the regolith overlying the bedrock becomes saturated. Even this groundwater, however, is transient and maintains baseflow in the streams rather than providing a groundwater resource.

These conclusions are consistent with the findings of a geotechnical investigation[4]. *"A series of hand-auger boreholes and Scala Penetrometer tests were undertaken by Geotechnics on 24 July 2025 to identify the thickness of alluvial material overlying greywacke rock mass. All but one of the tests were dry on completion. HA 25-1, located in the eastern sidling gully, encountered water inflow at 0.1 m below ground level (m bgl)."*

3.2 Hydrological data

As discussed, there are few hydrometric data available for the Waikoropupu catchment, or any of the small streams draining the Western Hutt hills and the Wellington Fault scarp in the vicinity of the OBDA. There are no instrumental flow records. The only data available are generalised flow parameters (***Table 3.1***) derived from hydrological modelling. Experience has shown that these data, since they are derived from the spatial interpolation of flow records from larger catchments, generally draining mountains and hill country, are conservative i.e., high, for small catchments draining lowland areas such as the OBDA. Consequently, the flow regimes of the various gullies and streams must be inferred from catchment characteristics and hydrological principles.

Table 3.1: Hydrological statistics interpolated for the locations shown on Figure 2.4 (NIWA, 2018).

Location*	Catchment area	Median flow (L/s)	Mean flow (L/s)	MALF (L/s)
1	84.6	9.5	18.2	2.5
2	78.0	9.9	18.7	2.6
3	27.9	3.4	6.1	0.8
4	153.9	19.5	34.7	5.1
5	89.2	13.7	24.4	3.9

Note: Although catchments 1 and 5 are outside of the area potentially affected by the proposed OBDA, they are included for completeness given the limited hydrometric data available.

4 Geotechnical Assessment Report – Belmont Quarry Proposed Overburden Disposal Area (BGL000252 v1.1) prepared by Baseline Geotechnical.

3.3 Spatial analysis

Because of the lack of empirical hydrometric data, the high resolution DTM was used to derive potential drainage lines and overland flow paths within the OBDA. A Strahler stream order six was chosen to indicate where sufficient runoff may accumulate to result in overland flow. This threshold appeared to provide a balance between an appropriate level of detail for the potential drainage network and unnecessary 'noise'.

Analyses identified and quantified the drainage lines within each sub-catchment, the relative sizes of these drainage lines using the Strahler order, and the catchment areas upstream of where the drainage lines exit the proposed OBDA (***Figure 2.6***).

The upstream catchment areas, longest length of the drainage lines within each catchment, and longest length of the drainage lines within each of the sub-catchments of the proposed OBDA are presented in ***Table 3.2***. While these metrics are derived solely from analysis of the DTM, this approach ensures that the entire area is treated in a consistent manner and that the results are both transparent and replicable. This allows considerable confidence to be placed in any comparisons or analyses. As discussed later in this report, following detailed site visits, it was apparent that the digital analysis over-estimated the length of assumed surface flow because of the inherent assumptions of this approach discussed earlier. However, as mentioned, any minor uncertainty is consistent across the OBDA.

Table 3.2: Various drainage metrics for the various sub-catchments within the proposed OBDA.

Catchment ID	Catchment area (ha)	Longest stream length in catchment (m)	Total stream length in catchment (m)
OBDA-1	4.7	186	496
OBDA-2	3.1	165	171
OBDA-3	3.9	265	444
OBDA-4	7.2	264	411
OBDA-5	4.9	208	371

4.0 Observations

Detailed site visits to the Belmont Quarry and its environs were undertaken on the 24th of June and 23rd of July 2025. During these visits, the two main tributaries of Waikoropupu Stream upstream of the culvert through which the stream passes under the road to the Cottle OBDA were investigated. Two of the headwater gullies within the proposed OBDA (OBDA-3 & OBDA-4) were also traversed downslope until continuous surface flow was observed (***Figure 2.6***).

Three factors need to be considered when considering these observations:

- The two site visits were undertaken during 'winter', and while there was no rain on the actual day of the visit, antecedent conditions were wet. It is therefore likely that the assessment of runoff and overland flow conditions was conservative i.e., greater flow, and flow commencing further upslope than 'normal';

- Despite the above, the commencement of surface flow was significantly further downslope than indicated by the digital analysis and the assumption of surface flow commencing at Strahler order six; and

- Despite the presence of overland flow, there was no defined channel or bed where surface flow commenced. This supports the argument that the flow conditions observed were wetter than normal and that the start of overland flow inferred from the DTM was conservative.

A further site visit to the proposed OBDA, predominantly to sub-catchments OBDA-2 & OBDA-5, was undertaken on the 25th of February 2026 (***Figure 2.6***). This visit was about 10 days after a major rainfall event when 138mm was recorded by GWRC in their gauge at Mabey Road (about 2.8km SW of Belmont Quarry). Conditions were again therefore likely to have been wetter than average.

The hydrological characteristics of various sub-catchments are described below.

4.1 Sub-catchments OBDA-2, 3, 4 & 5

The sub-catchments visited are all small topographic depressions that have eroded into the scarp of the Wellington Fault. OBDA-2 drains east from the interfluves with sub-catchment OBDA-1 to the west and OBDA-5 to the south. OBDA-3 drains west from the interfluves with sub-catchment OBDA-1 to the north and OBDA-4 & 5 to the east. OBDA-4 drains west from the interfluves with sub-catchment OBDA-5 to the north and OBDA-3 to the west. OBDA-5 drains east from the interfluves with sub-catchment OBDA-2 to the north and OBDA-3 to the west. (***Figure 2.6***).

The gullies that form these sub-catchments are depressions eroded into the bedrock that are infilled with colluvium from the surrounding slopes, primarily during the last glacial (Vaughan, 1989). Precipitation infiltrates the ground surface and percolates through the colluvium until it intercepts the bedrock interface. Water then flows parallel to the bedrock surface until it accumulates sufficient volume that it saturates the entire regolith, and runoff starts to flow on the ground surface. The position where surface flow commences at any time therefore depends on both antecedent conditions and the intensity and duration of rainfall.

The upper reaches of these gullies therefore tend to have moist valley floors (***Figure 4.1*** & ***Figure 4.2***) rather than having any surface flow or defined channel (***Figure 4.3***). As mentioned, during the site visit, surface flow commenced significantly further down the two gullies inspected than inferred from analysis of the DTM (***Figure 4.4***), even though antecedent conditions were wetter than average.

Figure 4.1: Commencement of surface flow during winter in sub-catchment OBDA-4. There is no defined channel or stream bed until further down the gully.

***Figure 4.2:** Commencement of surface flow during winter in sub-catchment OBDA-3. There is no defined channel or stream bed until further down the gully.*

***Figure 4.3:** Any defined channel and stream bed is present only further down the gully in OBDA-4.*

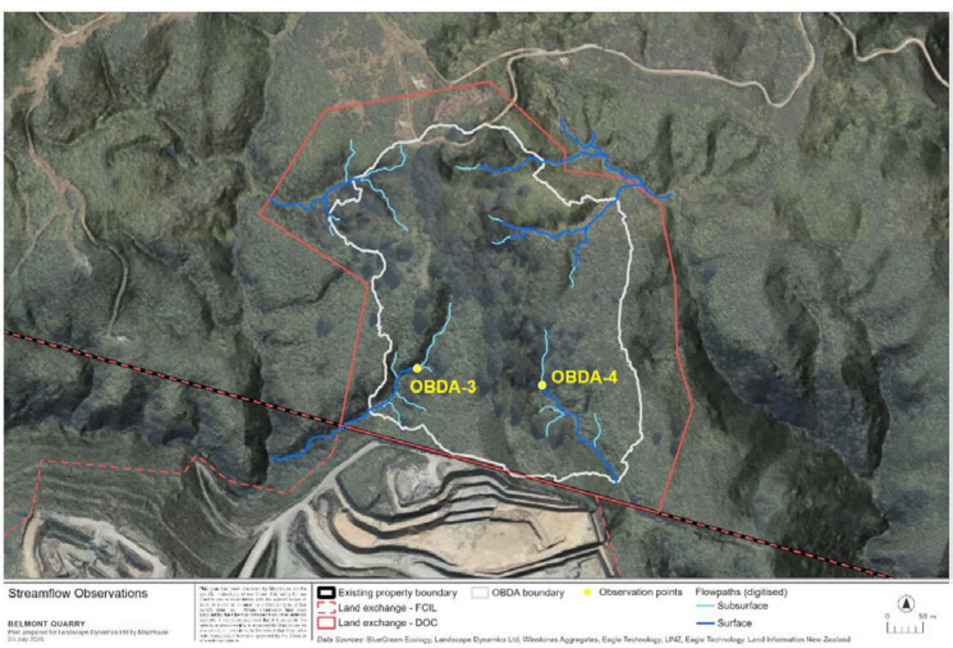

***Figure 4.4:** Boundary between subsurface and surface flow on the day of the field observations.*

It should be noted therefore, that the data shown on ***Figure 2.6***, and summarised in ***Table 3.2***, with respect to stream lengths will be conservative. The actual stream lengths in the various gullies and sub-catchments draining the proposed land exchange for the OBDA are likely to be shorter than indicated by the digital analysis.

4.2 Drainage calibration

As discussed, during a site visit the locations where surface flow commenced in sub-catchments OBDA-3&4 were identified (***Figure 4.4***). The drainage lines inferred from analysis of the DTM were therefore investigated in more detail to determine at what Strahler stream order surface flow commenced. Although there is only limited information, it appears that surface flow commences when the Strahler stream order was at least seven, and not six as assumed initially. It is likely that only subsurface flow occurs within the regolith and colluvium at Strahler stream order six.

The Strahler stream orders for the drainage lines derived from the DTM of the wider area are presented in ***Figure 2.4***. At a Strahler order of nine or greater, more significant flows are expected, especially during and immediately following rainfall events. Streams of this order are also expected to have perennial flow and are shown in the NZ River Maps database (NIWA, 2018). Various interpolated hydrological statistics for these streams were extracted from the database at the locations numbered 1-5 in ***Figure 2.4*** and these metrics were presented in ***Table 3.1***.

5.0 Development of the OBDA

The footprint of the proposed OBDA will be approximately 15.7ha and lie within the 23.86ha extended property boundary to the north of the current quarry. The OBDA will be located on the interfluve (catchment divide) between five small headwater gullies (***Figure 2.5***). It is anticipated that the OBDA will accommodate approximately 2.8 million cubic metres of overburden, including topsoil, subsoil, weathered greywacke, and process & pond fines over a 40-year operational period. The OBDA has been designed to function as a permanent engineered landform. It will be established and constructed across 10 stages, with supporting haul infrastructure, drainage, fines containment, and progressive rehabilitation.

There are several factors which mean that the effect of developing the OBDA on hydrology and runoff processes in the area and adjacent catchments will be extremely small, but likely positive. These include:

- The relatively small footprint of the proposed OBDA (~15.7ha).
- The distance and area between the footprint of the OBDA and Belmont Regional Park (over 8.2ha). This will act as a buffer that will moderate and attenuate any small effects of the OBDA on hydrology and hydrological processes, should they occur.
- The OBDA being located largely on the interfluve between five small headwater gullies.
- Limited surface runoff in the area, except possibly during intense or prolonged rainfall over highly modified surfaces.
- The small percentage of each sub-catchment potentially affected by the OBDA.

- The staged development of the OBDA, with each stage affecting only small discrete sub-catchments i.e., the stage boundaries are coincident with sub-catchment boundaries.
- Each stage only effects one sub-catchment (except Stage 1 which affects two) i.e., the stage boundaries are coincident with the sub-catchment boundaries.
- The lack of any cumulative effects since each stage will be rehabilitated, from a hydrological perspective, prior to work on the next stage commencing;
- Progressive development of the OBDA over 40-years; and
- Experience with the current Cottles OBDA which provides a real-world analogue for how runoff from the site can be managed to avoid any adverse effects.

5.1 Maintenance of hydrological processes

As discussed earlier, the runoff regimes within the various sub-catchments draining the proposed OBDA are relatively simple and controlled largely by catchment area and the distance from the interfluve.

To maintain the hydrological regimes, the OBDA will be designed, constructed, and managed in a manner similar to the existing Cottle's OBDA. Each Stage of development will generally correspond to a single natural sub-catchment. There will be active management of both surface and sub-surface drainage to ensure that the existing hydrological processes continue to operate, and that any hydrological effects of the development are limited to the OBDA. Beyond the boundary of the OBDA, it is my opinion that, once the principles within the Geotechnical and Erosion and Sediment Control assessments are implemented, any effects of development of the OBDA on hydrology will be negligible. Beyond the boundary of the OBDA, they can be considered 'less than minor'.

Surface drainage

The OBDA will be developed and operated using a staged stormwater management framework that differentiates between construction, operational, and post-rehabilitation phases. This approach is consistent with that which has been adopted and applied to the development and operation of the Cottle's OBDA and other large earthwork projects in the Wellington region.

Key principles for the management of surface runoff are effective erosion and sediment control (ESP) and the separation of 'clean' and 'dirty' water. As explained in the Erosion and Sediment Control assessment, the erosion and sediment controls for the development of the OBDA will be simple, traditional, and effective. The proposed design and methodology for ESC is in accordance with Greater Wellington Regional Council's guidance[5]. Consequently, there is no risk or uncertainty regarding the effectiveness of the proposed erosion and sediment controls in meeting regional guidelines and current best practice.

Construction of each stage of the OBDA, since each stage generally affects only one sub-catchment, will ensure that the contributing area to each drainage line downgradient of the OBDA remains the

[5] Erosion and Sediment Control Guide for Land Disturbing Activities in the Wellington Region. Version 1, February 2021.

same. For the reasons stated above, this will ensure that the hydrological regimes of drainage lines beyond the boundary of the OBDA are unaffected by the proposed development.

As explained in the ESC assessment, diversions will be installed to ensure separation of 'clean' and 'dirty' water. Clean water will be discharged as it is at present, into the same drainage lines beyond the OBDA.

All 'dirty' (i.e., sediment laden) water will pass through a sediment treatment device before being discharged. Sediment retention ponds will reduce the volume of sediment leaving site. This will protect downstream environments from excessive sedimentation, water quality degradation, and the impacts of changes to the flow regime. Diversion bunds or channels will prevent sediment laden water from entering any waterway.

The efficiency and effectiveness of the ESC within the OBDA will be confirmed using the same water quality metrics adopted for the Cottle's OBDA i.e., Total Suspended Solids, Turbidity (NTU) and pH.

Details of the management and treatment of surface runoff within the OBDA are provided within the Erosion and Sediment Control Assessment[5]. It is my opinion that, once the principles within the Erosion and Sediment Control assessment are implemented, any effects of development of the OBDA on surface runoff will be negligible and can be considered 'less than minor' beyond its boundary.

Sub-surface drainage

As discussed in the Geotechnical Assessment[6], the development of the OBDA will involve the installation of sub-surface drainage. To manage the potential development of groundwater pressures, both formal sub-soil drains and 'informal' drainage blankets will be installed. It is anticipated that a shallow trench will be excavated along the existing gully alignments, and that a filter-sock-wrapped perforated pipe, surrounded by drainage aggregate, will be installed. The drainage aggregate will be wrapped in geofabric. This conceptual design is illustrated in Appendix F of the Geotechnical assessment. Larger Type 1 drains are to be used for the main gully channels and smaller Type 2 drains used to 'capture' any localised seepages that may be identified during foundation preparation. Additional detail regarding the sub-surface drainage is provided in the Geotechnical assessment.

If the principles and methodology provided in the Geotechnical assessment are implemented, it is my opinion that any effects of development of the OBDA on sub-surface drainage will be negligible and can be considered 'less than minor' beyond its boundary.

Summary

It has been shown at the Cottle's OBDA that, by adopting the principles outlined above, it is possible to maintain both surface and subsurface flow, the existing flow regime, and existing water quality. The design and construction of the new OBDA, in the manner proposed, will therefore ensure that

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[6] Geotechnical Assessment Report – Belmont Quarry Proposed Overburden Disposal Area (BGL000252 v1.1) prepared by Baseline Geotechnical.

the existing hydrological processes are maintained, including both surface and subsurface flow. The existing discharge into each of the various drainage lines beyond the OBDA will continue.

As explained, the infilling of a gully does not need to stop, or even alter significantly, all runoff and hydrological processes. Any rainfall over the area, above evapotranspiration and storage requirements, will still runoff either over the ground surface or via sub-surface drainage. Using the principles and methodologies discussed above, and as shown at the Cottle's OBDA, it is possible to control subsurface drainage to maintain existing flow paths, to separate clean and dirty surface flow, to discharge clean water into original flow paths, and to treat dirty water to avoid the discharge of sediment.

Since the existing hydrological processes will be maintained within the OBDA, including both surface and subsurface flow, and discharge into each of the various drainage lines within the OBDA will continue, the hydrology of any wetlands downstream of the OBDA will likely be unchanged. The only wetland that will be affected adversely by the development of the OBDA, from a hydrological perspective, is that located within the footprint of the OBDA.

A significant distance and area is proposed between the footprint of the OBDA and the boundary with Belmont Regional Park. It is my opinion that, once the principles within the Geotechnical and ESC assessments are implemented, any effects of the development of the OBDA will be negligible. There will be no measurable adverse effects on hydrology or hydrological processes beyond the OBDA boundary. Any effects can therefore be considered 'less than minor'. This will be confirmed by monitoring water level conditions within the first wetland in each drainage line downgradient of the OBDA.

5.2 Hydrological processes

The development of the OBDA will have very small and short-term effects on some of the elements of the hydrological cycle (***Figure 5.1***). While there will be changes in the balance between surface and subsurface runoff during the initial development of each stage, with an increase in surface runoff during construction, these changes will affect only small areas for relatively short periods. Once the runoff and erosion and sediment control devices have been installed, the hydrological processes will return to their existing state and condition. Any effects of the development are unlikely to be measurable after the initial construction period downstream of the property boundary.

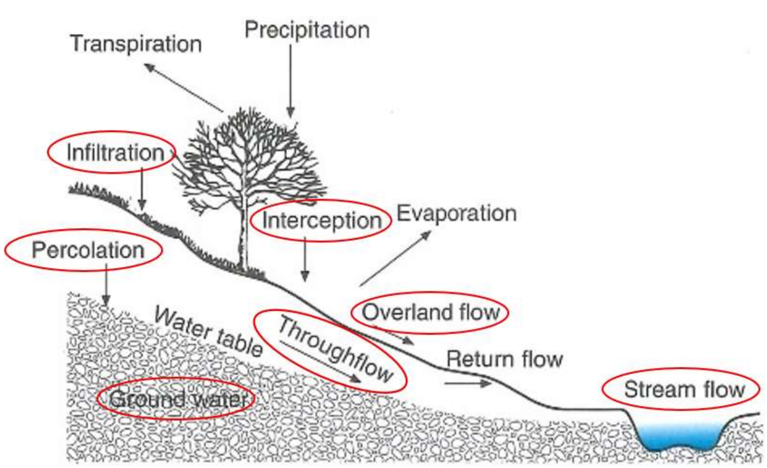

Figure 5.1: Elements of the hydrological cycle potentially affected in the short-term by the development of each stage of the OBDA (After McConchie, 2001).

Developing the OBDA has the potential to have small effects on various elements of the hydrological cycle. These are highlighted in ***Table 5.1***.

Table 5.1: Summary of hydrological effects of developing the OBDA.

Component of the hydrological cycle	Potential effect of developing the OBDA
Interception	The clearance of vegetation during each stage of development of the OBDA will cause reduced interception. Consequently, more rainfall will reach the ground. However, any effect on interception will only exist until vegetation cover is restored. Also, because of the staged development, any reduction in interception will affect only a very small area at any time. The reduction in interception may result in a small increase in runoff but any change will depend on the characteristics of the rainfall i.e., the magnitude, frequency and duration of specific rainfall events.
Infiltration	There will be a small decrease in infiltration during the initial phase of development of each stage, however, this will be small and of short duration. This will be caused by the removal of the vegetation and soil cover, and compaction of the surface. Water controls and erosion and sediment control devices will ensure the separation of 'clean' and 'dirty' water and that any increase in runoff is managed within the footprint of the OBDA. Any changes in runoff caused by decreased infiltration are unlikely to be measurable beyond the property boundary.
Overland flow	There is unlikely to be any, or only very limited, overland flow within the proposed OBDA at present. This is because of the generally flat and smooth slopes on the interfluve and the good vegetation cover. The only areas where overland flow may occur at present will be on the roads and tracks where the surface is compacted and vegetation sparse. While there may be a small increase in overland flow during the initial phase of development of each stage, this will be small and of short duration. This will be caused by the removal of the vegetation and soil cover and compaction of the surface. Water controls and erosion and sediment control devices will ensure the separation of 'clean' and 'dirty' water. Within the footprint of the OBDA any surface runoff will be discharged to the existing drainage lines via soakage and diffuse drainage. Consequently, while there may be small change in overland flow within the footprint of each stage of the OBDA for a short period, there are unlikely to be any effects beyond the boundary of the OBDA.
Percolation & Throughflow	The design of each stage of the OBDA, in a manner like the existing Cottles OBDA, will ensure that the current percentage of rainfall that contributes to percolation and throughflow is maintained. The disposal of 'wet fines' to the OBDA, above what can be evaporated, may increase the rate of throughflow slightly. This could potentially enhance baseflow in the small gullies downgradient of the property boundary. This could improve the hydrology of any wetland in these downstream drainage lines. The hydrology of any wetland not in a drainage line emanating from the OBDA will be unaffected.
Stream flow	There may be a small change in the ratio of surface and subsurface flow within the OBDA during the initial development of each phase. However, any change will be of short duration and its effects not measurable downstream of the boundary. Any small change will be within the range of existing natural variation.
Groundwater	The design of the subsurface drainage within each stage of the development of the OBDA will ensure that existing groundwater flow paths, and their connection to existing drainage lines and streams, will be maintained. Consequently, there should be no changes to the continuity of flow. Existing baseflow will be maintained and this will avoid any adverse effects on the hydrology of any wetlands downstream of the property boundary. The hydrology of any wetland not in a drainage line emanating from the OBDA will be unaffected.

Consequently, the development of the proposed OBDA in the area suggested, in a manner consistent with the principles within the Geotechnical and ESC assessments, and similar to the existing Cottles OBDA, will have no adverse effects on hydrology or the flow regimes of the small streams downstream of the property boundary. It is my opinion that the hydrology of any wetlands further down the drainage lines emanating from the proposed OBDA may be enhanced by a slightly more stable flow regime, although any changes are unlikely to be measurable.

5.3 Sequencing

Any potential effects of developing the OBDA will be minimised by the proposed sequencing of the development (***Figure 5.2***). This means that only a small proportion of the total footprint of the OBDA will be developed at any one time. The development of the subsequent stage will not commence until hydrological rehabilitation, including the reinstatement of any surface drainage lines, of the previous stage is complete. The existing pattern of subsurface drainage will be provided during the development of each stage as described above.

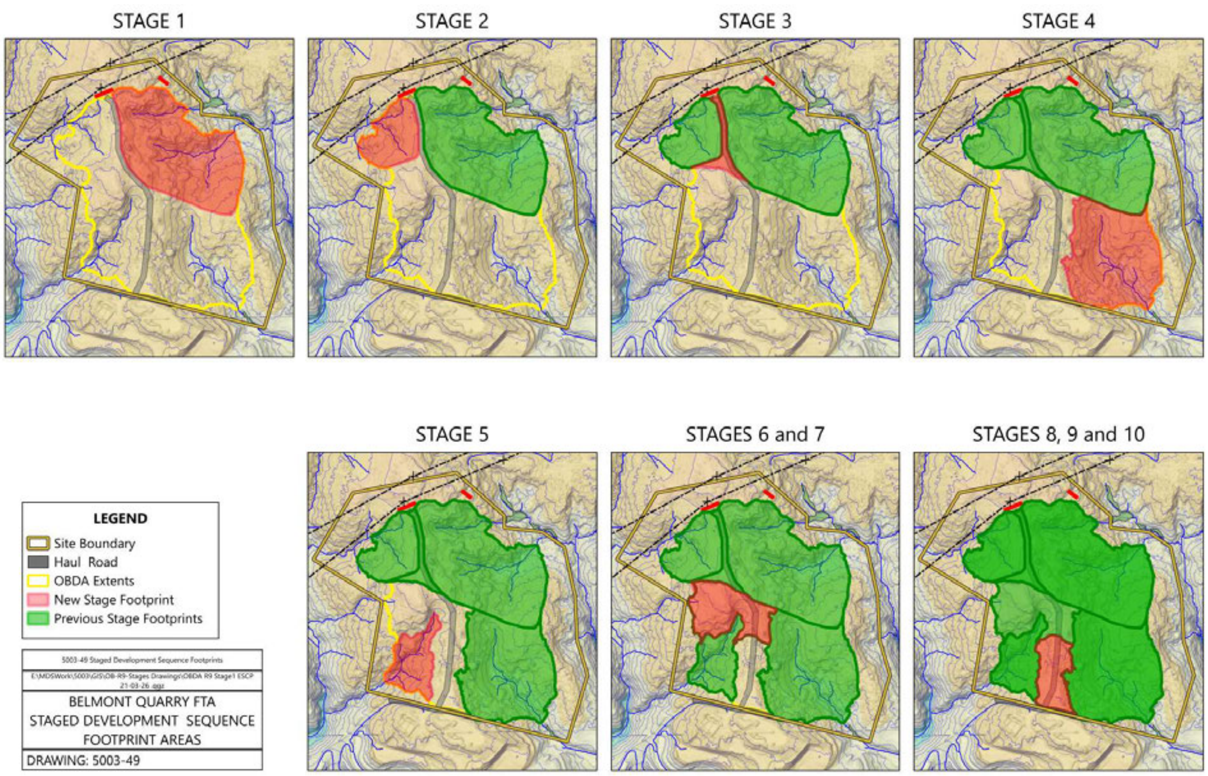

Figure 5.2: Various stages proposed for the development of the OBDA. Each stage generally only effects one of the small gully heads.

It is also significant that the boundaries of the various development stages are coincident with the catchment boundaries of the various small gully heads. Consequently, generally only one small gully head (but two during Stage 1) will be affected during any stage over the 40-year development period.

Stage 1, despite having the largest footprint, only effects sub-catchments OBDA-2 and OBDA-5 (***Figure 5.3***). These are two of the small headwater tributaries of the small stream draining east from the OBDA (FB4). Stage 2 affects only OBDA-1 (***Figure 5.4***). Stage 3 is located on the interfluve between the various small headwater gullies and tributaries and so has little potential to affect the hydrology of any catchments downgradient (***Figure 5.5***). Stage 4, the second largest of the stages, affects only OBDA-4 (***Figure 5.6***). Stage 5 affects only OBDA-3, one of the headwater gullies of NG-2, a major tributary of Waikoropupu Stream (***Figure 5.7***). Stages 6-10 are all located on the interfluves between the various headwater gullies and therefore have little potential to affect the hydrology of any drainage lines downgradient. Any small potential adverse effects will be avoided or mitigated by the water controls and sediment control devices installed during earlier phases (***Figure 5.8***).

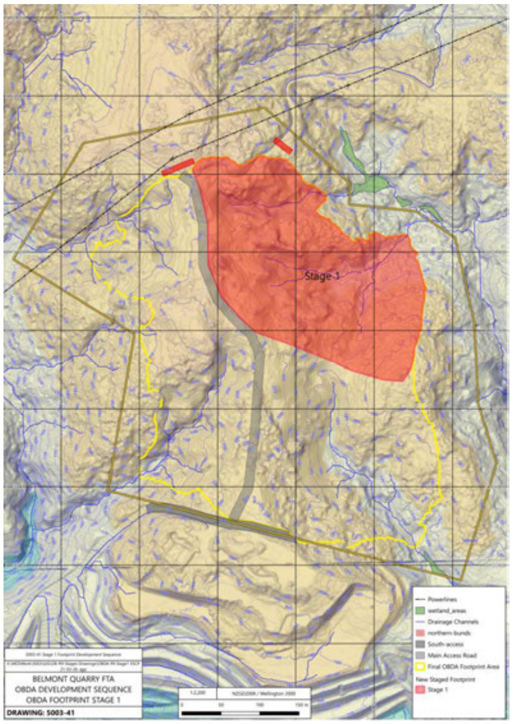

Figure 5.3: Stage 1 will affect only sub-catchment ODBA-2 and OBDA-5.

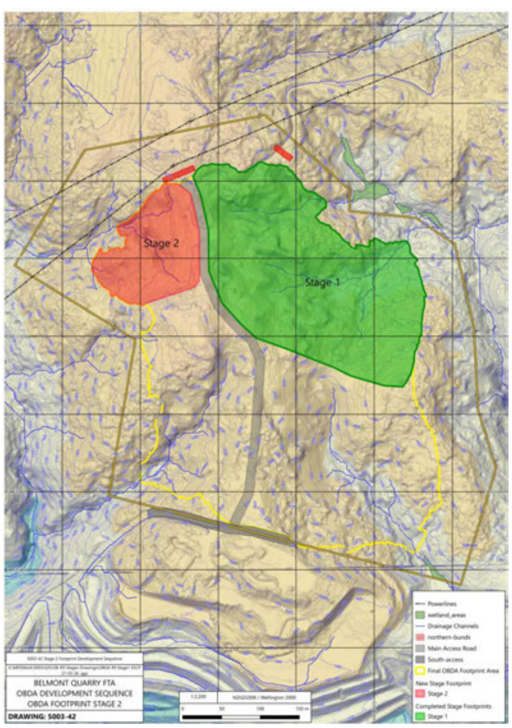

Figure 5.4: Stage 2 will affect only sub-catchment ODBA-1.

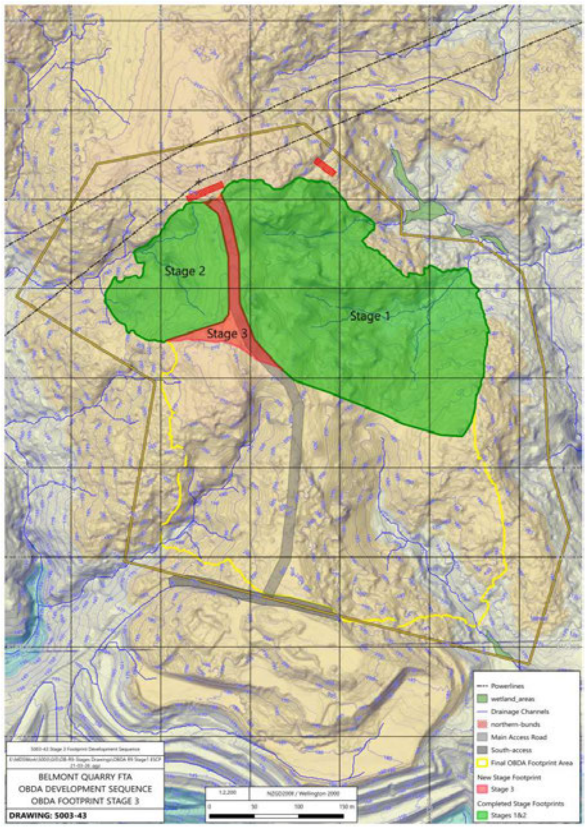

Figure 5.5: ***Stage 3 is on the interfluve between the various gully heads and so will have little effect on hydrology downgradient.***

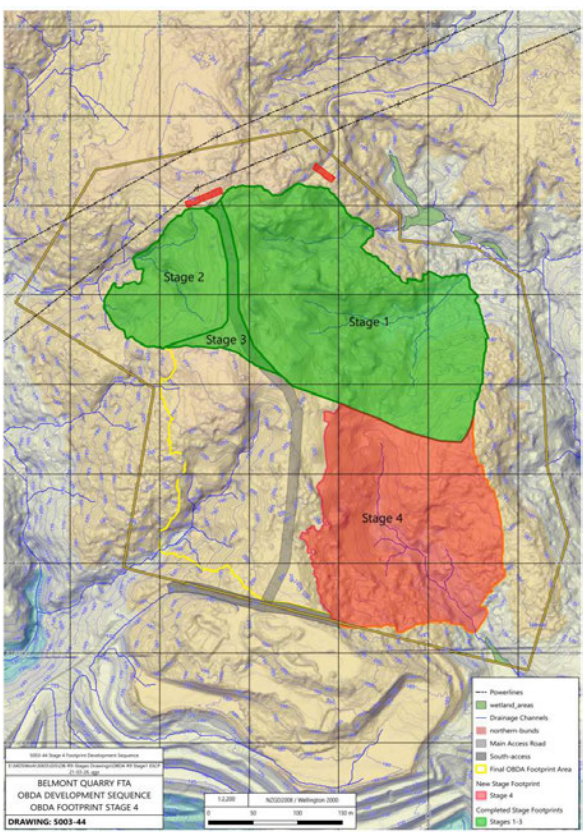

Figure 5.6: ***Stage 4 will affect only sub-catchment ODBA-4.***

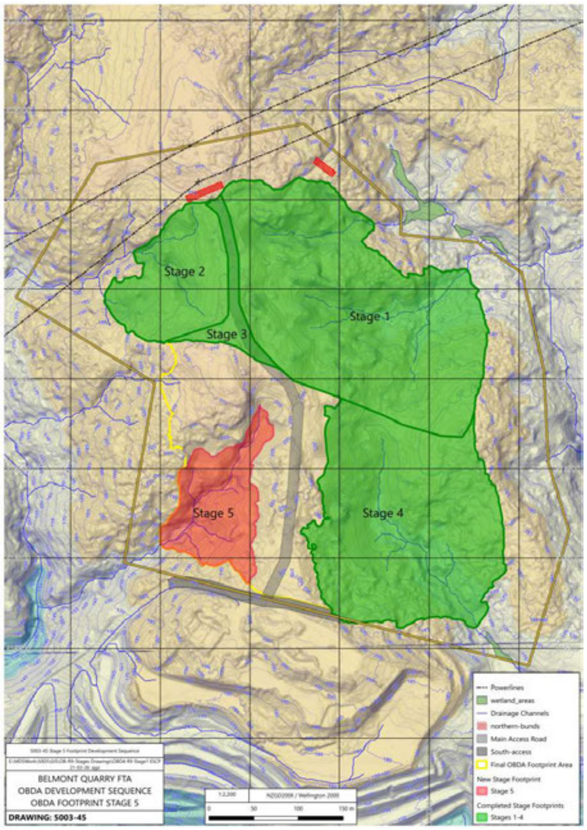

Figure 5.7: Stage 5 will affect only sub-catchment ODBA-3.

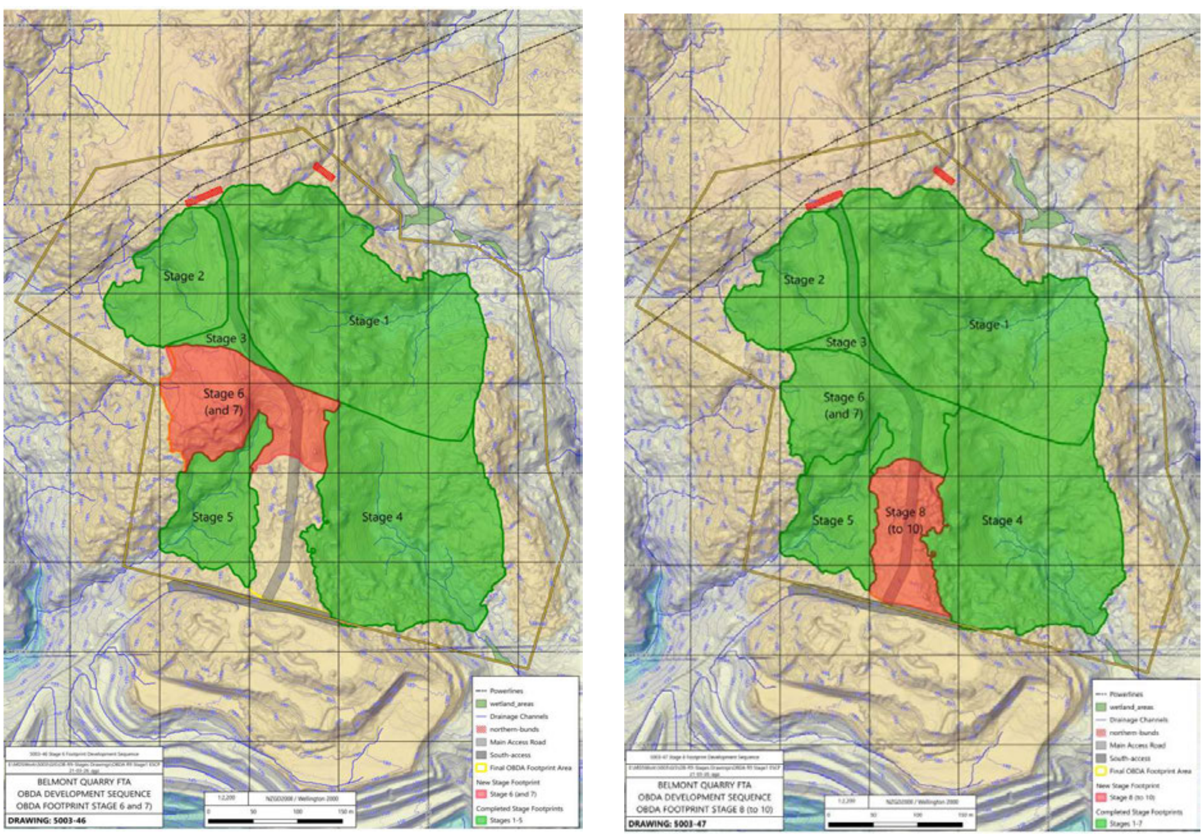

Figure 5.8: Stages 6-10 are on the interfluve between the various gully heads and so will have negligible effect on hydrology downgradient.

5.4 Area

Any potential effects of developing the OBDA on the hydrology and runoff regimes of the various streams in the area are also mitigated by the small areas subject to works at any time, and the fact that the footprint for the OBDA lies within a wider property extent.

For example, Stage 1 is located within sub-catchments OBDA-2 and OBDA-5, with a total footprint of 5.71ha (***Figure 5.9*** & ***Table 5.2***). This comprises approximately 91% of the catchment area upstream of the property boundary. These sub-catchments are the headwater gullies of the stream labelled FB4 in this report. The footprint of Stage 1 occupies only 13% of this catchment and this limits any potential effects which, as argued above, will be less than minor anyway. The proposed OBDA will have no effect on the hydrology and flow regime of FB4.

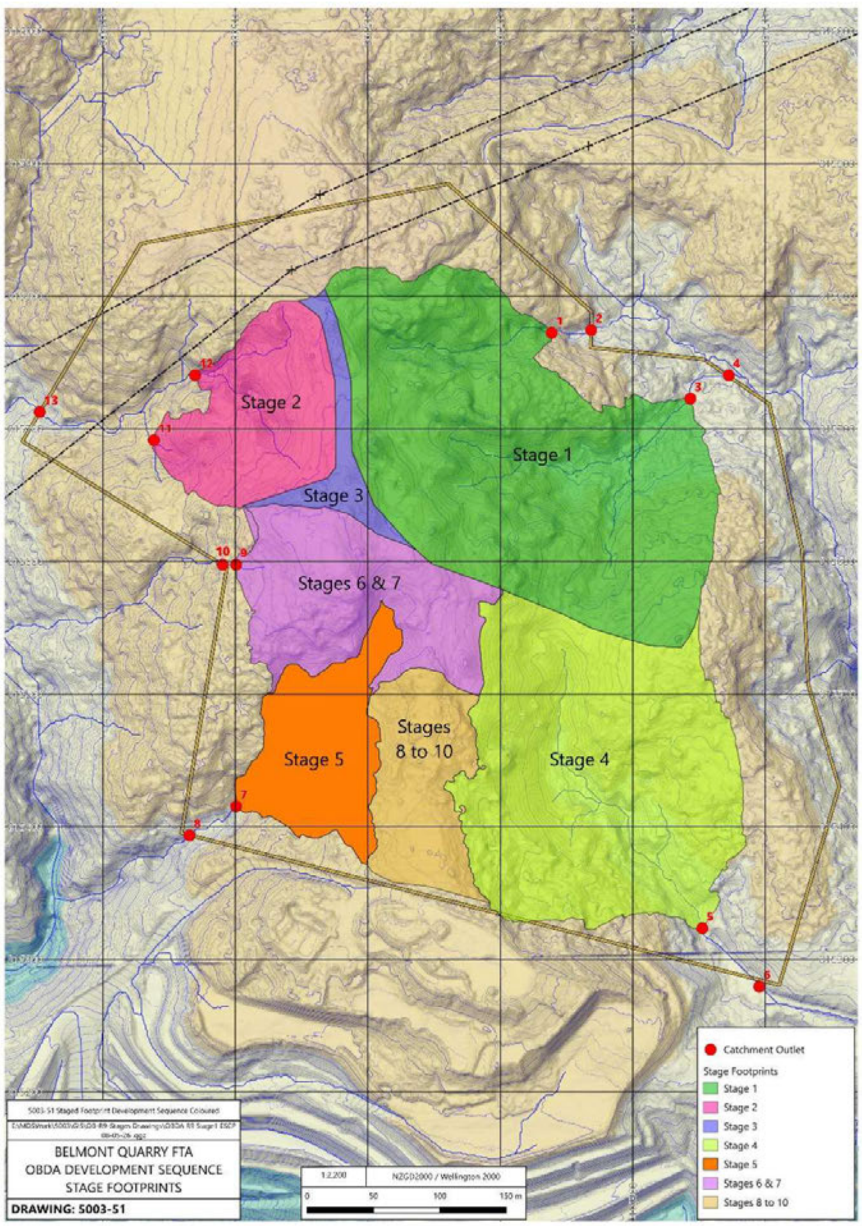

***Figure 5.9:** Various sub-catchments within each development stage. Numbers indicate the locations from which the catchment areas in Table 5.2 were derived i.e., for each sub-catchment the area above the edge of the OBDA footprint and from the OBDA boundary.*

Table 5.2: Areas of the various sub-catchments potentially affected by each stage of the development. Note: for each drainage line there are two areas, one up-gradient of the footprint and the other up-gradient of the boundary of the OBDA.

Development stage	Sub-catchment(s) affected	Area (ha)	Footprint as percentage of area to OBDA boundary	Percentage of catchment
1	1 - OBDA-2 (Footprint)	1.53		
1	2 - OBDA-2 (Boundary)	1.67		
1	3 - OBDA-5 (Footprint)	4.18		
1	4 - OBDA-5 (Boundary)	4.62	91	FB-4 -13%
2	9 – OBDA-1 (Footprint)	0.19		
2	10- OBDA-1 (Boundary)	0.22		
2	11 – OBDA-1 (Footprint)	0.69		
2	12- OBDA-1 (Footprint)	1.71		
2	13- OBDA-1 (Boundary)	4.30	57	NG-2: 8%
				Culvert: 2%
				Waikoropupu: 1.5%
4	5 - OBDA-4 (Footprint)	5.73		
4	6- OBDA-4 (Boundary)	6.14	93	FB-4 -13%
5	7 – OBDA-3 (Footprint)	2.89		
5	8- OBDA-3 (Boundary)	3.18	91	NG-2: 8.9%
				Culvert: 2.5%
				Waikoropupu: 1.7%
	NG-2	32.5		
	NG-culvert	114		
	Waikoropupu Stream	170		
	FB-4	43		

Stage 2 is located entirely in OBDA-1. The footprint of Stage 2 occupies only 57% of the catchment area upstream of the property boundary. Any effects on the hydrology and flow regime, which will be negligible, will be moderated and attenuated with increasing distance down the catchment and with increasing catchment area. The area affected by Stage 2 will be only 8% of catchment of the tributary of Waikoropupu Stream labelled NG-2. Assuming that flow is proportional to catchment area, any effect within the footprint of the Stage 2 would not be able to be measured, even using industry best practices. At the culvert under the existing haul road to the Cottles OBDA, the area of

Stage 2 is only 2% of the area upstream, and only 1.5% of the Waikoropupu catchment (***Figure 5.9*** & ***Table 5.2***).

The footprint of Stage 4 is 93% of the catchment area upstream of the property boundary, and only 13% of the catchment area of FB4 (***Figure 5.9*** & ***Table 5.2***).

The footprint of Stage 5 is 91% of the catchment area upstream of the property boundary in the affected sub-catchment. The area affected by Stage 5 will be only 8.9% of the catchment area of the tributary of Waikoropupu Stream labelled NG-2. Assuming that flow is proportional to catchment area, any effect of Stage 5 would not be able to be measured, even using industry best practices. By the culvert under the haul road to the Cottles OBDA, the area of Stage 5 is only 2.5% of the area upstream, and only 1.7% of the Waikoropupu catchment (***Figure 5.9*** & ***Table 5.2***).

As discussed above, because of how the OBDA will be constructed, any effects on the hydrology and flow regimes of the headwater gullies and streams will be negligible. Any extremely small effects will be moderated and attenuated within increasing distance downgradient of the footprint of the OBDA. The small footprints of the various stages, especially relative to the catchments into which they discharge, and the staging proposed for the development of the OBDA, mean that any effects on the hydrology and flow regimes of the stream draining the area will be negligible. Any effects will be so small that they will not be able to be measured. In my opinion therefore, any effects of the proposed development of the OBDA will be 'less than minor'.

6.0 Monitoring

As discussed, there are few hydrological data or metrics relating to the baseline environment within the proposed OBDA. Consequently, this hydrological assessment is underpinned by clear and unambiguous hydrological principles and processes, which are widely understood and agreed. The location of the proposed OBDA, and its manner of development and operation, mean that these principles provide a robust framework for assessing the potential effects of the OBDA on hydrology, hydrological processes, and hydrological effects.

The principal driver of the hydrological processes is rainfall, which will not be affected by the development of the OBDA. Winstone Aggregates have maintained a rain gauge and climate station above the Belmont Quarry since 2009. Consequently, there are over 15-years of excellent, high-resolution data that can be used to characterise the rainfall, temperature and wind conditions affecting the site. These climate data provide the context when considering any potential effects of the OBDA on hydrological processes.

Because of the environment, all potential hydrological metrics are small and subject to significant spatial and temporal variability. Consequently, the magnitude and range of any potential metrics are generally within the accuracy, resolution and uncertainty of the relevant measurement device i.e., any change caused by the OBDA is unlikely to be quantifiable.

In my expert opinion, the lack of any significant potential hydrological effects, limited baseline hydrological data, the relatively short period over which any small sub-catchment might be affected, and the magnitude and natural variability of hydrological metrics limit any value from a Hydrological Monitoring Plan.

The principal concern appears to be the potential ecological effects of any change in the hydrological processes, rather than the hydrological metrics themselves. In my opinion, the extremely small potential effects caused by the OBDA on hydrology can therefore best be assessed through the Ecological Monitoring Plan. This will provide the most robust, practical, and pragmatic means of assessing any small hydrological effects of the proposed OBDA.

Given the interest and concern regarding the wetlands, and particularly swamp maire, the Ecological Monitoring Plan could include the installation of a shallow (1m) slotted PVC standpipe and water level recorder within the most upstream wetland in each of the drainage lines down-gradient of the OBDA. A water level recorder should also be installed adjacent to the 'pond' on the Firth QEII boundary. These sensors should be installed as soon as practical and remain in place for one year after all works associated with the OBDA in the upstream sub-catchment have been completed.

The water level in each wetland should be recorded at an interval of no longer than one-hour. The summary statistics of each water level record, including the maximum, minimum, mean, median, standard deviation can be compared to those over the length of record to identify any significant changes in behaviour and conditions. This monitoring would also confirm the results of this hydrological assessment.

If any departures from longer-term conditions are identified, which are not related to climatic variation, the causes of these changes can be investigated and changes implemented to the stormwater and erosion and sediment control devices to promote 'natural' conditions.

In my expert opinion, the final draft conditions of consent recognise and reflect the above recommendations appropriately. The implementation of these conditions will confirm that any effects of the development of the OBDA on hydrological processes are 'less than minor'.

7.0 Conclusions

The proposed OBDA will be approximately 15.7ha and lie within a 23.86ha area located on the interfluve (catchment divide) between five small headwater gullies. It is anticipated that the OBDA will accommodate approximately 2.8 million cubic metres of overburden, including topsoil, subsoil, weathered greywacke, and process & pond fines over a 40-year operational period. The OBDA will be established and constructed across 10 stages, although only four of these stages have any potential to affect the hydrology and flow regime of the small watercourses which drain the area.

There are several factors which mean that the effect of developing the OBDA on hydrology and runoff processes in the area and adjacent catchments will be extremely small, but likely positive. These include:

- The relatively small footprint of the proposed OBDA (~15.7ha).
- The distance and area between the footprint of the OBDA and Belmont Regional Park (over 8.2ha). This will act as a buffer that will moderate and attenuate any small effects of the OBDA on hydrology and hydrological processes, should they occur.
- The OBDA being located largely on the interfluve between five small headwater gullies.
- Limited surface runoff in the area, except possibly during intense or prolonged rainfall over highly modified surfaces.
- The small percentage of each sub-catchment potentially affected by the OBDA.

- The staged development of the OBDA, with specific stages affecting only small discrete sub-catchments i.e., the stage boundaries are coincident with sub-catchment boundaries.
- Each stage generally only effects one sub-catchment, although two in the case of Stage 1.
- The lack of any cumulative effects, since each stage will be rehabilitated, from a hydrological perspective, prior to work on the next stage commencing.
- Progressive development of the OBDA over 40-years.
- Experience with the current Cottles OBDA which provides a real-world analogue for how runoff from the site can be managed to avoid any adverse hydrological effects.

It has been shown at the Cottle's OBDA that, by adopting the principles outlined in the Geotechnical and ESC assessments for this project, it is possible to maintain both surface and subsurface flow, the existing flow regime, and existing water quality. The design and construction of the new OBDA, in the manner proposed, and by implementing the principles and methodologies suggested, will ensure that the existing hydrological processes are maintained, including both surface and subsurface flow. The current discharge into each of the various drainage lines beyond the OBDA will continue.

The infilling of a gully does not need to stop, or even alter significantly, all runoff and hydrological processes. Any rainfall over the area, above evapotranspiration and storage requirements, will still runoff either over the ground surface or via sub-surface drainage. Using the principles and methodologies discussed above, and as shown at the Cottle's OBDA, it is possible to control subsurface drainage to maintain existing flow paths, to separate clean and dirty surface flow, to discharge clean water into original flow paths, and to treat dirty water to avoid the discharge of sediment.

Since the existing hydrological processes will be maintained within the OBDA, including both surface and subsurface flow, and discharge into each of the various drainage lines within the OBDA will continue, the hydrology of any wetlands downstream of the OBDA will likely be unchanged. The only wetland that will be affected adversely, from a hydrological perspective, by the proposed development is that located within the footprint of the OBDA.

A significant distance is proposed between the footprint of the OBDA and the boundary with Belmont Regional Park. It is my opinion that, once the principles within the Geotechnical and ESC assessments are implemented, any effects of the development of the OBDA will be negligible. There will be no measurable adverse effects on hydrology or hydrological processes beyond the boundary of the OBDA. Any effects can therefore be considered 'less than minor'. This will be confirmed by monitoring water levels within the first wetland in each drainage line downgradient of the OBDA.

In my expert opinion, the final draft conditions of consent recognise and reflect the recommendations from this technical report appropriately. The implementation of these conditions will confirm that any effects of the development of the OBDA on hydrological processes are 'less than minor'.

8.0 References

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