

Stormwater Management for the Regeneration of the Three Kings Quarry

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Three Kings

Quarry Development

Part A: Introduction

A background to the development



Te Tātua Riu ki uta



Kinder watercolour of the Three Kings



BEAUTIFUL AUCKLAND PROPERTY PURCHASED FOR STATE HOUSING

Scenes on the Wesley Trust Estate, Three Kings, which has been purchased by the Government for the erection of about 600 houses. It is hoped that the hundreds of fine trees, planted while the Wesley Training College occupied the property between 1848 and 1922, will be preserved. The upper view shows the remains of the first college buildings. The Big King, 440ft. high, appears in the lower photograph.



Aerial Photograph of Three Kings Quarry Site (Date: 1955)

Quarrying
and housing
development
1940s



The Quarry
surrounds



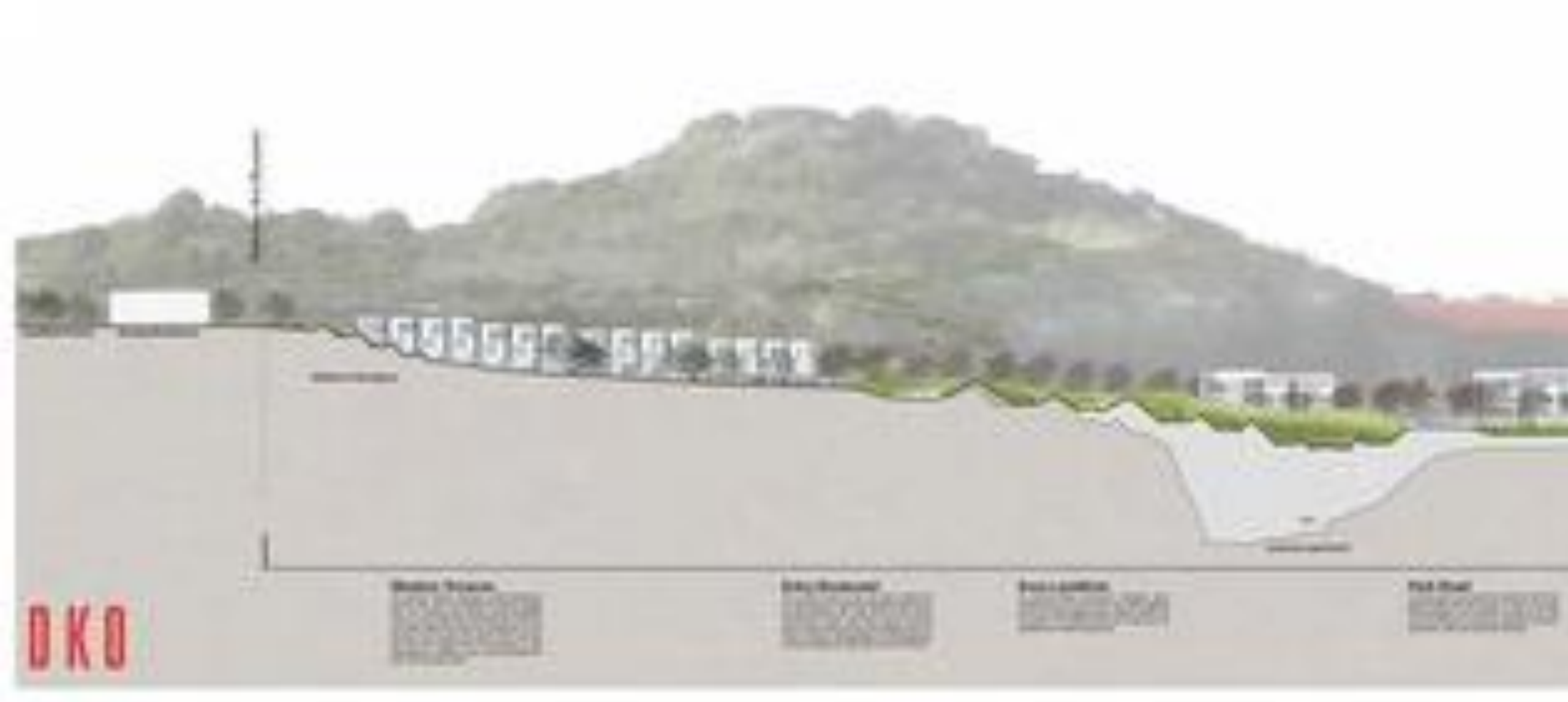
The Quarry

Three Kings
today



Masterplan vers 22B, Sept 2017





Section west to east

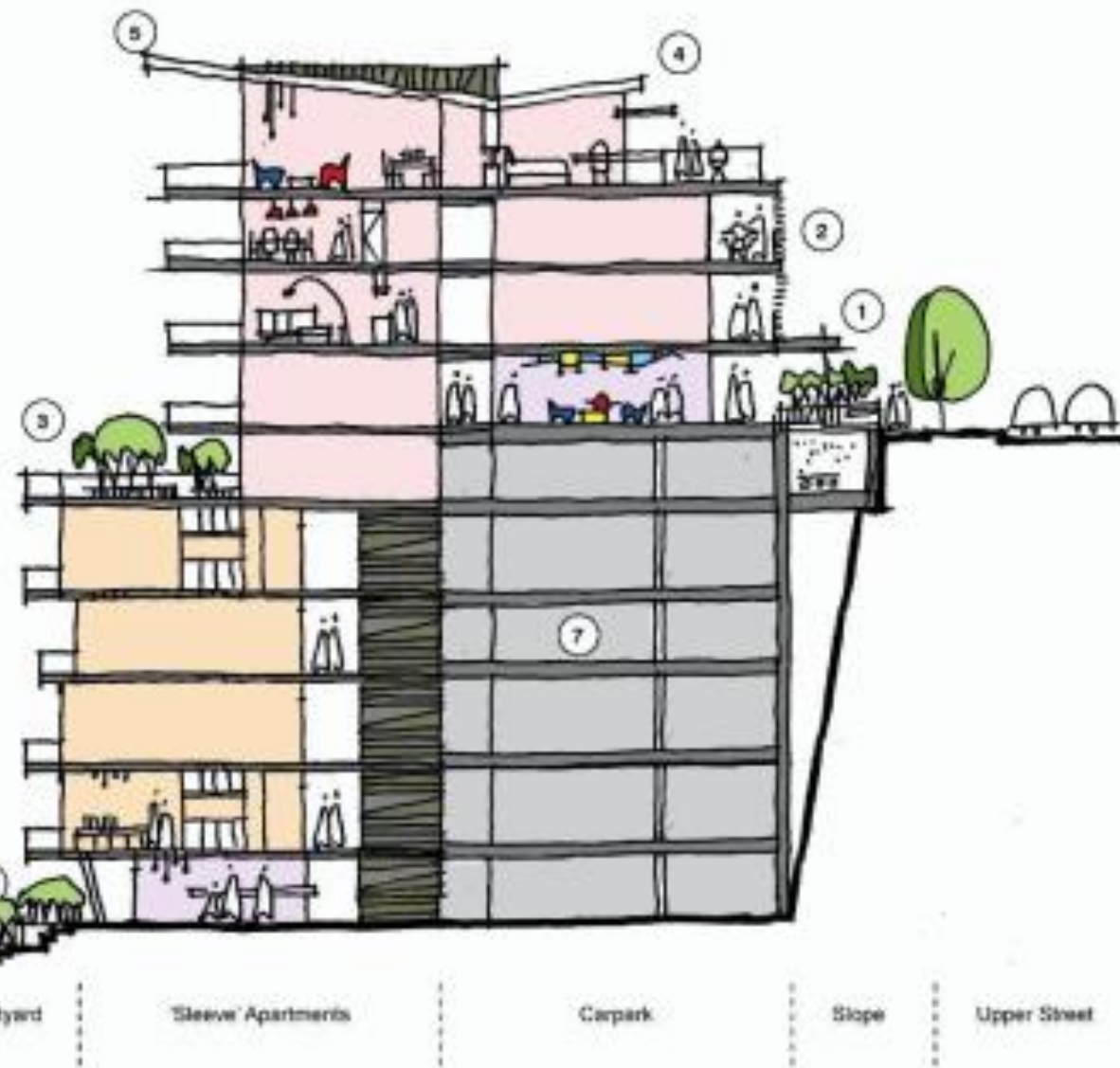


Section west to east

Cascading Apartments

LEGEND

1. Upper Level pedestrian entry
2. Balconies and living spaces activate the facade and provide passive surveillance of open spaces
3. Landscaped podium-top
4. Top floor apartment setback from bottom levels
5. Floating roof element
6. Lower level pedestrian entry
7. Carpark and service spaces built against slope



Section through proposed cascading apartments

Tatua on Eden

Onyx Apartments



In this established neighbourhood you're spoilt for choice! With great transport links on your doorstep, the CBD is within 6km from home and you'll enjoy easy access to cafes, restaurants, schools,

The kitchen is complete with quality Fisher & Paykel appliances including an integrated fridge, Caesarstone benchtop and lacquered & laminate cabinetry.

The two bedroom apartments offer two

Part B: Concept

Soakage and geology

Why use Soakage?

2000 MIN

Ground level

Cast iron lid and frame -heavy duty in road reserve/ public and sealed areas -standard duty elsewhere

1500 Min

BOUNDARY

uPVC sewer grade pipe, sized from Table A.

-Runoff from roof areas must pass through a settling device. Refer to Drawing 09.

-If the total paved area exceeds 20m², site runoff must be pre-treated. Refer to Drawings 07, 08, 10.

Notes :

- All dimensions are in mm (unless otherwise specified).
- Depth will vary depending on type of ground encountered.
- If rock is deeper than shown, then construct manhole on standard precast base.
- The drilled bore is to be positioned under the MH access for ease of cleaning.
- ARC requirements:-
Where 1000m² or more of impermeable area is to be drained to ground soakage, a Resource Consent will be required.
- Soakholes may not be located within any building or in a subfloor/basement carpark.
- Refer plan No. 12908/201 for precast manhole construction details.
- An operation and maintenance plan is required. Refer to Form SM005.

1050mm or 1200mm precast manhole riser

Grate cap

Entry head loss up to 50%

1500 MIN depth

Galvanised iron steps

Break out rock and backfill with free draining hardfill

500 MIN

1000 MIN

uPVC liner pipe grouted into rock

100mm Drilled bore MIN - number to be determined by size of development and results of test drilling. Multiple bores to be staggered in height

Table A

| MAX Catchment Area* | MIN Overflow Pipe Size (mm) | |
|---------------------|-----------------------------|--|
| 210 m ² | 100 | |
| 350 m ² | 125 | |
| 550 m ² | 150 | |
| 1000 m ² | 200 | |

* Measured as equivalent impervious area (tick)

Client : **AUCKLAND CITY**

Project : **Stormwater Soakage Design Manual**

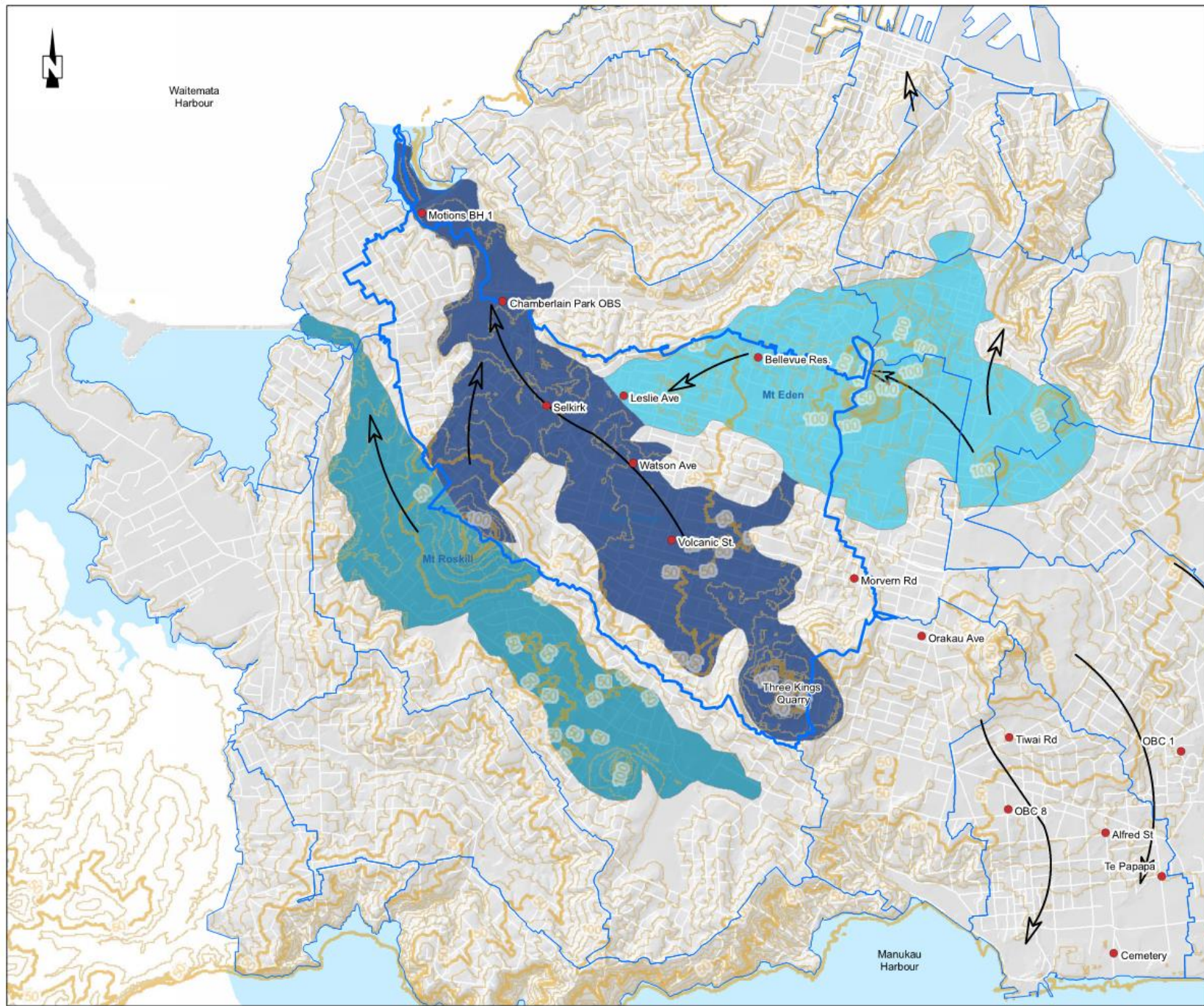
Title : **Rockbore Soakhole**

pdp partners for your development

PATILE DELAMORE PARTNERS LTD

Scale: **NTS**

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| Project No. : AJ88301 | Drawing No. : 05 | Revision : A |
|------------------------------|-------------------------|---------------------|



KEY

- Contours
- Existing Auckland Council Monitoring Bores (formerly ARC)
- Estimated Stormwater Flowpaths

Stormwater Catchments

- Meola Stormwater Catchment Boundary
- Other Stormwater Catchment Boundaries

Aquifers

- Mt Edon
- Mt Roskill
- Three Kings

SOURCE:

- STORMWATER CATCHMENT BOUNDARIES HAVE BEEN SOURCED FROM GHQ (2017).
- MEOLA CATCHMENT BOUNDARY HAS BEEN SIGNED BY POP (2016).
- EXISTING AUCKLAND COUNCIL MONITORING BORES (FORMERLY ARC) PROVIDED BY ARC (2017).
- AQUIFER INFORMATION WAS SOURCED FROM THE GLOBAL AQUIFER STUDY (POP, 2008).

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| A | ISSUED FOR CONSENT | 16/10/17 R.B. |
| NO. | REVISION | DATE APP |

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CLIENT:

Fletcher Living

PROJECT:

**THREE KINGS PRECINCT
STORMWATER MANAGEMENT
PLAN**

TITLE:

**MEOLA CATCHMENT &
GROUNDWATER AQUIFERS**

pdp solutions for your environment

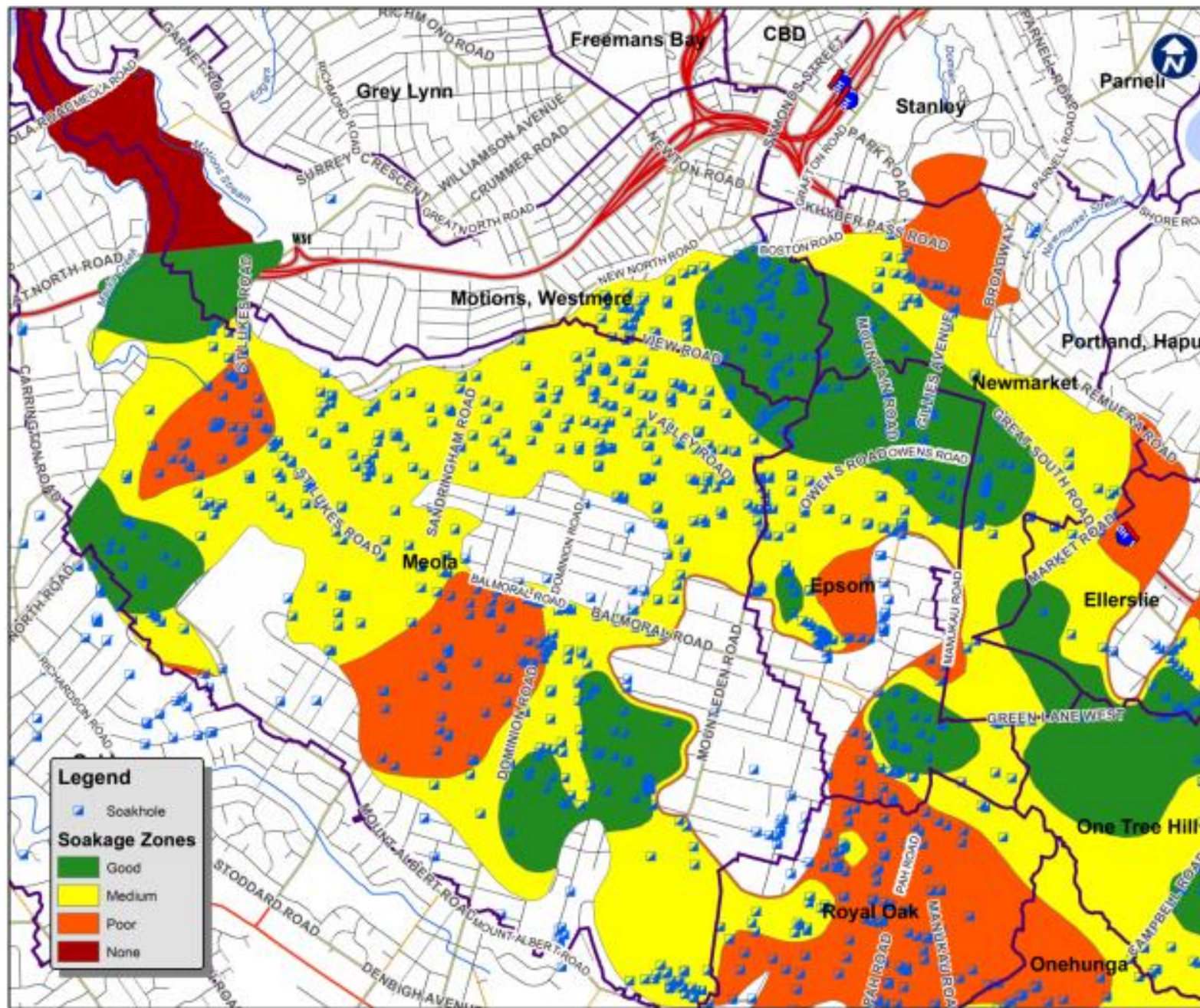
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| AJ456307 | 4 | A |

Groundwater aquifers

Figure 2: Soakage Potential in the Meola Catchment



Soakage
Potential
(after PDP
and Miselis)

Data source: Auckland Council Stormwater Asset GIS Dataset.



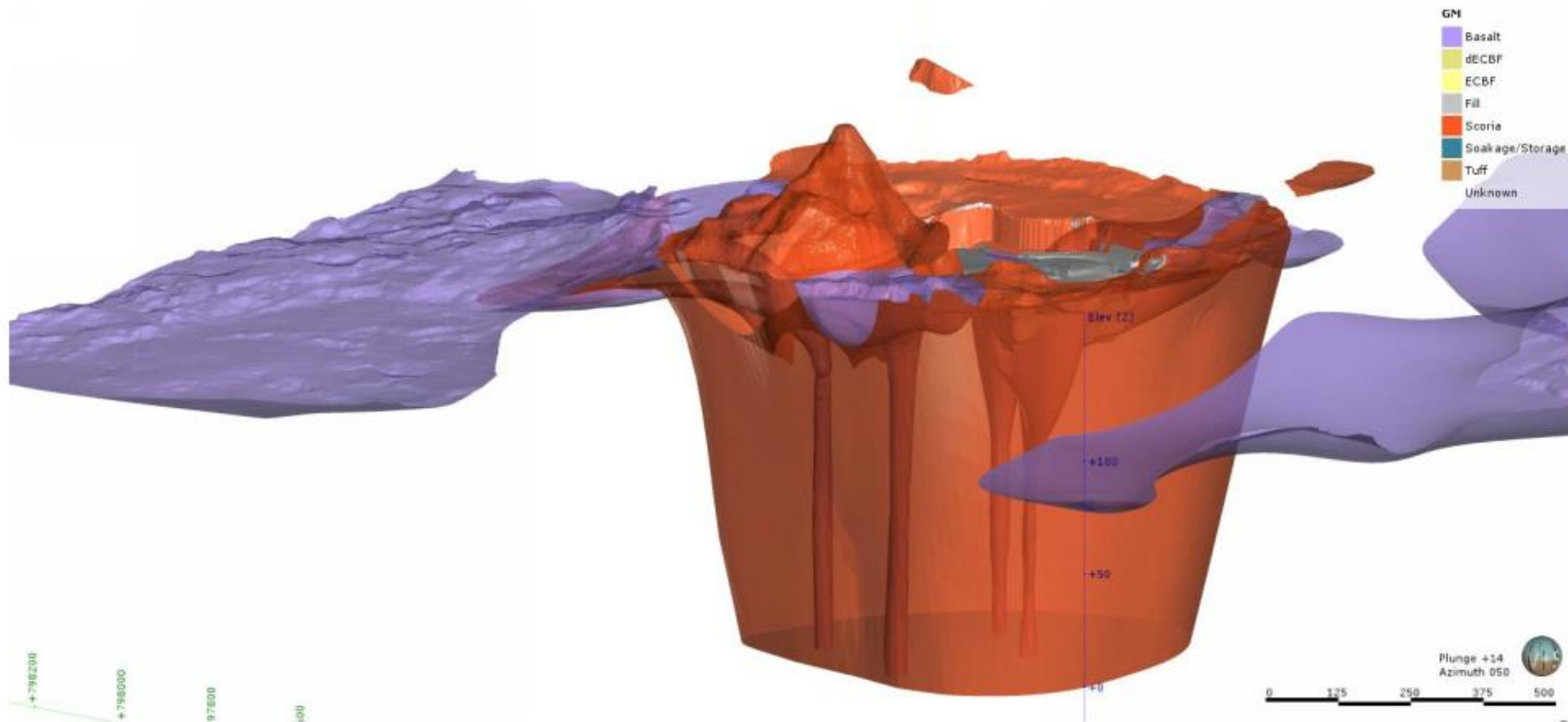
Landscape
Road Cave



Landscape
Road Cave



Geology



The Bucket

FIGURE 3A: 3D REPRESENTATION OF CRATER

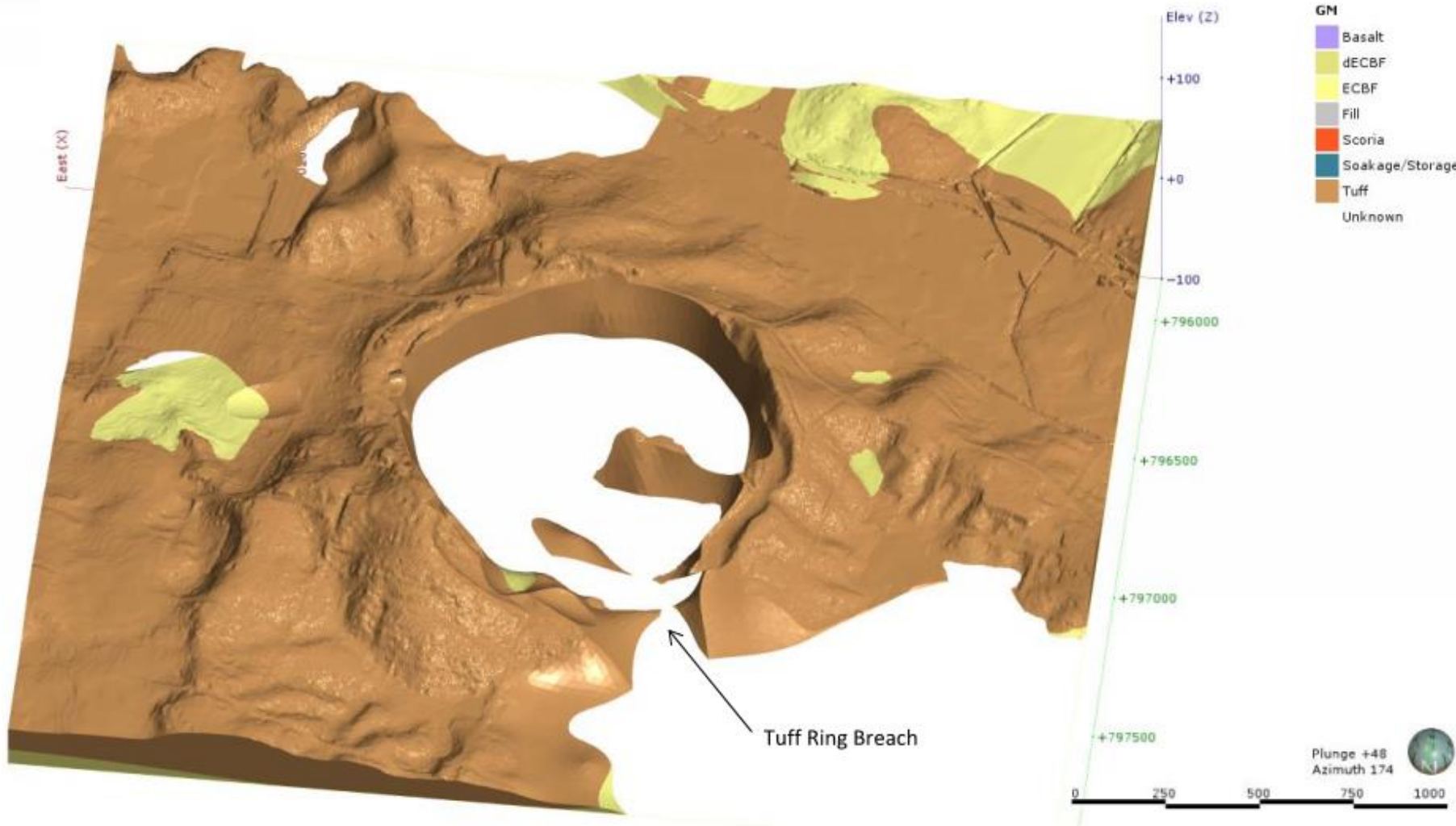


FIGURE 3C: "BUCKET" OR TUFF RING LIP ABOVE R.L. 49.0 M

The Bucket

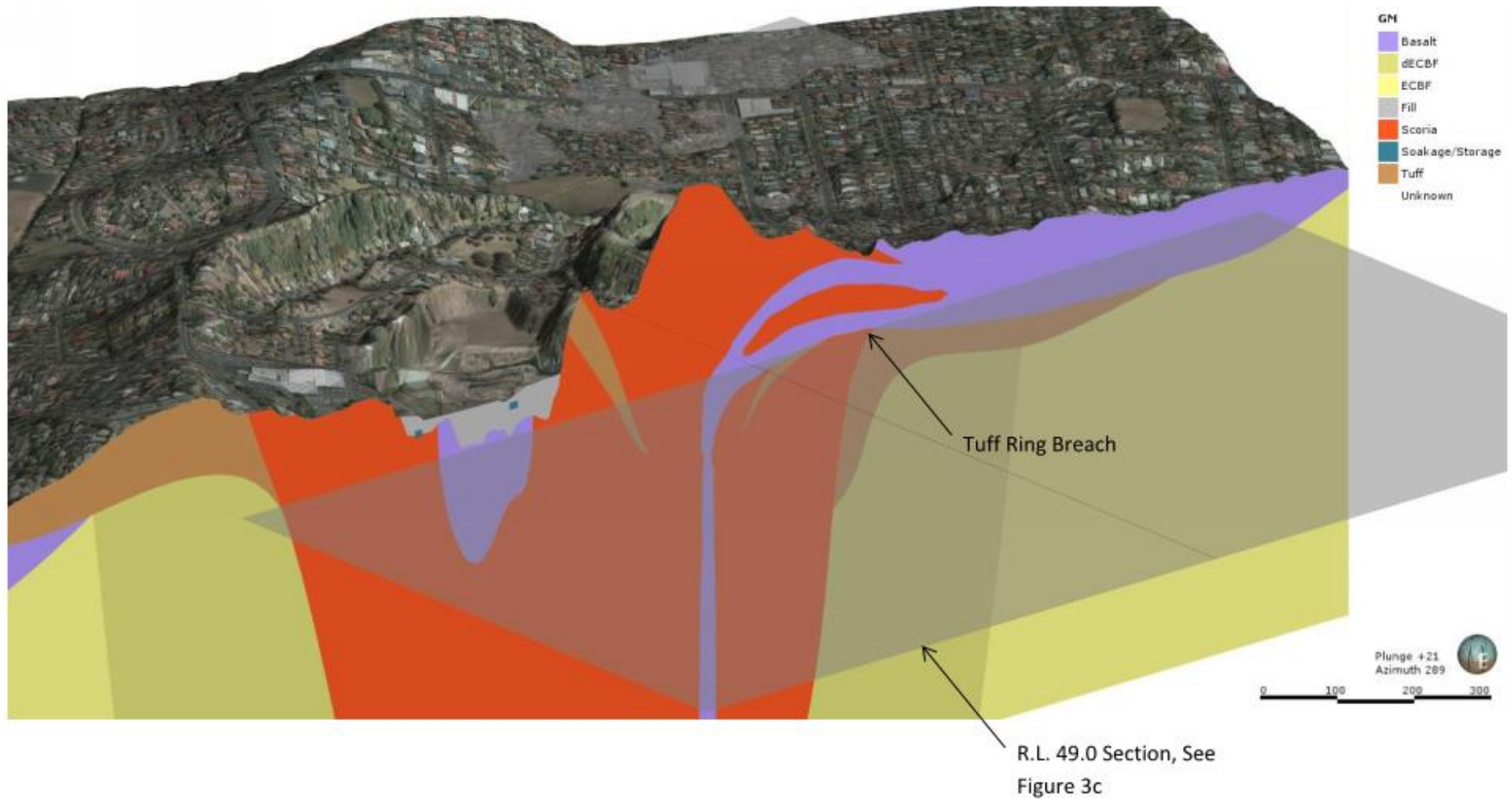


FIGURE 3B: CROSS SECTION THROUGH CRATER

The Bucket



The Design

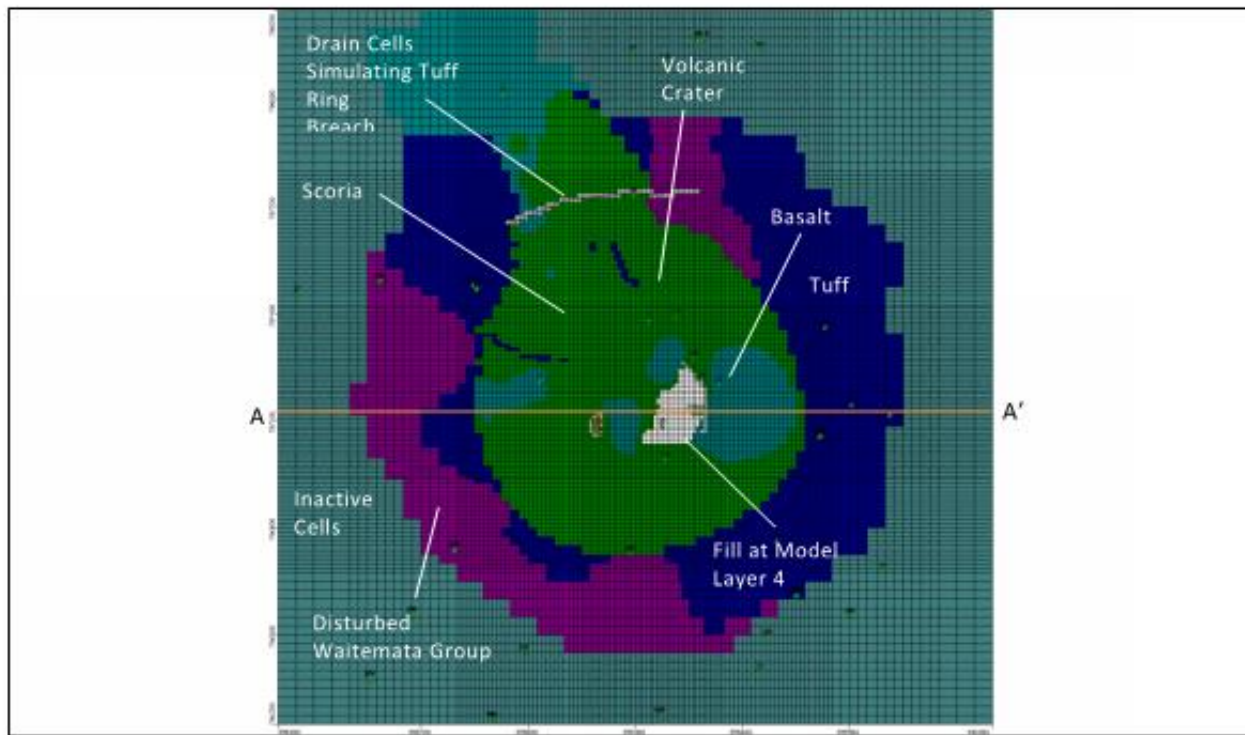
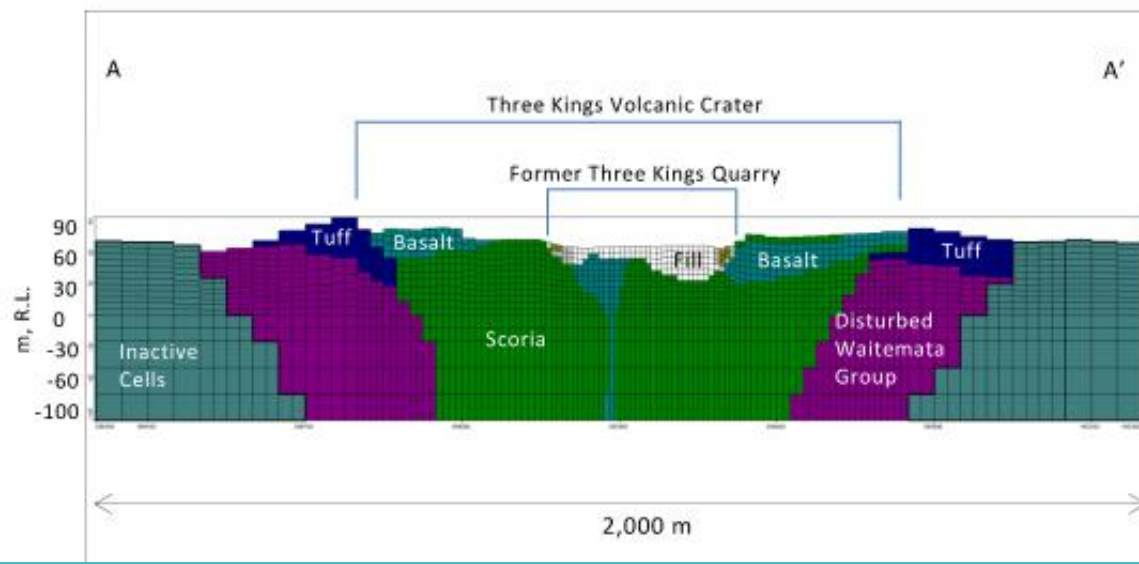


Figure D-5: Model Grid and Boundary Conditions (model layer 4)



Groundwater
model

Groundwater
model and
soakage

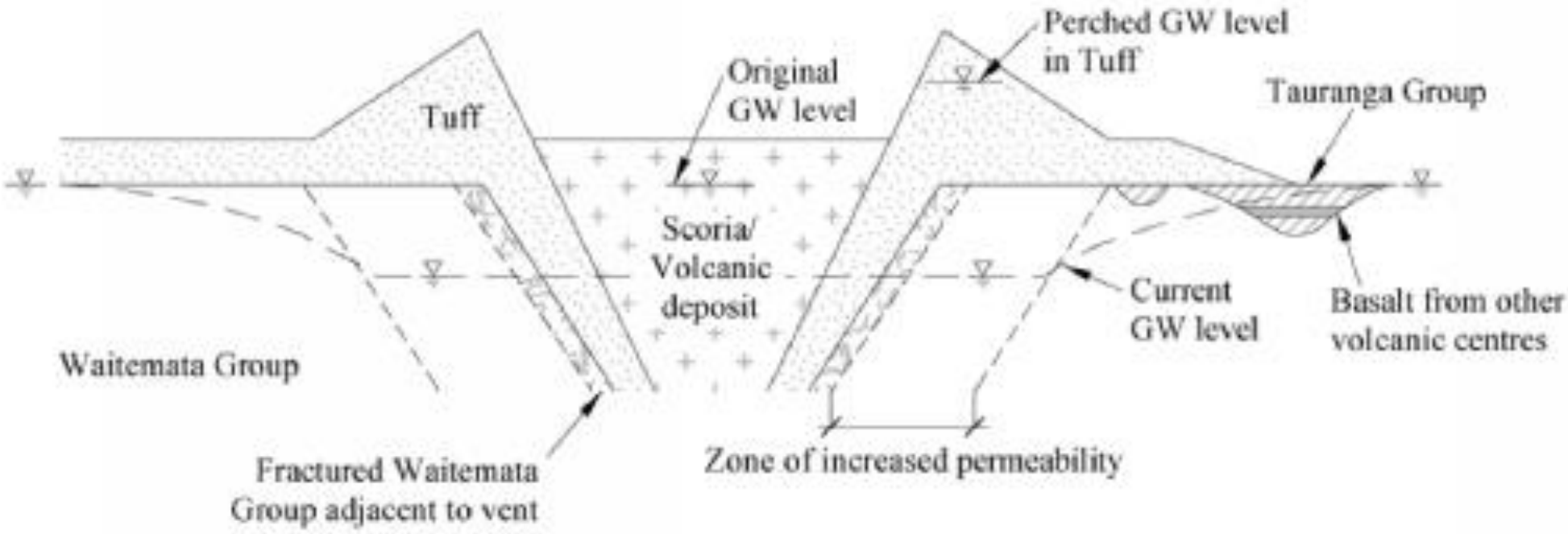


Figure D-12: Modelled Infiltration Zones (also showing Section BB')

Part C: Design Approach

Key design constraints and overall approach

Ground water levels



BH2B (Inside the cones)

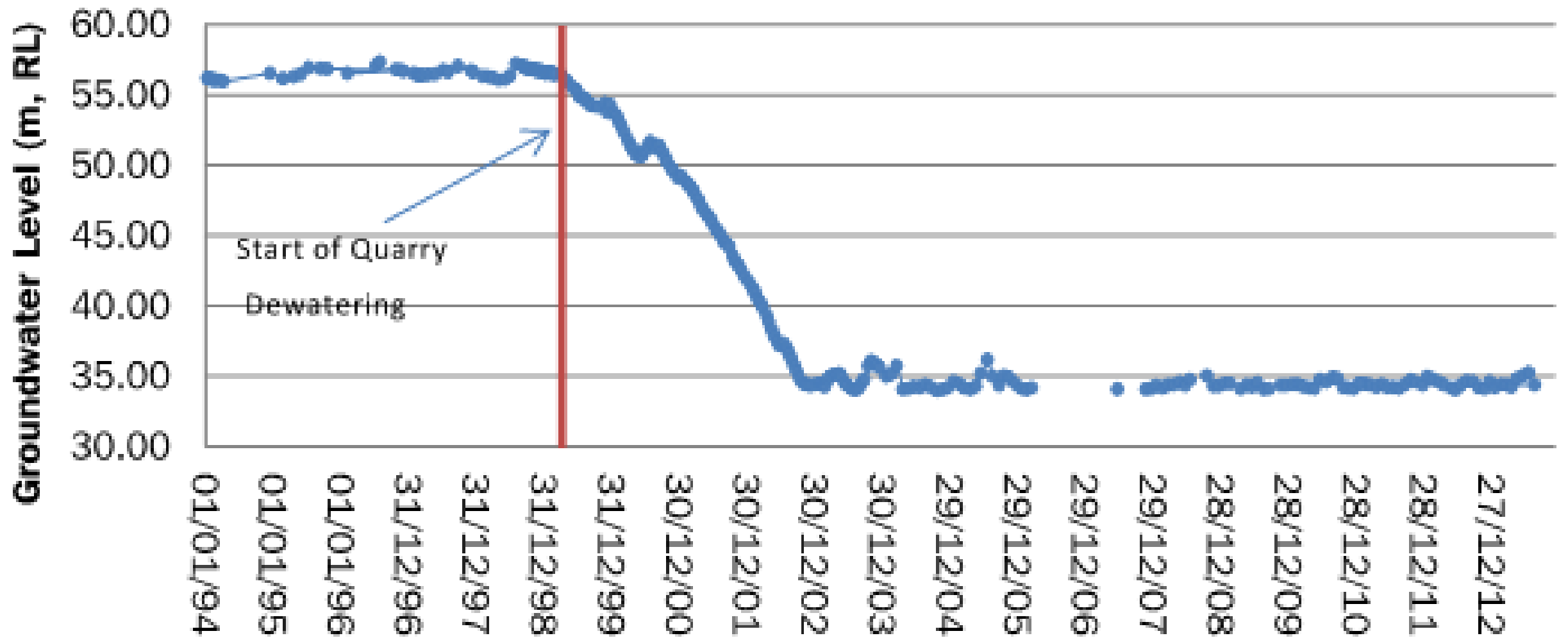


Figure D-2: Groundwater Level Hydrographs for BH2B (inside the crater)

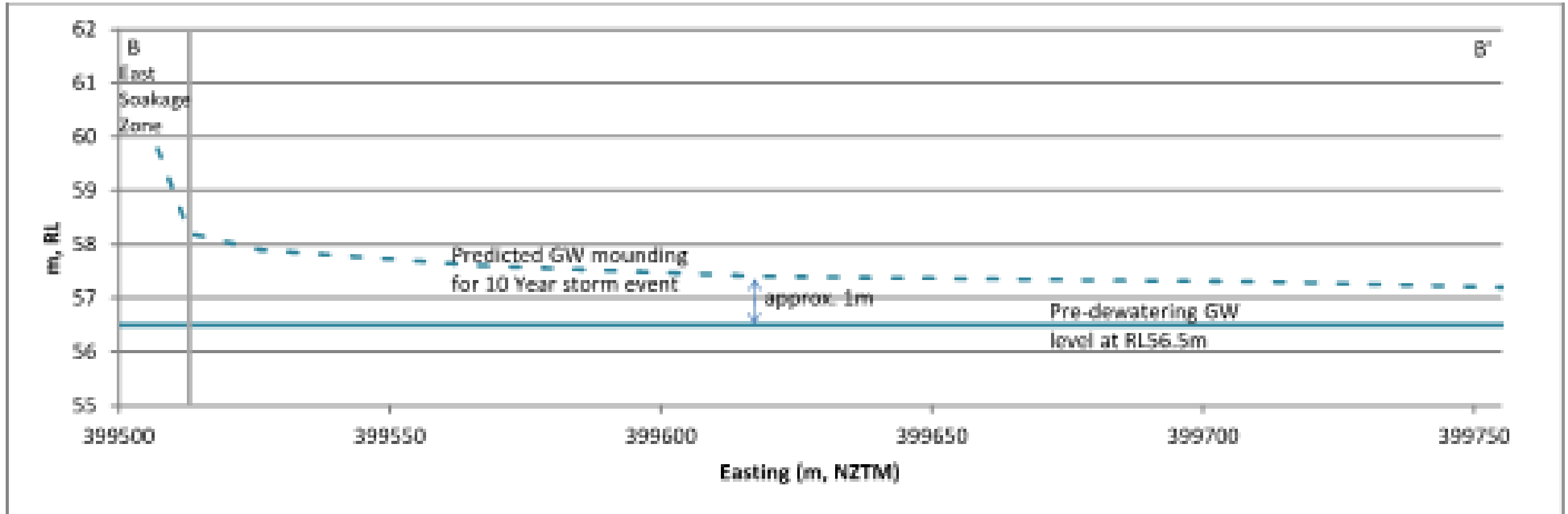


Figure D-13: Groundwater Mounding along Section BB' (Figure D-12)



KEY :

- EXISTING DEVELOPMENT
STORMWATER CATCHMENT
BOUNDARY TO SOAKAGE
- EXISTING DEVELOPMENT
STORMWATER SUB-CATCHMENT
BOUNDARY TO SOAKAGE

NOTES:

1. AERIAL IMAGERY - QUARRY AREA (FLOWN JAN 2014) SUPPLIED BY PRECISION AERIAL SURVEYS.
2. AERIAL IMAGERY - REMAINDER (FLOWN 2010) PROVIDED UNDER LICENCE FROM AUCKLAND COUNCIL WHO MAKES NO CLAIMS AS TO ITS RELIABILITY, ACCURACY OR SUFFICIENCY FOR ANY PARTICULAR PURPOSE.
3. CADASTRAL INFORMATION DERIVED FROM LINZ DATA.

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CLIENT :
Fletcher Living

PROJECT :
THREE KINGS,
STORMWATER
MANAGEMENT PLAN

TITLE :
POTENTIAL
SURFACE WATER CATCHMENTS
TO THREE KINGS DEVELOPMENT

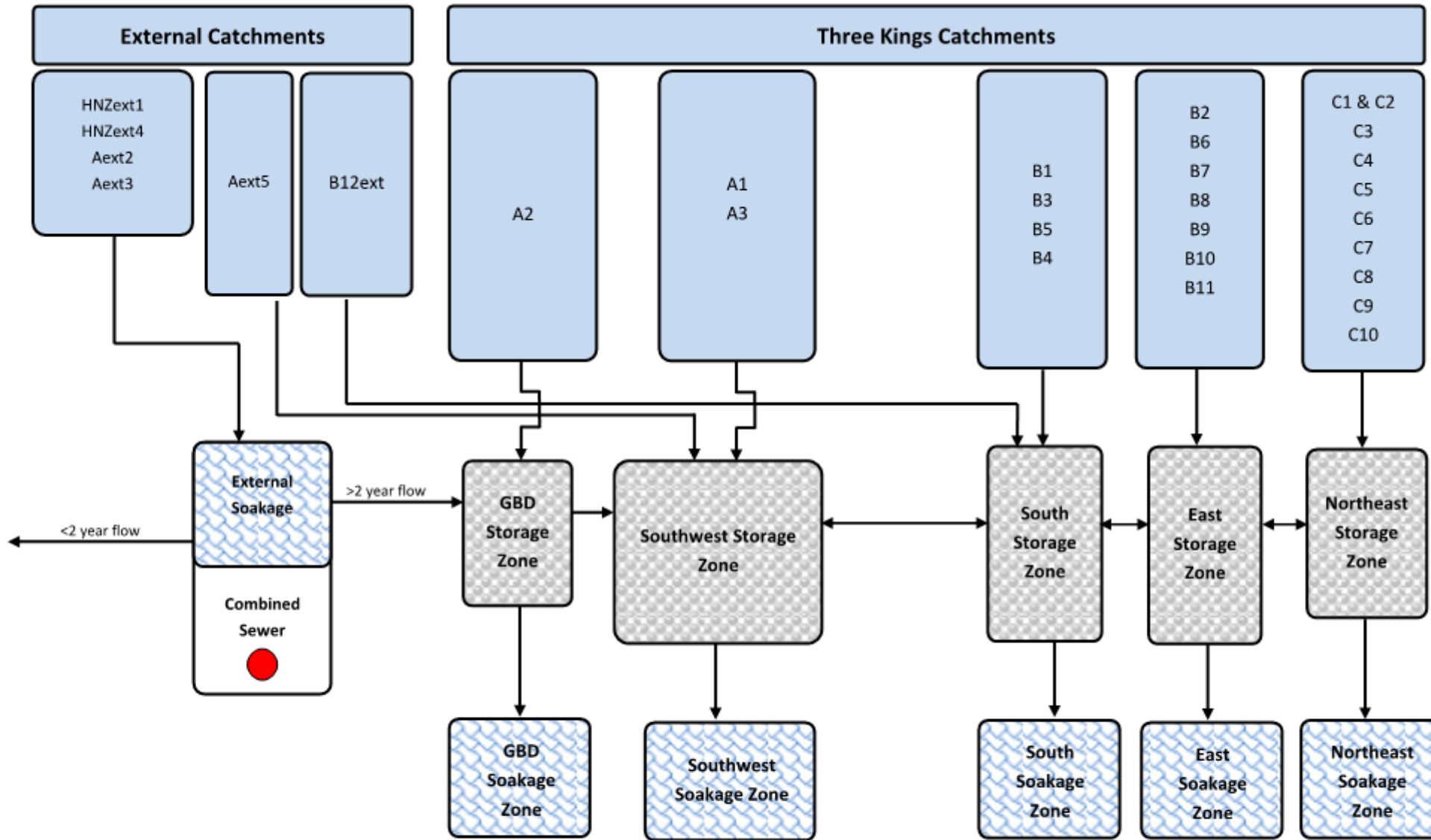


SCALE 1:4,000 (A3)

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| PROJECT NO. : AJ456307 | FIGURE NO. : 007 | REVISION : A |
|---------------------------|---------------------|-----------------|

FILED : AJ456307001_REV A.dwg IMAGE :

Catchments



Ground water levels

FIGURE 11: HEC-HMS STORAGE AND SOAKAGE MODEL SCHEMATIC

Flood Risk

Floor levels adjacent to the sports field were set based on either:

1. keeping building floor levels above the 100-year ARI flood level;
2. keeping road low points above 100-year ARI flood levels and overland flow grades; or
3. pipe drainage hydraulics above the 10 year ARI flood level and minimum required cover.

Flood Risk Scenarios

1. Regular operation of the sports fields (no ponding in the 10 year event)
2. An impaired drainage system scenario
3. Overland flow paths
4. No soakage. Storing the entire rainfall, not runoff, volume for the 100 year event
5. Two sequential 100 year events with the soakage system operating at an impaired rate
6. Consideration of the Probable Maximum Flood effects

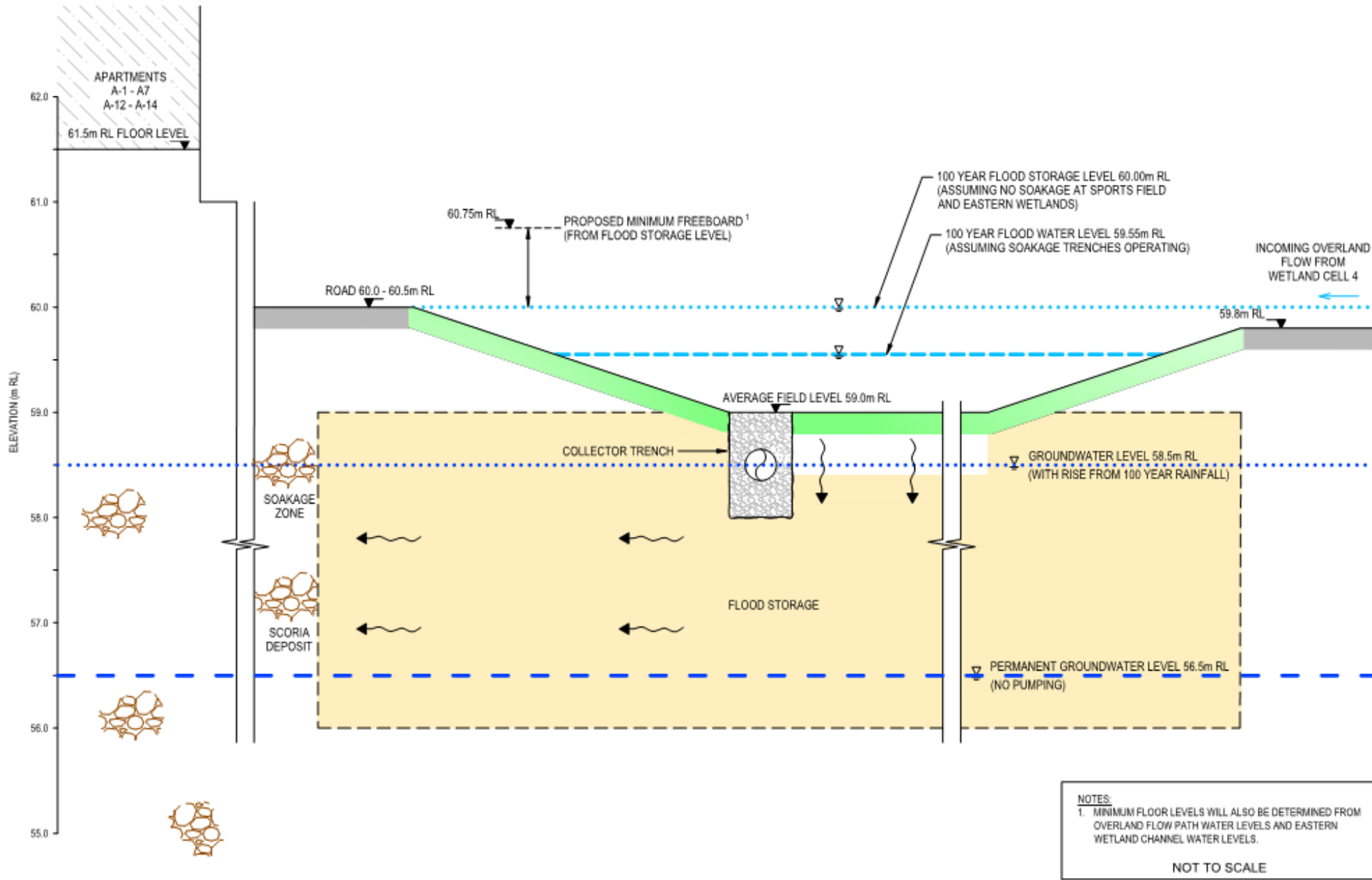
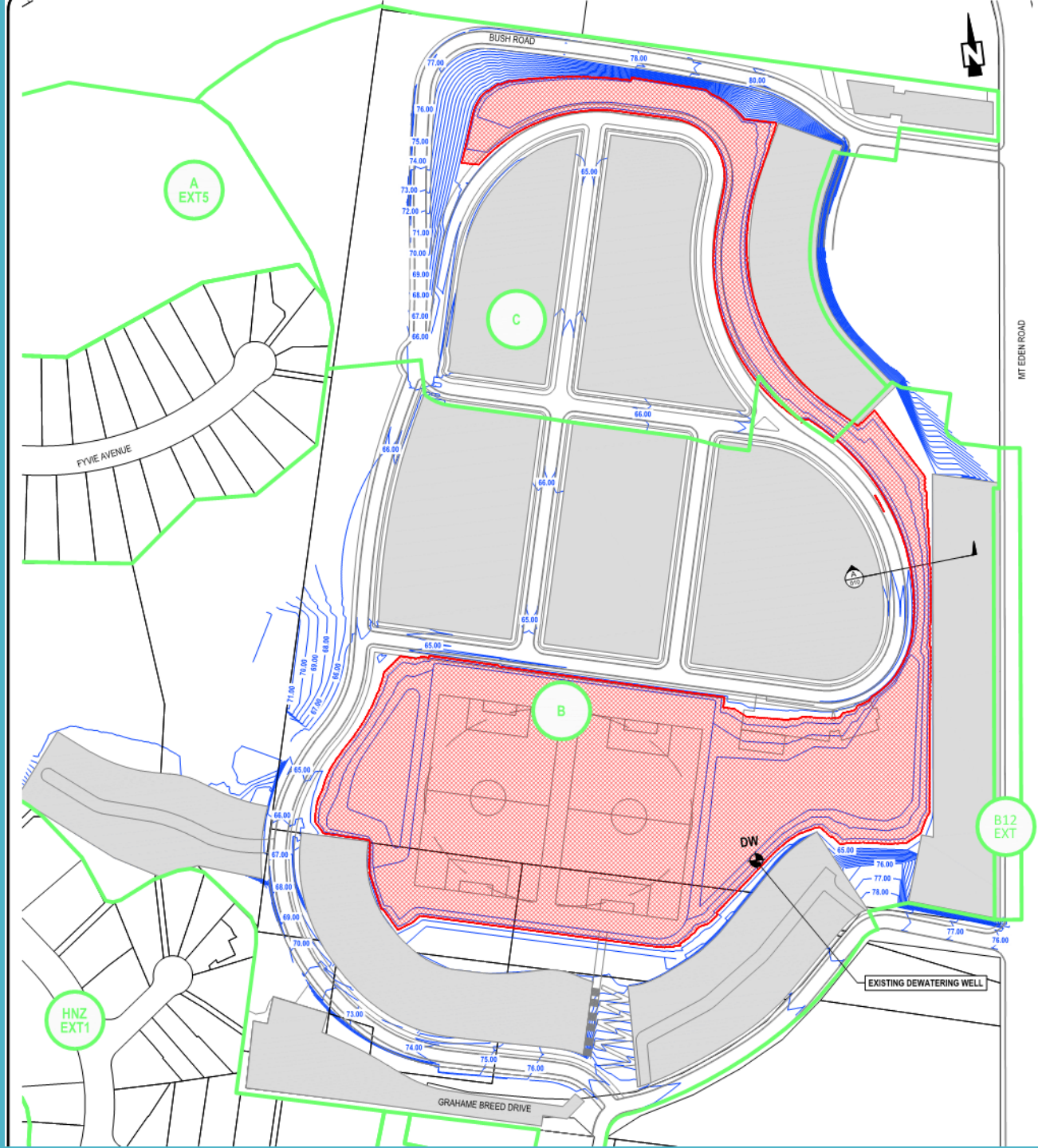
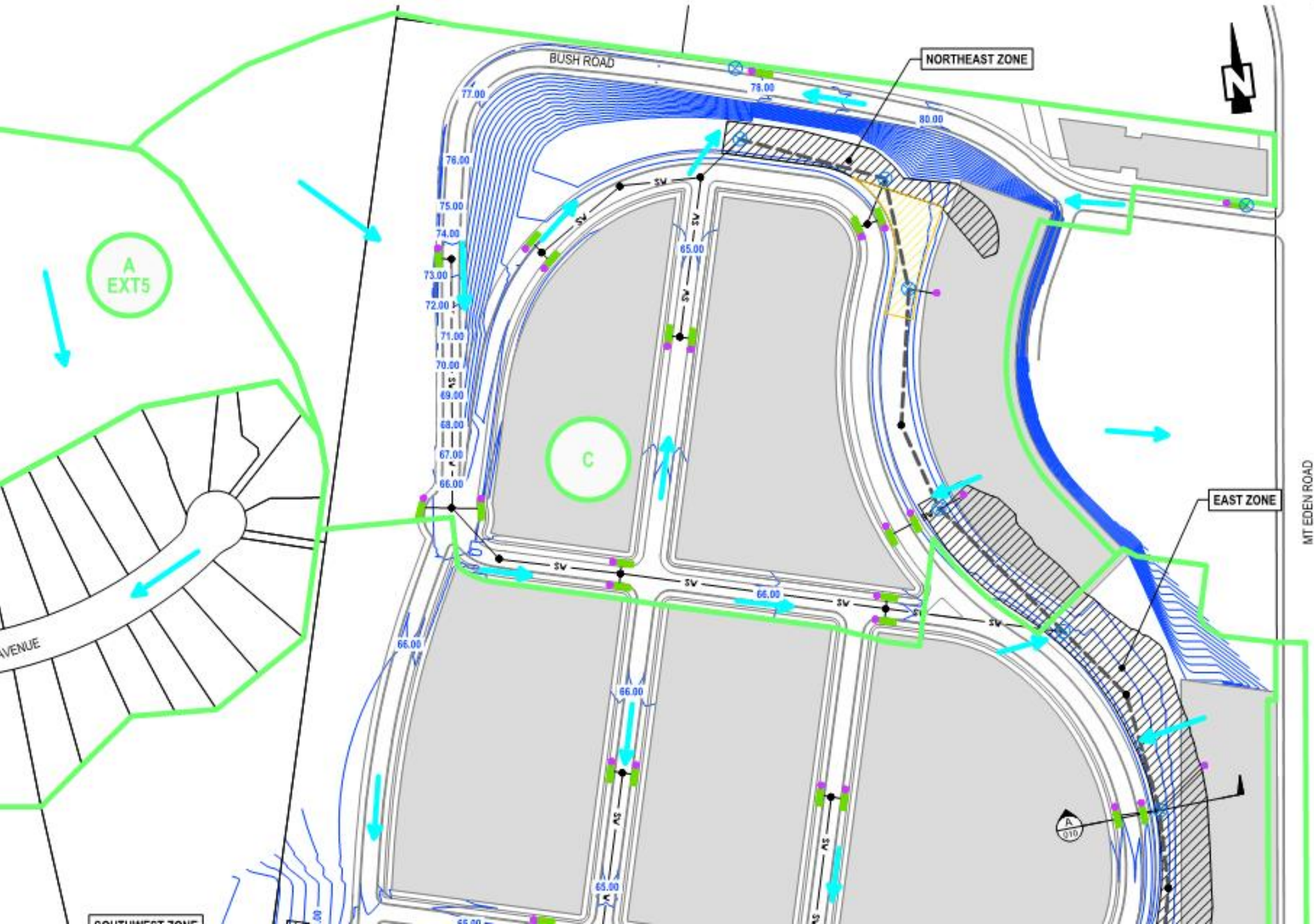


FIGURE 5 : FLOOD MANAGEMENT CONCEPT TYPICAL SECTION

The Sandwich of Groundwater and Flooding



Flood Levels

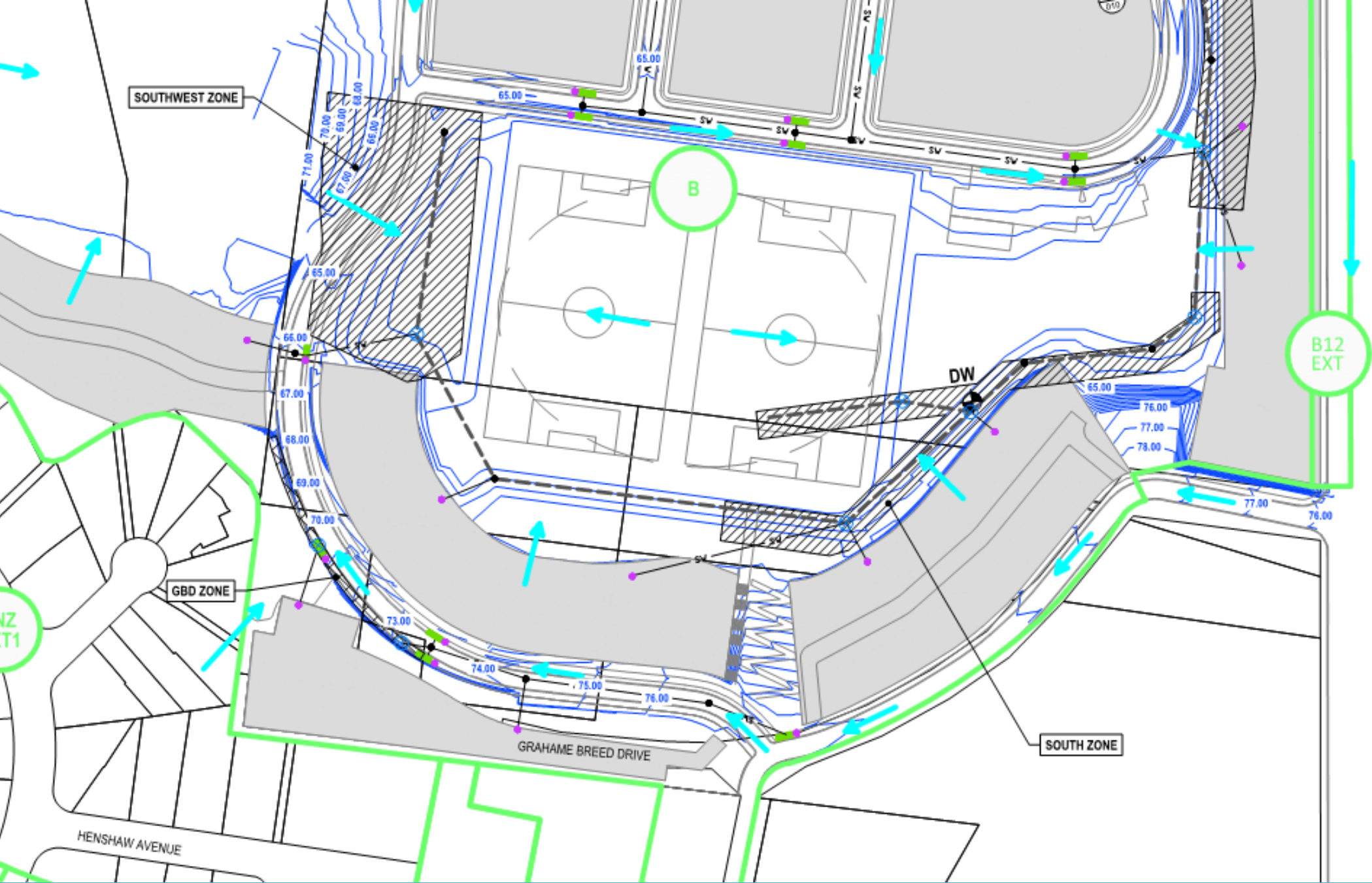


The Design

Design Approach

The drainage system operates as follows:

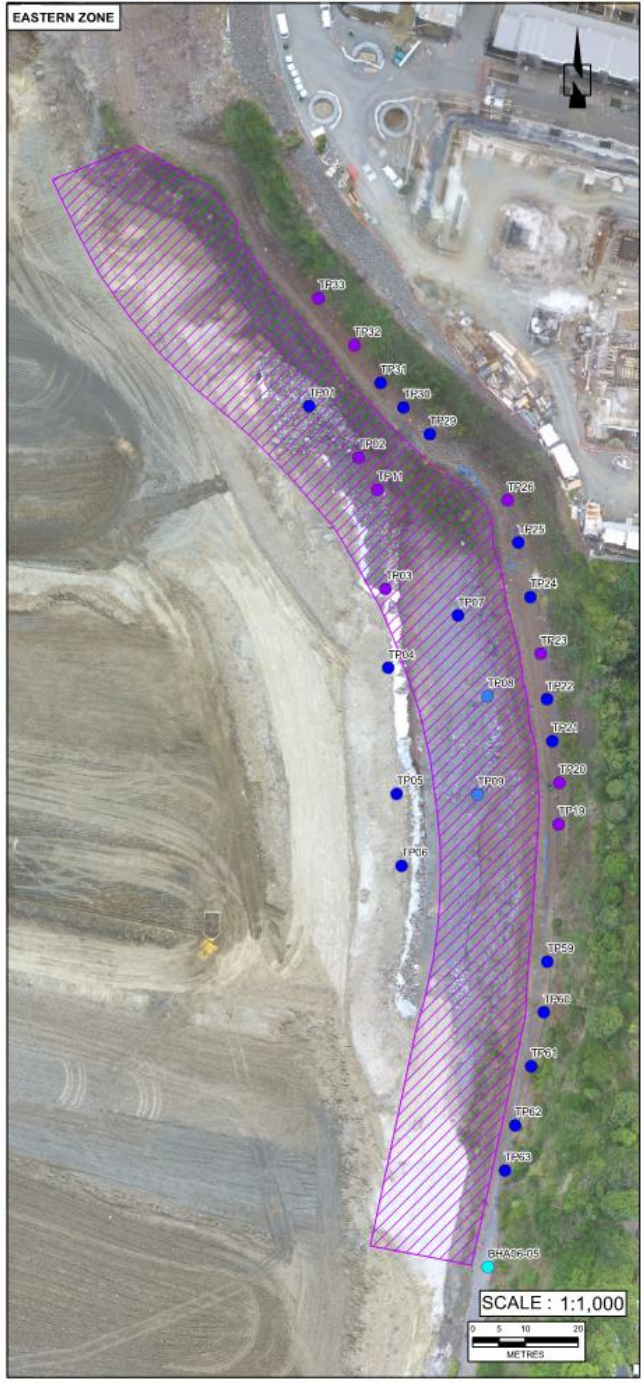
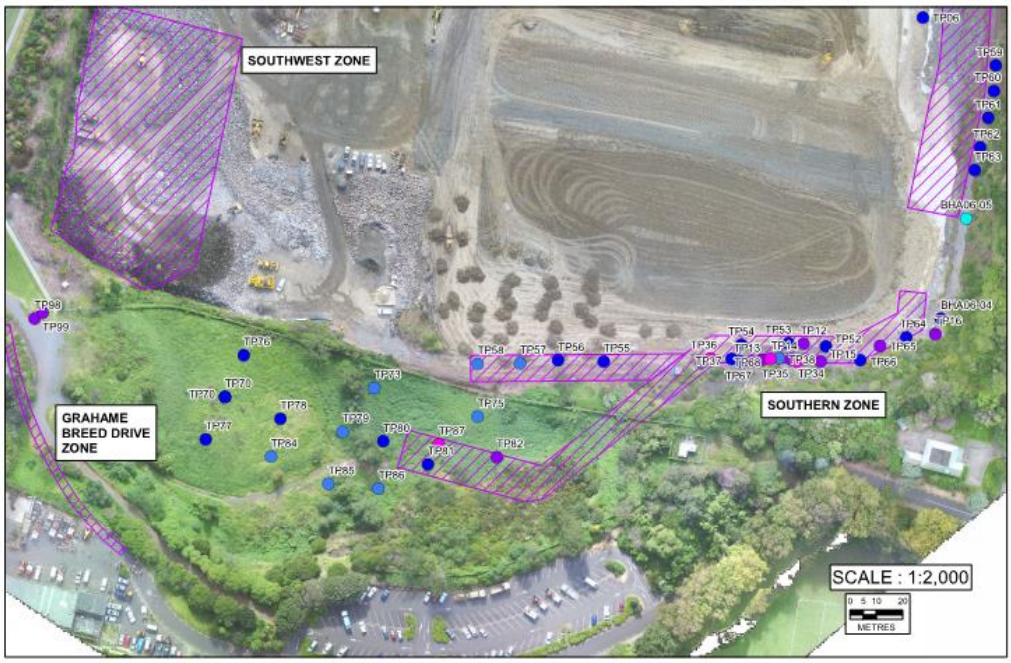
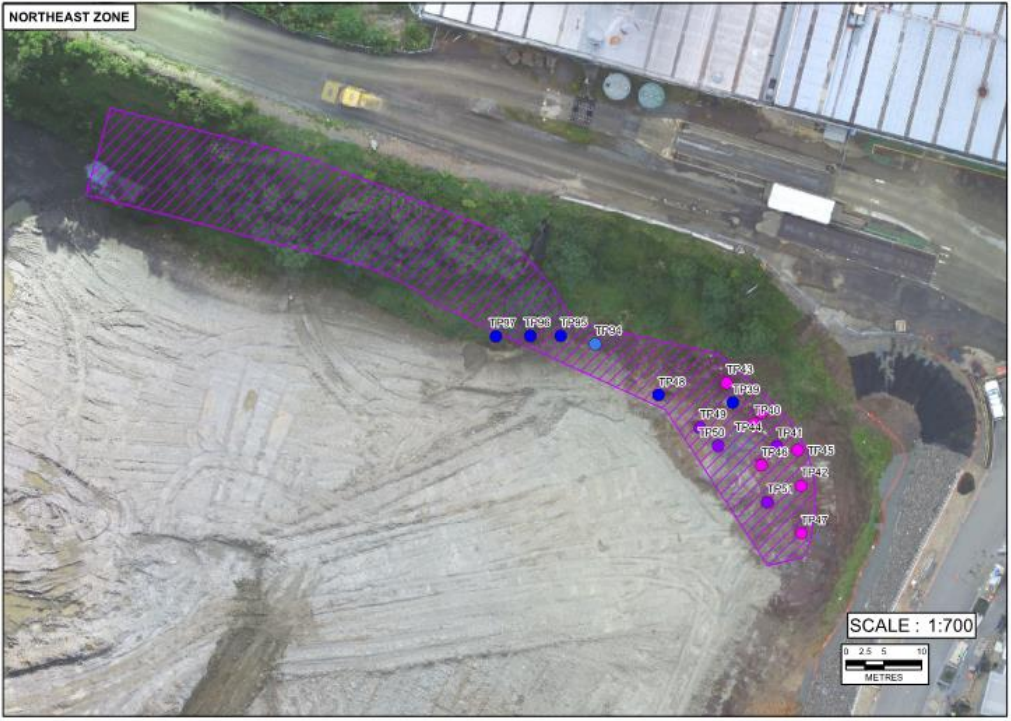
1. Stormwater from individual buildings and roads is treated and discharged to nearby soakage zones.
2. Excess runoff from the north is collected in an eastern swale and discharges to underground flood storage and soakage in the north east corner of the site.
3. Runoff from the eastern apartment buildings goes to the eastern soakage zone below the eastern swale.



The Design

Design Approach

4. The eastern swale ends at soakage areas to the north-east and south-east of the sports field.
5. The sports field drains toward the south eastern or south western soakage zones.
6. Soakage allows for short term rises in groundwater levels and drains both vertically into the aquifer and horizontally into unsaturated zones.
7. A balancing stormwater pipe connects all soakage zones to make the best use of the available soakage.



KEY :

TEST PIT PERMEABILITY (m/s):

- 0 - 0.0001
- 0.0001 - 0.0004
- 0.0004 - 0.002
- 0.002 - 0.004
- >0.004

▨ Soakage Zones

LOCATION PLAN

SOURCE:
1. AERIAL IMAGERY (FLOWN 27 APR 17) SUPPLIED BY DGL. AREA OUTSIDE THREE KINGS FLOWN 2016. PROVIDED UNDER LICENSE FROM AUCKLAND COUNCIL UNDER THE CREATIVE COMMONS ATTRIBUTION LICENSE 3.0.
2. TOPOGRAPHICAL INFORMATION DERIVED FROM LIDAR DATA.

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CLIENT :

Fletcher Living

PROJECT :

THREE KINGS
PRECINCT
SOAKAGE INVESTIGATION

TITLE :

TEST PIT PERMEABILITY

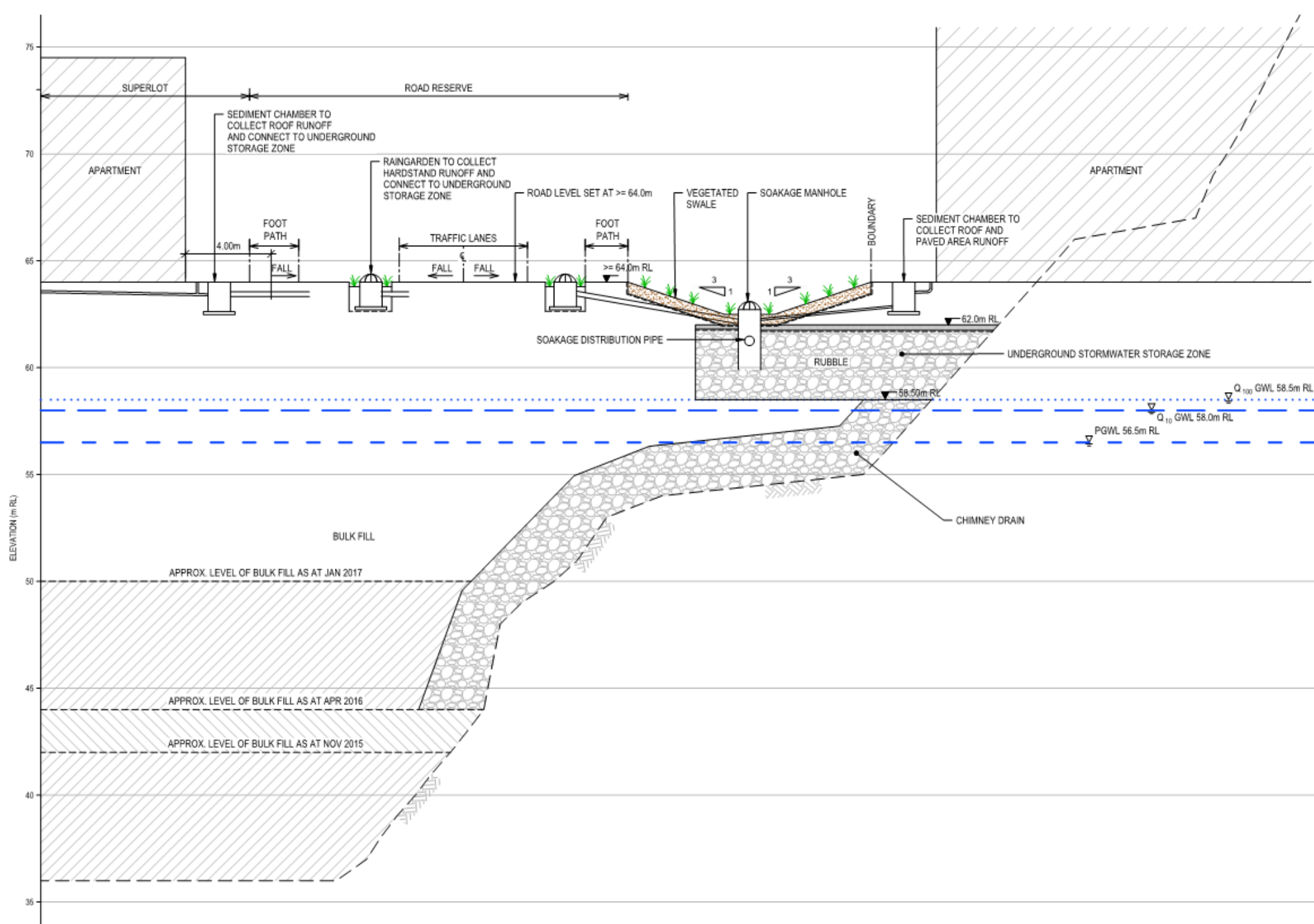
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| PROJECT NO : | FIGURE NO : | REVISION : |
| AJ456307 | 1 | A |

Soakage Zones

Soakage Zones





Eastern
face



Eastern
face



Eastern
soakage
blanket



Eastern
Soakage
Blanket

Factor of Safety

Review of soakage factors of safety across NZ – 2 to 3

Mean permeability rates and level of confidence analysis

Larger extent of soakage adopted based on available geological strata

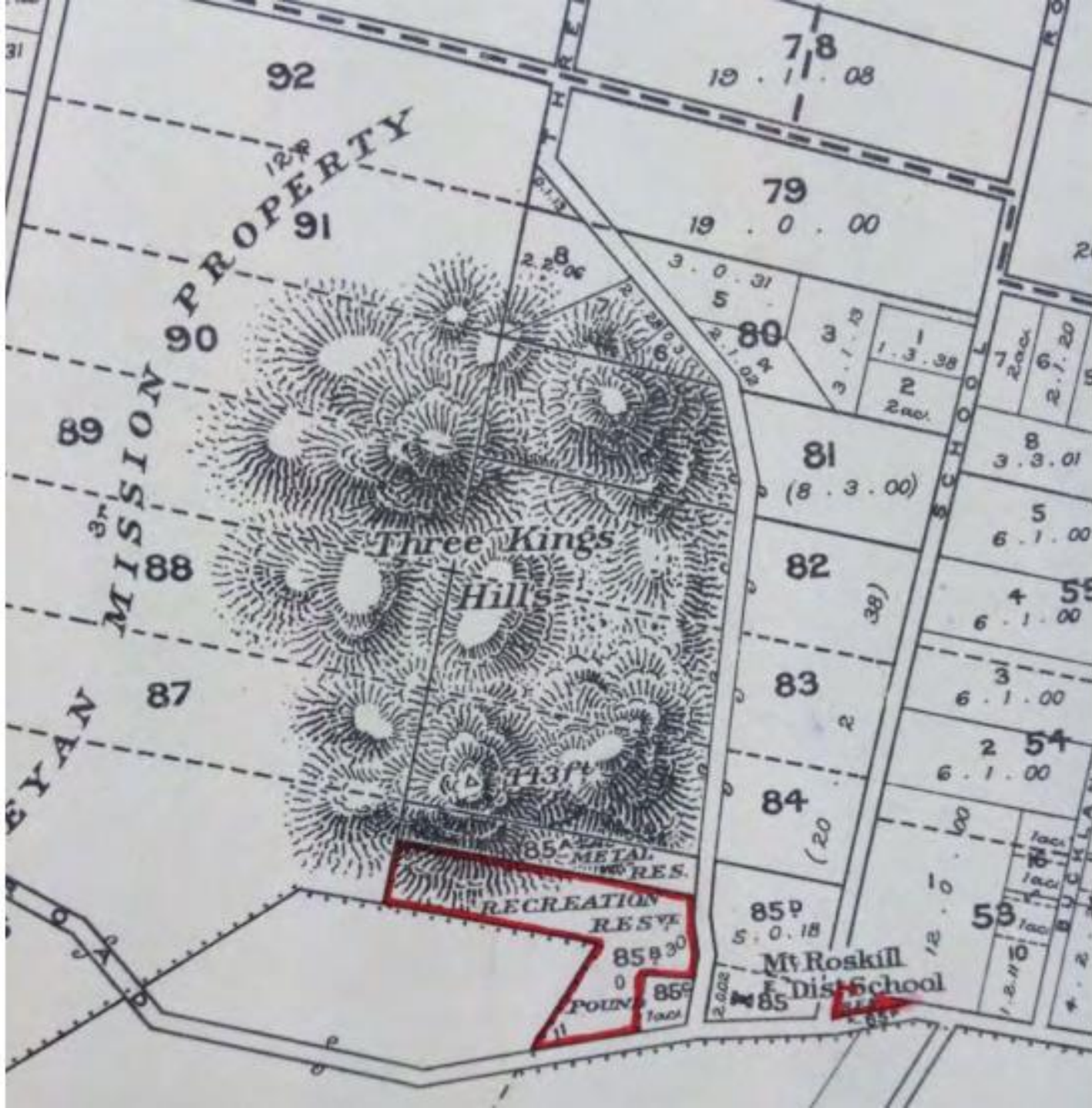
Physical testing to achieve the design flow rates

Part D: Design Issues

Points of interest

Cultural

Early engagement and providing design elements in recognition of Te Tātua a Riu-ki-uta

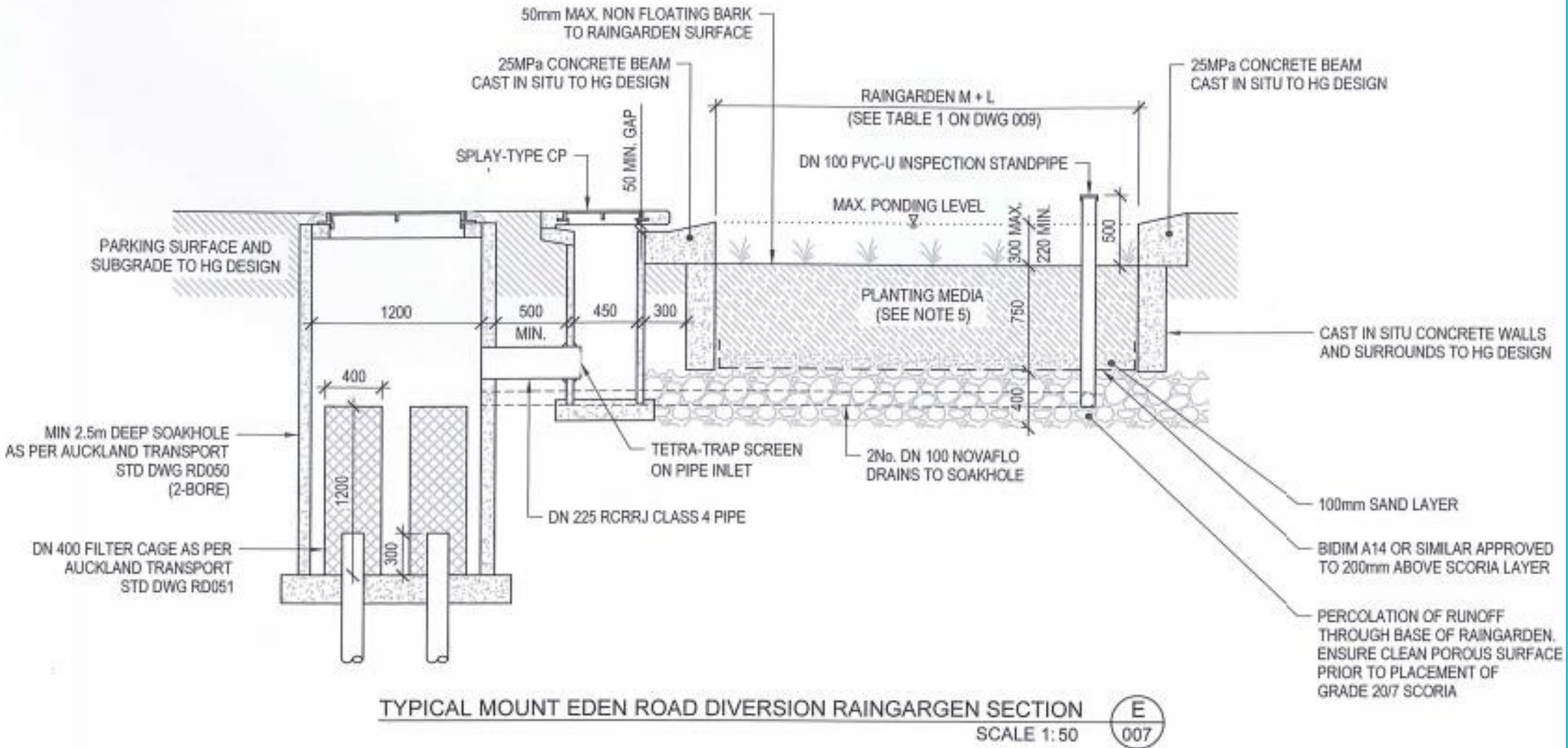


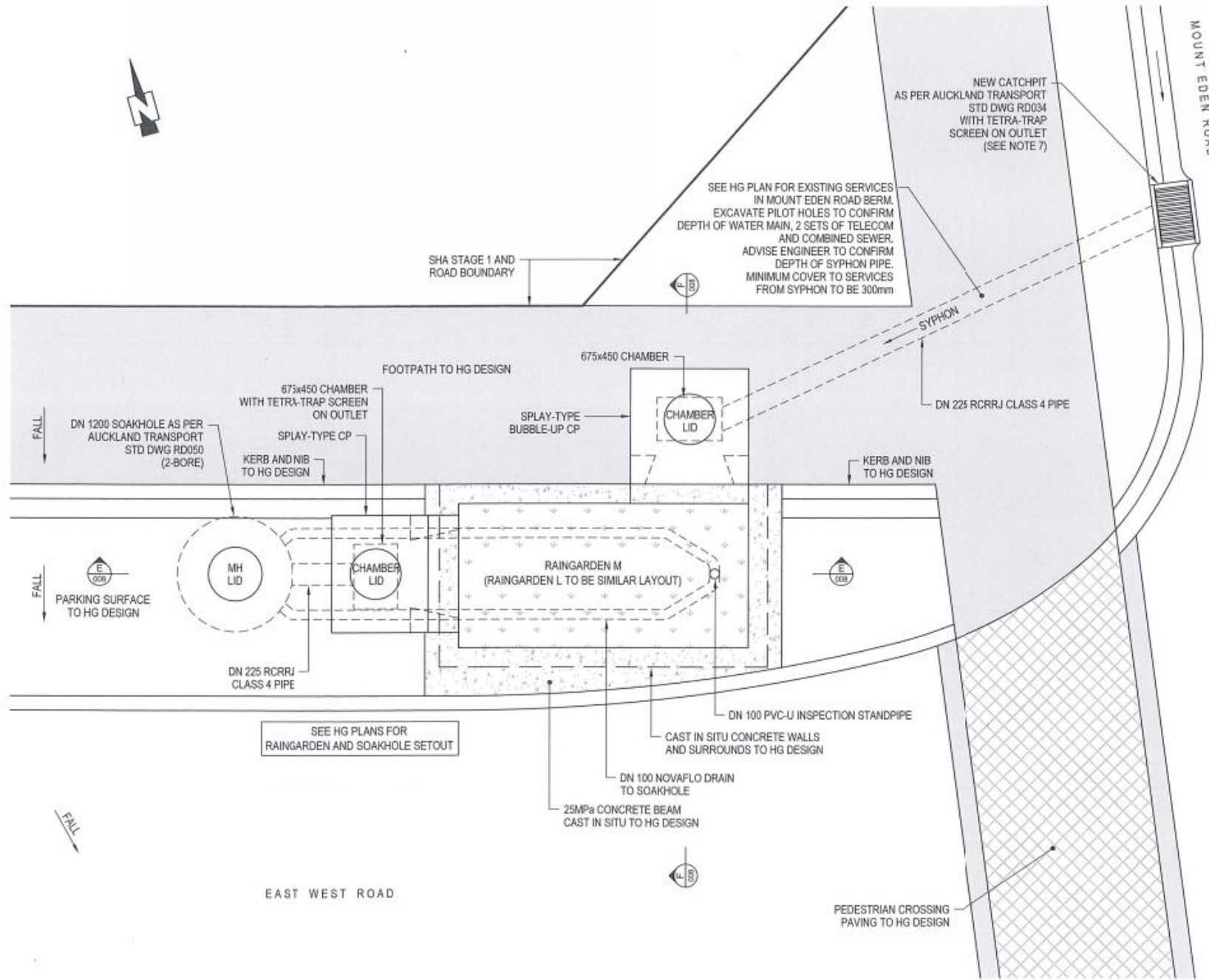
Heritage

WSD

Soakage presented a unique opportunity to manage stormwater on site at a large scale across a full range of hydrological events

Example from the SHA





MOUNT EDEN ROAD DIVERSION RAINGARDEN AND SOAKHOLE - PLAN

SCALE: 1:50

Removal of stormwater from the combined sewer and provide treatment

Water
Sensitive
Design
and
combined
Sewers



Sediment during construction

Construction phase sediment is a key risk to soakage



Filling
the
quarry



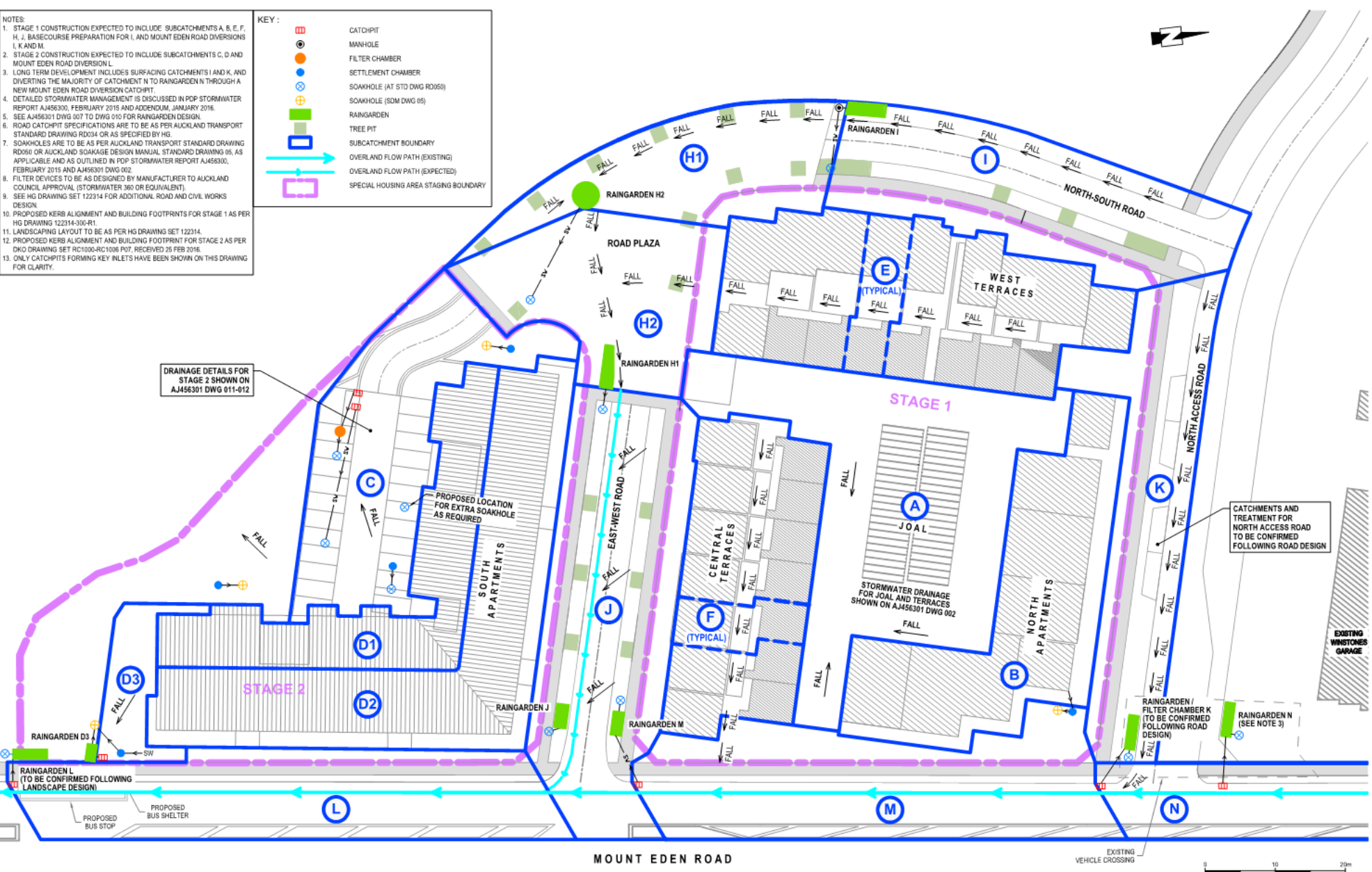
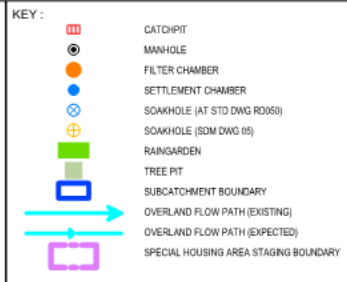
Filling
the
quarry

Stormwater Quality Treatment

Removing contaminants and part of the system to maintain long term viability

SHA Treatment

- NOTES:**
- STAGE 1 CONSTRUCTION EXPECTED TO INCLUDE SUBCATCHMENTS A, B, E, F, H, J, BASECOURSE PREPARATION FOR I, AND MOUNT EDEN ROAD DIVERSIONS L AND M.
 - STAGE 2 CONSTRUCTION EXPECTED TO INCLUDE SUBCATCHMENTS C, D AND MOUNT EDEN ROAD DIVERSION L.
 - LONG TERM DEVELOPMENT INCLUDES SURFACING CATCHMENTS I AND K, AND DIVERTING THE MAJORITY OF CATCHMENT N TO RAINGARDEN N THROUGH A NEW MOUNT EDEN ROAD DIVERSION CATCHPIT.
 - DETAILED STORMWATER MANAGEMENT IS DISCUSSED IN PDP STORMWATER REPORT AJ456300, FEBRUARY 2016 AND ADDENDUM, JANUARY 2016.
 - SEE AJ456301 DWG 007 TO DWG 010 FOR RAINGARDEN DESIGN.
 - ROAD CATCHPIT SPECIFICATIONS ARE TO BE AS PER AUCKLAND TRANSPORT STANDARD DRAWING RD034 OR AS SPECIFIED BY HG.
 - SOAKHOLES ARE TO BE AS PER AUCKLAND TRANSPORT STANDARD DRAWING RD050 OR AUCKLAND SOAKAGE DESIGN MANUAL STANDARD DRAWING 05, AS APPLICABLE AND AS OUTLINED IN PDP STORMWATER REPORT AJ456300, FEBRUARY 2016 AND AJ456301 DWG 002.
 - FILTER DEVICES TO BE AS DESIGNED BY MANUFACTURER TO AUCKLAND COUNCIL APPROVAL (STORMWATER 360 OR EQUIVALENT).
 - SEE HG DRAWING SET 122314 FOR ADDITIONAL ROAD AND CIVIL WORKS DESIGN.
 - PROPOSED KERB ALIGNMENT AND BUILDING FOOTPRINTS FOR STAGE 1 AS PER HG DRAWING 122314-300-R1.
 - LANDSCAPING LAYOUT TO BE AS PER HG DRAWING SET 122314.
 - PROPOSED KERB ALIGNMENT AND BUILDING FOOTPRINT FOR STAGE 2 AS PER DRK DRAWING SET RC1000-RC1006 P07, RECEIVED 25 FEB 2016.
 - ONLY CATCHPITS FORMING KEY INLETS HAVE BEEN SHOWN ON THIS DRAWING FOR CLARITY.



Drainage details for Stage 2 shown on AJ456301 DWG 011-012

Proposed location for extra soakhole as required

Stormwater drainage for Joal and Terraces shown on AJ456301 DWG 002

Catchments and treatment for North Access Road to be confirmed following road design

Raingarden / Filter Chamber K (to be confirmed following road design)

Raingarden N (see note 3)

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| G | EPA RAINGARDEN L | APR 16 | | | |
| F | STAGE 2 DESIGN UPDATE | MAR 16 | | | |
| E | ENGINEERING PLAN APPROVAL | FEB 16 | | | |
| D | ENGINEERING PLAN APPROVAL (FORMERLY FIGURE 1 AJ456300) | JUN 15 | | | |
| C | ISSUED FOR BUILDING CONSENT | FEB 15 | | | |
| B | ISSUED FOR REVIEW | JAN 15 | | | |

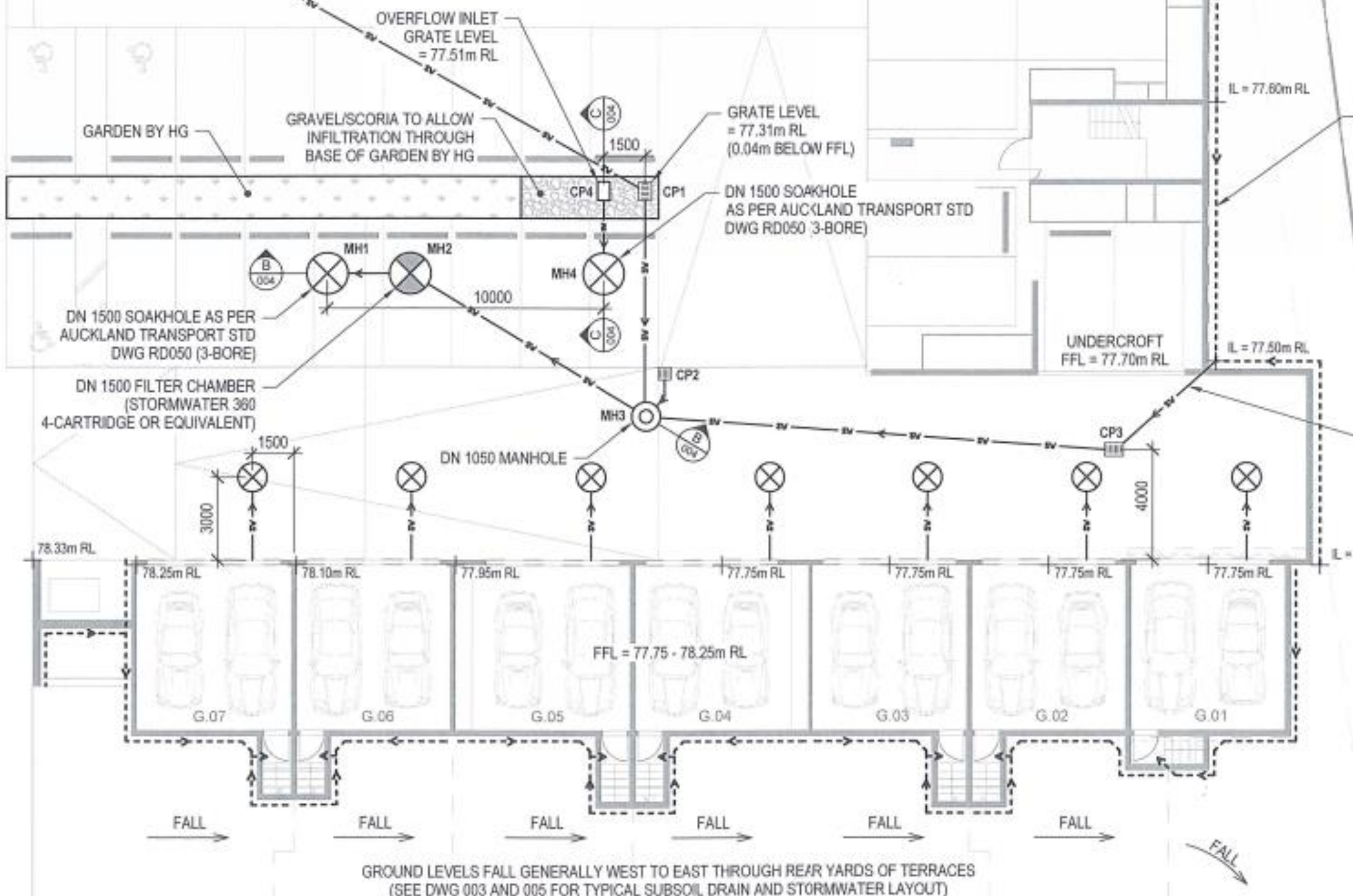
BY: E.B. R.S. NOV 14
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PROJECT: THREE KINGS SHA STORMWATER MANAGEMENT
TITLE: STORMWATER SUBCATCHMENTS AND DEVICES
PROJECT NO.: AJ456301
SCALE: 1:500 (A3)
SHEET: - OF: -
DRAWING NO.: 006
REV: G

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 Auckland Taunanga Wellington Christchurch

Public Assets - Resilience

1. Maintenance of sediment treatment devices
2. Monitoring of groundwater levels and performance of soakage areas
3. What if it blocks?, needs more soakage?
 - Monitoring during construction to allow adaption,
 - Extension of soakage zones
 - Existing groundwater pump



SHA
soakage
resilience

Summary

Summary

1. The Three Kings Crater acts like a bucket with a overflow to the Meola aquifer to the north-west
2. No long term pumping
3. Groundwater provides the lower bound for stormwater storage
4. Flood levels during extreme events set the upper bound for storage and minimum building floor levels

Summary

5. Floor levels set above storage of the 100 year rainfall volume
6. Water Sensitive Design across a full range of hydrology
7. Construction sediment and post development treatment is integral to the soakage approach

Acknowledgements

This work was carried out by PDP Ltd for Fletcher Residential.

Thank you to Fletcher Residential, PDP Ltd and my co-author for their support in preparing this paper.