REPORT

TO
CATHOLIC METROPOLITAN CEMETERIES TRUST

ON
GEOTECHNICAL ASSESSMENT

OF
EXISTING DAMS

AT
166-176 ST ANDREWS ROAD, VARROVILLE, NSW

10 January 2018
Ref: 30510ZArpt

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1 INTRODUCTION

This report presents the results of a geotechnical assessment of the existing dams at 166-176 St Andrews Road, Varroville, NSW. A site location plan is presented as Figure 1. The assessment was commissioned by Mr John Richardson of Catholic Metropolitan Cemeteries Trust (CMCT) by signed 'Acceptance of Proposal' form dated 18 May 2017. The commission was on the basis of our fee proposal, Ref. 'P44858A' dated 8 May 2017.

Based on the supplied 'Site Masterplan' for the proposed Macarthur Memorial Park, prepared by Florence Jacquet Landscape Architect (Job No. 1210, Drawing No. L100, Sheet No. 2, dated 18 September 2017), we understand that a cemetery is proposed at the 114 hectare site. There are currently ten farm dams on site. For the purpose of this report, we have referred to the dams as Dam 1 to Dam 10. Their locations are shown on Figure 1. The landscape design of the proposed cemetery has incorporated Dam 1 and Dams 4 to 10, and the removal of Dams 2 & 3.

The purpose of the assessment was to carry out a geotechnical inspection of each dam and to provide our comments on embankment stability and recommendations on remedial measures and additional investigations.

This report confirms and amplifies our preliminary letter report, Ref. '30510ZA Let' dated 8 September 2017.

2 ASSESSMENT PROCEDURE

On 29 May 2017, our Senior Associate level geotechnical engineer, Andrew Jackaman, and our Senior Geotechnical Engineer, Owen Fraser, visited site to carry out a walkover inspection of the topographic, surface drainage and geological conditions of each dam. The inspection was completed after a relatively 'dry' two month period.

Limited mapping of the primary geotechnical features identified on site was carried out and is presented on the attached Figures 2 to 11. These figures are based on the supplied survey drawings prepared by Degotardi Smith & Partners (Drawing No. 33618A02, Sheets 1 to 18, Revision A, dated 10 July 2013).

Figure 12 presents details of the geotechnical mapping terms and symbols used in the geotechnical site plans. Slope angles were measured using a hand held clinometer and the dimensions of

features which were accessible were tape measured, otherwise they were estimated. The feature locations shown on Figures 2 to 11 are only approximate and, should any of these features be critical, we recommend they be located more accurately using instrument survey techniques.

A summary of the observations made during the walkover inspection is presented in Section 3.1 below.

3 RESULTS OF THE ASSESSMENT

3.1 Site Observations

The site is located on a gently to moderately sloping hillside, which generally grades down to the south-east. A maximum elevation relief of about 109m exists between the northern corner of the site and the lower eastern corner. St Andrews Road bounds the site to the south-west.

The subject 114 hectare site extends around a 3 hectare battle-axe property at 196 St Andrews Road ('Varroville House'). The higher lying north-western end of the site is moderately to steeply sloping and covered in bushland. Elsewhere the site is essentially grass covered with scattered trees and 'pockets' of bushland. From the northern corner of the site, a ridgeline extends mid-length along the north-eastern boundary and returns in a southerly direction towards Varroville House. The hillsides flanking the ridgeline are also moderately to steeply sloping. Elsewhere within the site, the hillsides which form gullies are generally gently to moderately sloping.

At time of our inspection, the site was used to graze cattle. Ten farm dams (Dams 1 to 10) were located within gullies across the site. The locations of these dams are shown on Figure 1. Detailed observations and photographs of each dam are presented in the attached Appendix A, and the geotechnical mapping is presented in Figures 2 to 11.

3.2 Regional Geology

The 1:100,000 series geological maps of Wollongong-Port Hacking (Geological Survey of NSW, Geological Series Sheet 9029-9129) and Penrith (Geological Survey of NSW, Geological Series Sheet 9030) indicate the site to be underlain by Bringelly Shale of the Wianamatta Group.

4 GEOTECHNICAL ASSESSMENT

Based on the results of our inspection, we consider that all ten 'farm' dams are in poor condition for the following primary reasons:

1. ***Presence of trees on the embankments***: Existing trees located on the embankment could cause seepage, internal erosion and ultimately piping failure along decaying tree roots. An abundance of tree roots through the embankment could also result in loosening of the earthfill and surface erosion. Furthermore, trees which topple over as a result of strong winds and/or bushfire, could remove support or cause a breach of the embankment. The vegetation may also attract burrowing animals into the embankment and obscure the entrances.

2. ***Presence of burrows and ant hills***: Burrows and ant hills could also cause seepage, internal erosion and ultimately piping failure. The burrows and ant hills could also cause the mechanical weakening of the embankment, as well as collapse of the earthfill and subsequent settlement of the crest. These factors could cause a breach of the embankment.

3. ***Presence of over-steep uphill and downstream shoulders***: From a stability perspective, for a farm dam embankment ranging in height between 3m and 4.5m, we would expect the shoulders to be graded at no steeper than 1V on 3H (18°), assuming the earthfill comprised homogenous clay soils of high plasticity (typical of the soil residual from Bringelly Shale), and a crest width of at least 3m. The sectional geometry of the nine large dams did not meet this minimum design criteria.

4. ***Evidence of seepage through the foundation material***: There was evidence of seepage through the foundation material at all dams, except Dam 6 (due to the presence of Dam 7) and Dam 10. Based on the nature of the dams, it is unlikely that any measures to control seepage through the foundation (eg. cut-off trench, etc.) were ever constructed. The implication of the seepage and the likely elevated pore pressures below the embankments relates to the stability of the downstream shoulder. If the pore pressures are high, then uplift pressures below the embankment may be present, thus potentially compromising stability. Furthermore, internal erosion and ultimately piping failure though the foundation material and/or earthfill material may occur. These factors could cause a breach of the embankment. We note that seepage emanating from the downstream toe and erosion were observed at the Dam 8 embankment.

5. ***Evidence of scour and erosion along the toe of the downstream shoulder***: The toe of the downstream shoulder at Dams 7 & 10 was sub-vertical in places due to scour and erosion. Regression of this erosion feature could ultimately cause a breach of the embankment.

6. ***Evidence of dispersive soils***: The scour and erosion of the embankment shoulders observed at most of the dams may have been exacerbated by the presence of dispersive soils (ie. soils which are susceptible to erosion by water). The soils residual from Bringelly Shale are typically moderately to highly dispersive. The dispersivity of a soil affects the critical hydraulic shear stress at which erosion is initiated, and must be taken into account in dam design.

7. ***Lack of formal spillways***: Though not uncommon in farm dams, none of the ten dams had spillway structures. Uncontrolled discharge through informal spillways (constructed ad-hoc, typically at the ends of the embankments) and/or over the embankments (due to insufficient freeboard) could cause scour and erosion of the downstream shoulder, and ultimately a breach of the embankment. The erosion would be exacerbated if trees were toppled during the discharge.

5 COMMENTS AND RECOMMENDATIONS

We understand that for the proposed cemetery development, Dams 2 & 3 are to be removed. Removal of the stored water and vegetation must be completed in consultation with the project ecologist (Travers), as protected fauna may be present. Similarly, removal of the embankments must be completed in consultation with the project archaeologist/heritage consultant, if appropriate.

In our opinion, the embankments at Dam 1 and at Dams 4 to 10 are in poor condition and require significant rehabilitation/improvement if they are to be incorporated into the proposed cemetery development. It is likely that a breach could occur at any time at any of the eight embankments. A breach of a higher lying embankment will surcharge a lower dam if located within the same gully, potentially initiating a breach of the lower embankment as well.

We strongly recommend that existing embankments at Dam 1 and at Dams 4 to 10 be replaced with properly engineered embankments. This would be an iterative process between all members of the design team including:

- CMCT;
- The project manager (NettCorp);
- Florence Jacquet Landscape Architect;
- The project civil engineer (Warren Smith + Partners);
- The project hydrologist/hydraulic engineer (GRC Hydro);
- The project ecologist (Travers);
- The project stormwater treamtment consultant (Stormy Water);
- The project archaeologist/heritage consultant (if appropriate); and,
- JK Geotechnics.

The design of the new embankments will be dependent on their height and the nature of the earthfill materials from the borrow areas on site. At this stage, we consider that the existing embankment earthfill materials should not be reused in the construction of the new embankments as they are likely to contain an abundance of roots and organic matter (eg. decomposed roots, buried topsoil, etc.). If however during excavation of the embankments, the existing earthfill materials can be zoned, then it may be possible to reuse the low organic content materials.

The geotechnical investigation for the design and construction of the new embankments should comprise the following scope of work:

1. Test pit investigation within designated borrow areas. We expect that the construction of the proposed cemetery will include substantial cut and fill earthworks. Potential borrow areas could be in large areas of cut. The investigation will need to include an appropriate laboratory test program (eg. dispersion testing, particle size distribution and hydrometer testing, Atterberg Limits testing, Standard compaction and permeability testing, etc.) on representative samples to assess the soil properties for design.

2. Test pit and borehole investigation along the alignments of the proposed embankments to assess the nature of the foundation materials.

3. Geometric design of the embankment, including stability analyses. As a guide, and as discussed in Section 4, a minimum crest width of 3m and shoulders at no steeper than 1V on 3H can be assumed for preliminary design purposes for an embankment up to 4.5m high (to

be confirmed by the geotechnical investigation). Depending on the dispersive potential of the earthfill, it may be necessary to construct a zoned earthfill embankment with a lime stabilised upstream shoulder, or a homogenous earthfill dam with a chimney drain (comprising appropriately graded filter material).

4. Advice on the embankment foundation (including cut-off), subgrade preparation, outlet pipes/culverts through the foundation material and/or earthfill materials, material and compaction specifications for earthfill (including around outlet pipes/culverts and/or adjacent to spillway structures), filter design (if appropriate), and erosion protection.

In the interim to facilitate the investigation, we recommend that the following works be carried out at Dam 1 and at Dams 4 to 10:

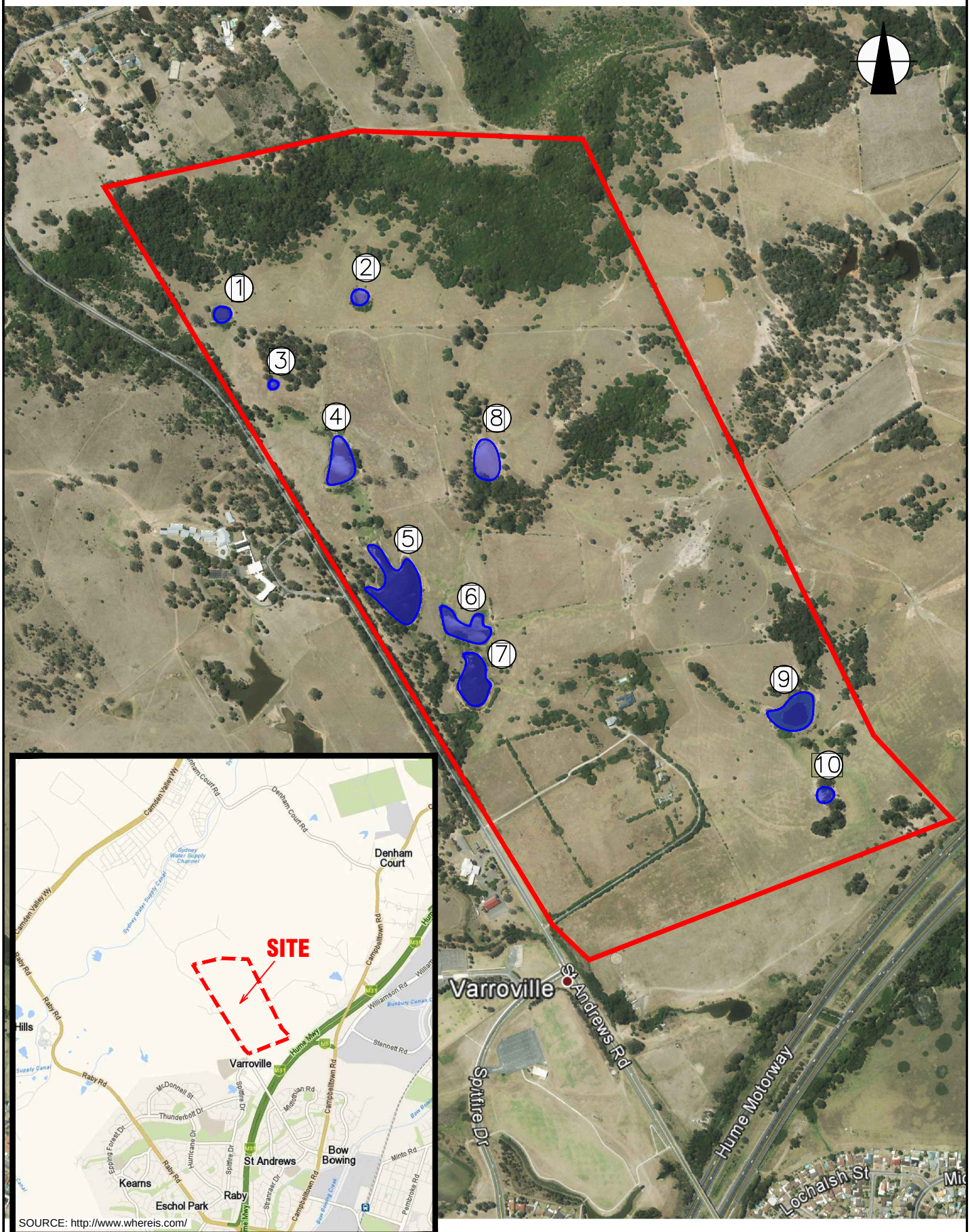
- Removal of all vegetation (including fallen trees) along the crest of each embankment. Trees should be cut down to crest level. No excavation into the embankments (eg. for removal of root balls, etc.) is permitted whilst there is stored water in the dams. This also applies to any intrusive investigations undertaken by the archaeologist/heritage consultant.

- Removal of all vegetation and creation of access tracks along the downstream toe of each embankment (except Dam 6). These cleared tracks along the downstream toes should be at least 5m wide to permit access for excavators (to dig test pits) and track mounted drill rigs (to drill boreholes).

The investigation may reveal alternative options for the rehabilitation/improvement of the eight retained dams, including sheet pile walls through the embankment crests and/or lining the storage area with an HDPE membrane or similar. Both options would require removal of all vegetation on the embankments, grouting of burrows and re-profiling the shoulders. These options may not be appropriate however, if the embankment heights are to be increased. We could carry out the above investigation, and provide alternative design options, if commissioned to do so.

6 GENERAL COMMENTS

This report has been prepared for the particular project described and no responsibility is accepted for the use of any part of this report in any other context or for any other purpose. If there is any change in the proposed development described in this report then all recommendations should be reviewed. Copyright in this report is the property of JK Geotechnics. We have used a degree of care, skill and diligence normally exercised by consulting engineers in similar circumstances and locality. No other warranty expressed or implied is made or intended. Subject to payment of all fees due for the investigation, the client alone shall have a licence to use this report. The report shall not be reproduced except in full.



AERIAL IMAGE SOURCE: GOOGLE EARTH PRO 7.1.5.1557
AERIAL IMAGE ©: 2015 GOOGLE INC.

LEGEND

(7) DAM NUMBER

This plan should be read in conjunction with the JK Geotechnics report.

Title: **SITE LOCATION PLAN**

Location: 166-176 ST ANDREWS ROAD
VARROVILLE, NSW

Report No: 30510ZA

Figure No: 1

J K **Geotechnics**

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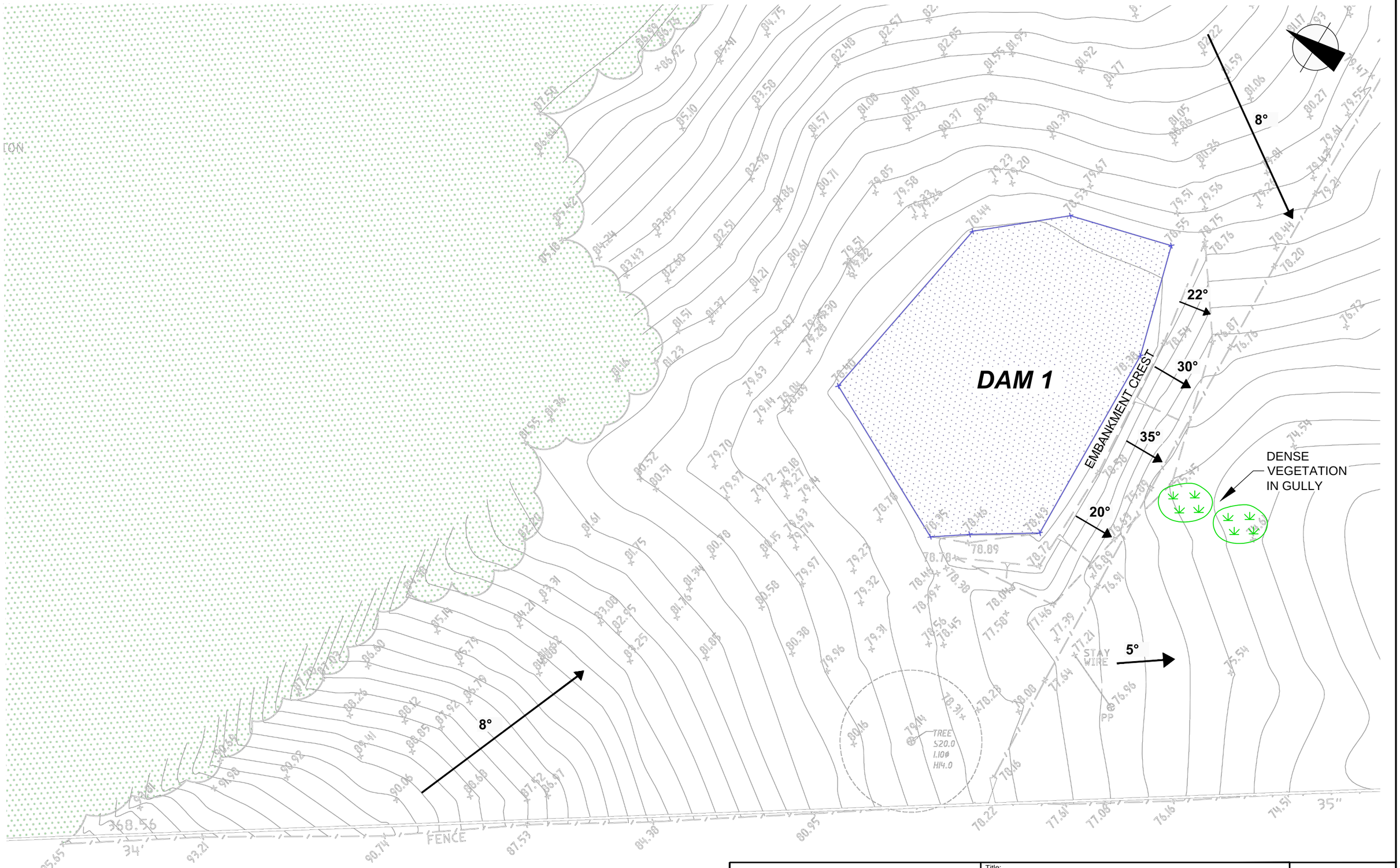

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This plan should be read in conjunction with the JK Geotechnics report.

Title: **GEOTECHNICAL SITE PLAN (DAM 1)**

Location: 166-176 ST ANDREWS ROAD
VARROVILLE, NSW

Report No: 30510ZA

Figure No: 2

JK **Geotechnics**

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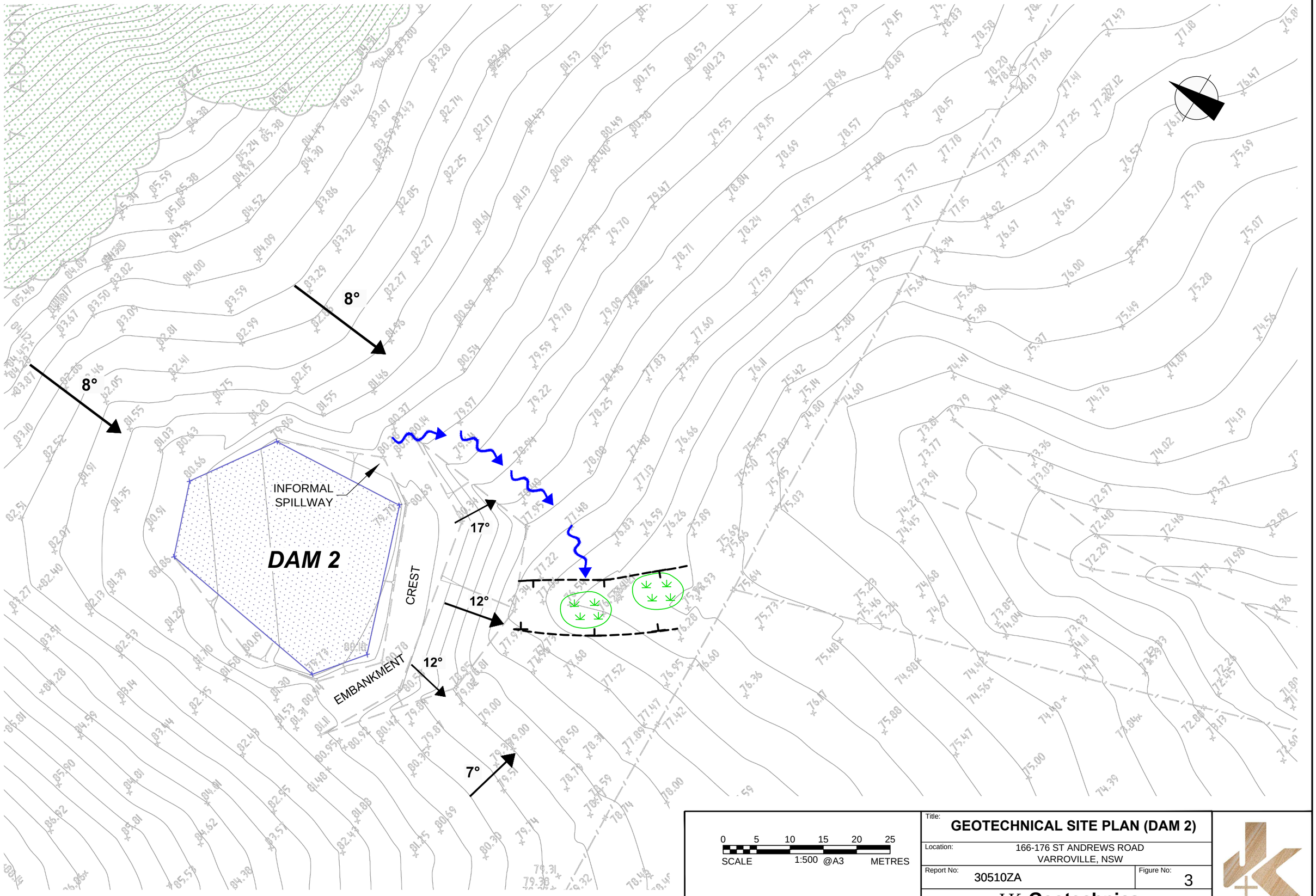

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Title: **GEOTECHNICAL SITE PLAN (DAM 2)**

Location: 166-176 ST ANDREWS ROAD VARROVILLE, NSW

Report No: 30510ZA

Figure No: 3

JK Geotechnics

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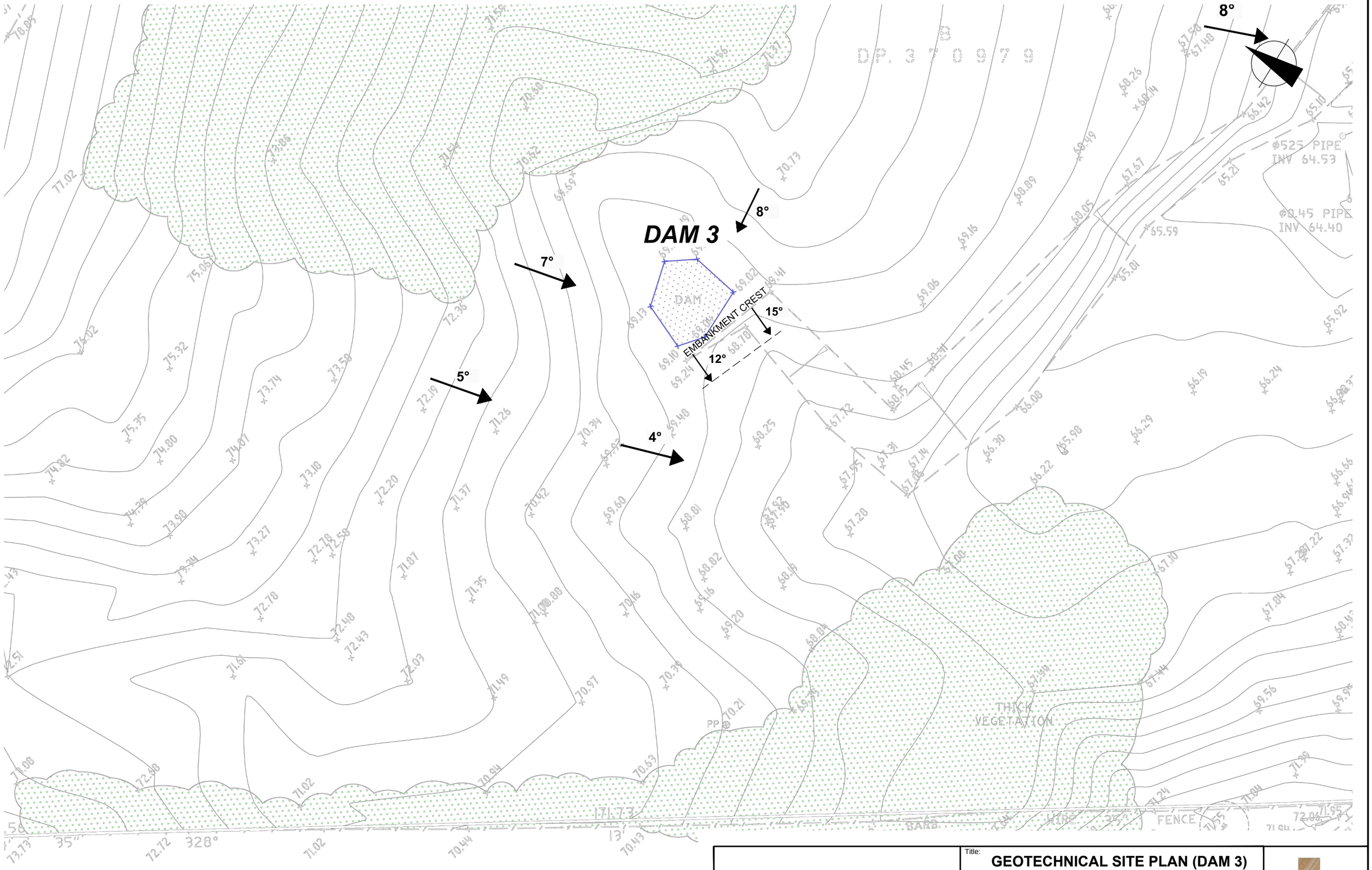

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This plan should be read in conjunction with the JK Geotechnics report.

Title: **GEOTECHNICAL SITE PLAN (DAM 3)**

Location: 166-176 ST ANDREWS ROAD
VARROVILLE, NSW

Report No: 30510ZA

Figure No: 4

JK **Geotechnics**

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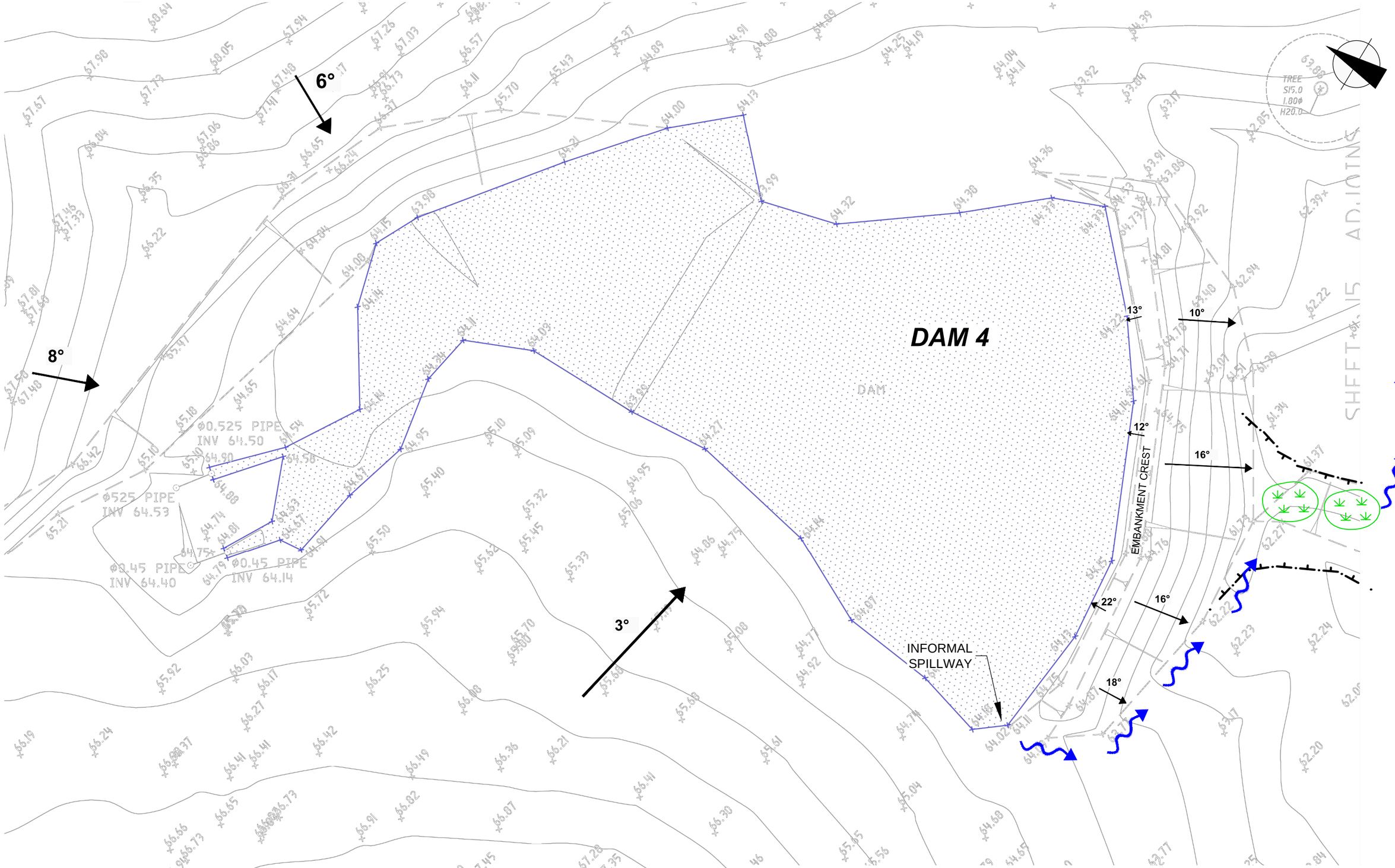

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This plan should be read in conjunction with the JK Geotechnics report.

Title: **GEOTECHNICAL SITE PLAN (DAM 4)**

Location: 166-176 ST ANDREWS ROAD
VARROVILLE, NSW

Report No: 30510ZA

Figure No: 5

JK **Geotechnics**

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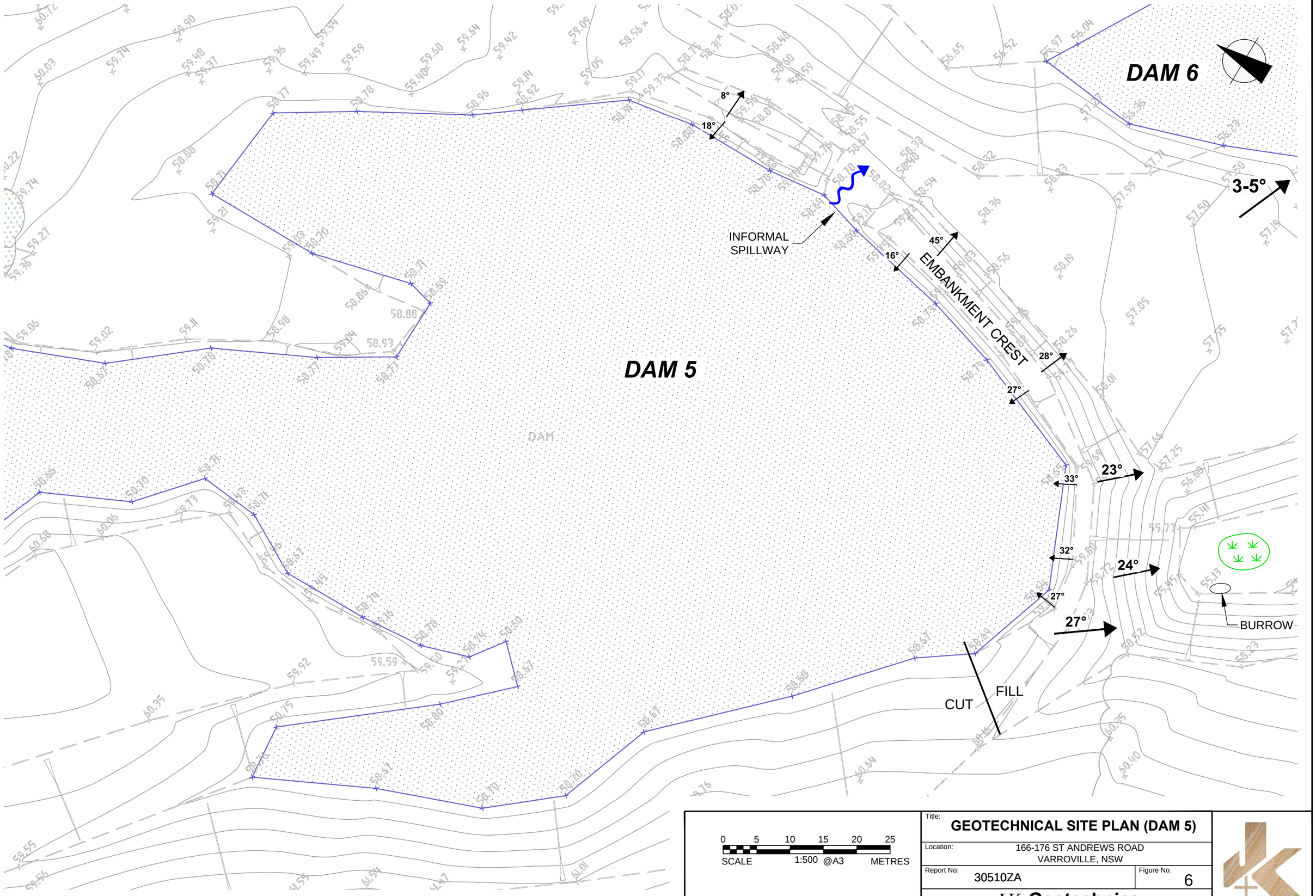

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Title: **GEOTECHNICAL SITE PLAN (DAM 5)**

Location: 166-176 ST ANDREWS ROAD
VARROVILLE, NSW

Report No: 30510ZA

Figure No: 6

J K **Geotechnics**

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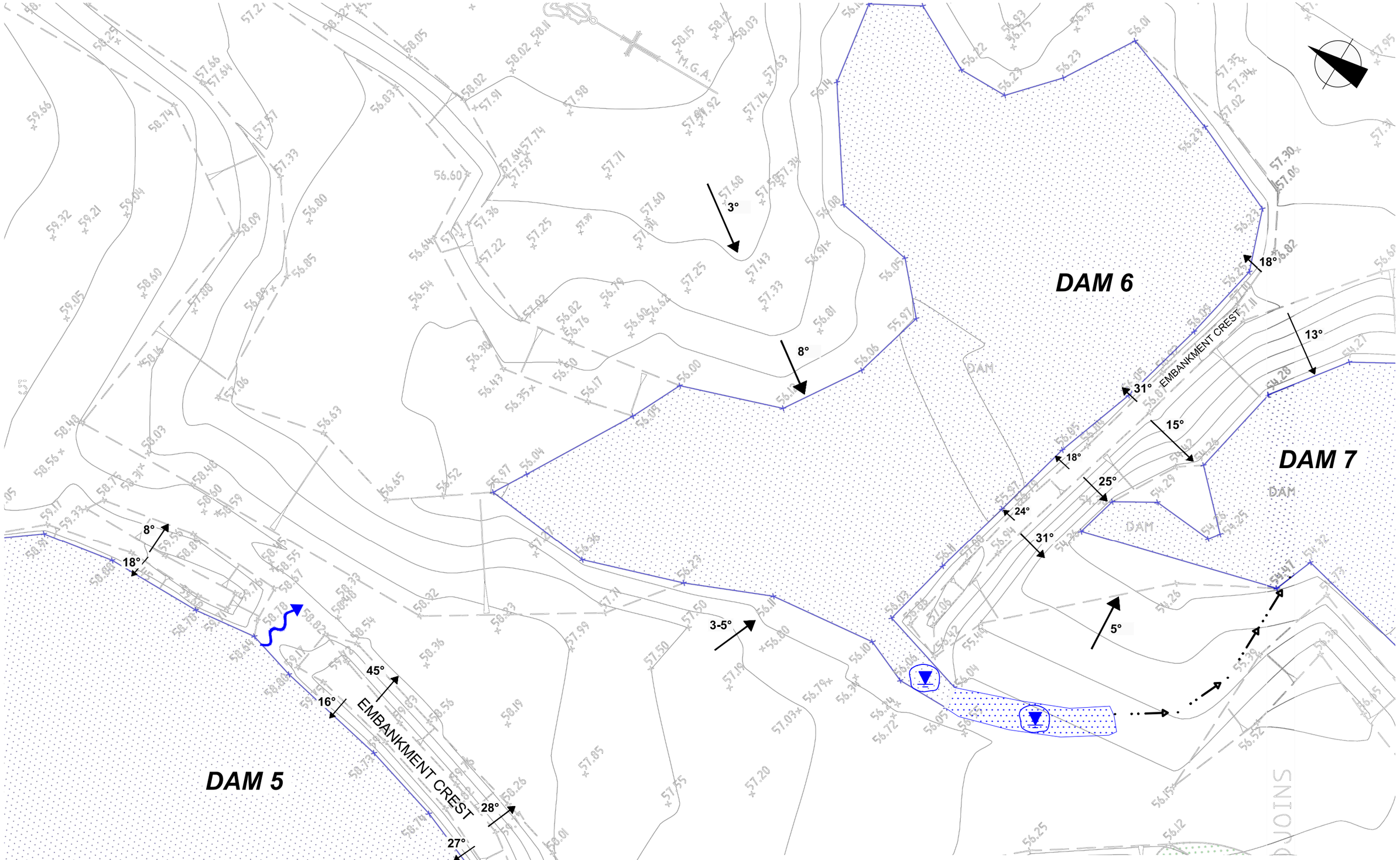

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Title: **GEOTECHNICAL SITE PLAN (DAM 6)**

Location: 166-176 ST ANDREWS ROAD VARROVILLE, NSW

Report No: 30510ZA

Figure No: 7

JK Geotechnics

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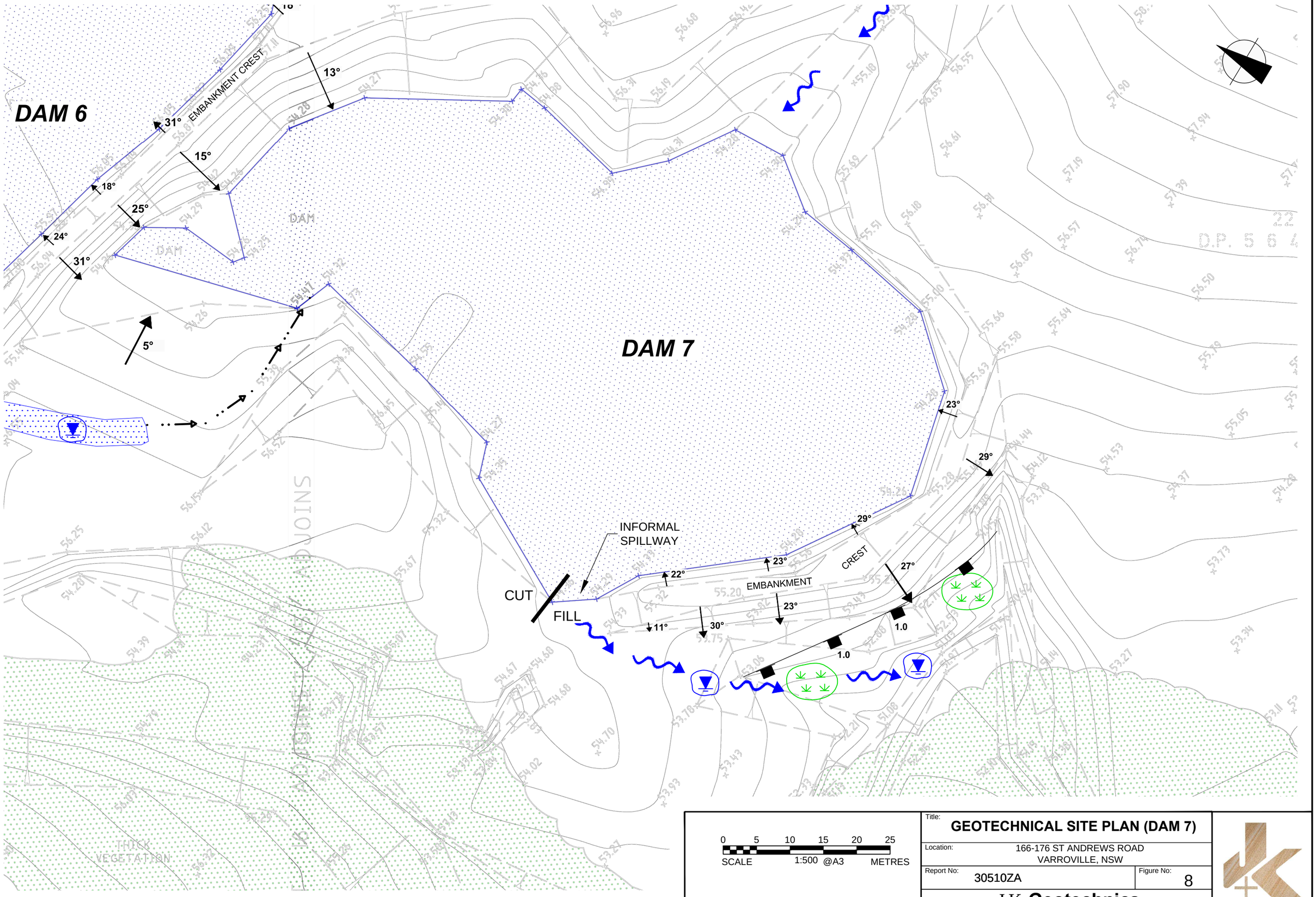

This plan should be read in conjunction with the JK Geotechnics report.

Title: **GEOTECHNICAL SITE PLAN (DAM 7)**

Location: 166-176 ST ANDREWS ROAD
VARROVILLE, NSW

Report No: 30510ZA

Figure No: 8

JK **Geotechnics**

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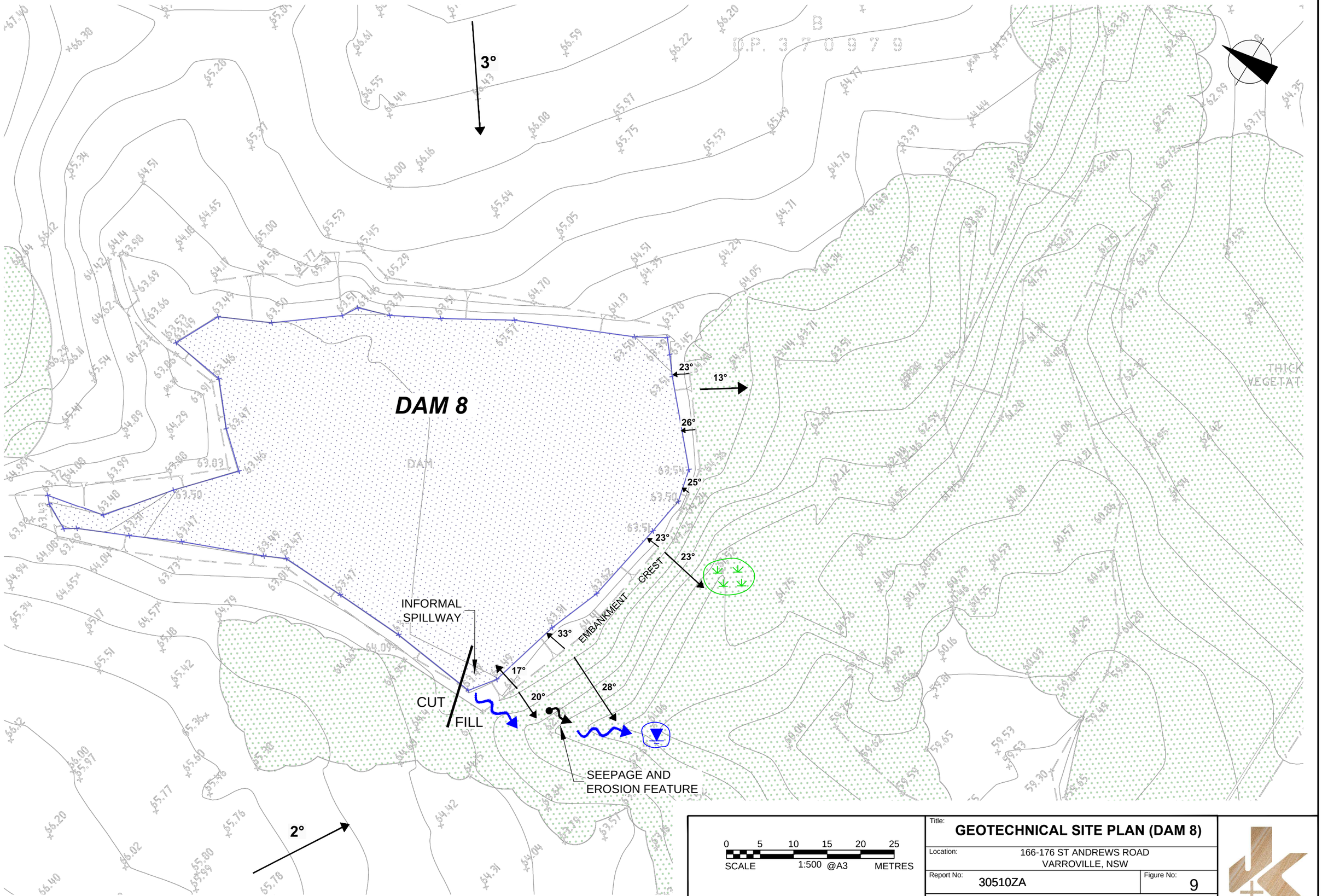

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This plan should be read in conjunction with the JK Geotechnics report.

Title: **GEOTECHNICAL SITE PLAN (DAM 8)**

Location: 166-176 ST ANDREWS ROAD
VARROVILLE, NSW

Report No: 30510ZA

Figure No: 9

JK **Geotechnics**

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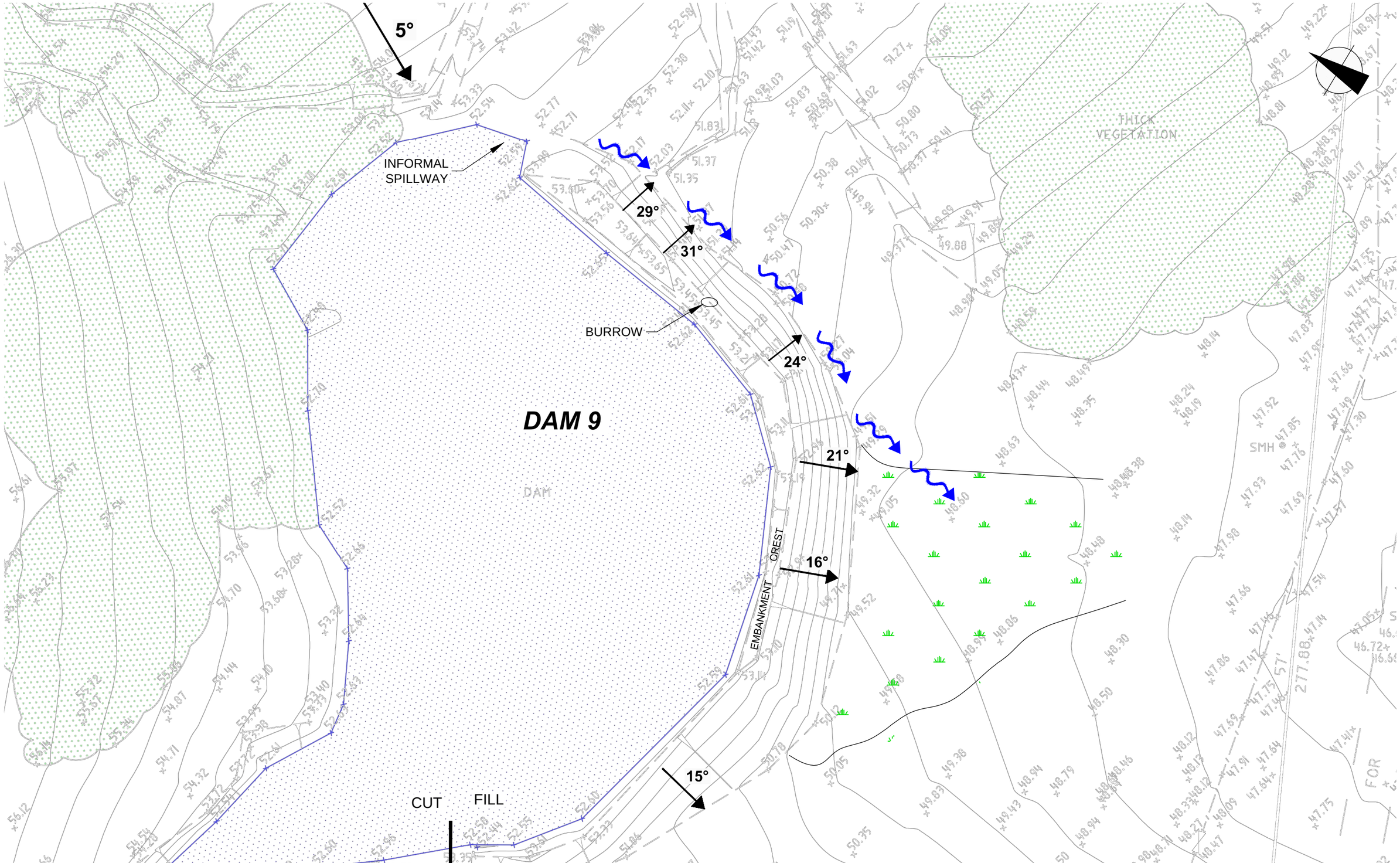

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Title: **GEOTECHNICAL SITE PLAN (DAM 9)**

Location: 166-176 ST ANDREWS ROAD VARROVILLE, NSW

Report No: 30510ZA

Figure No: 10

JK **Geotechnics**

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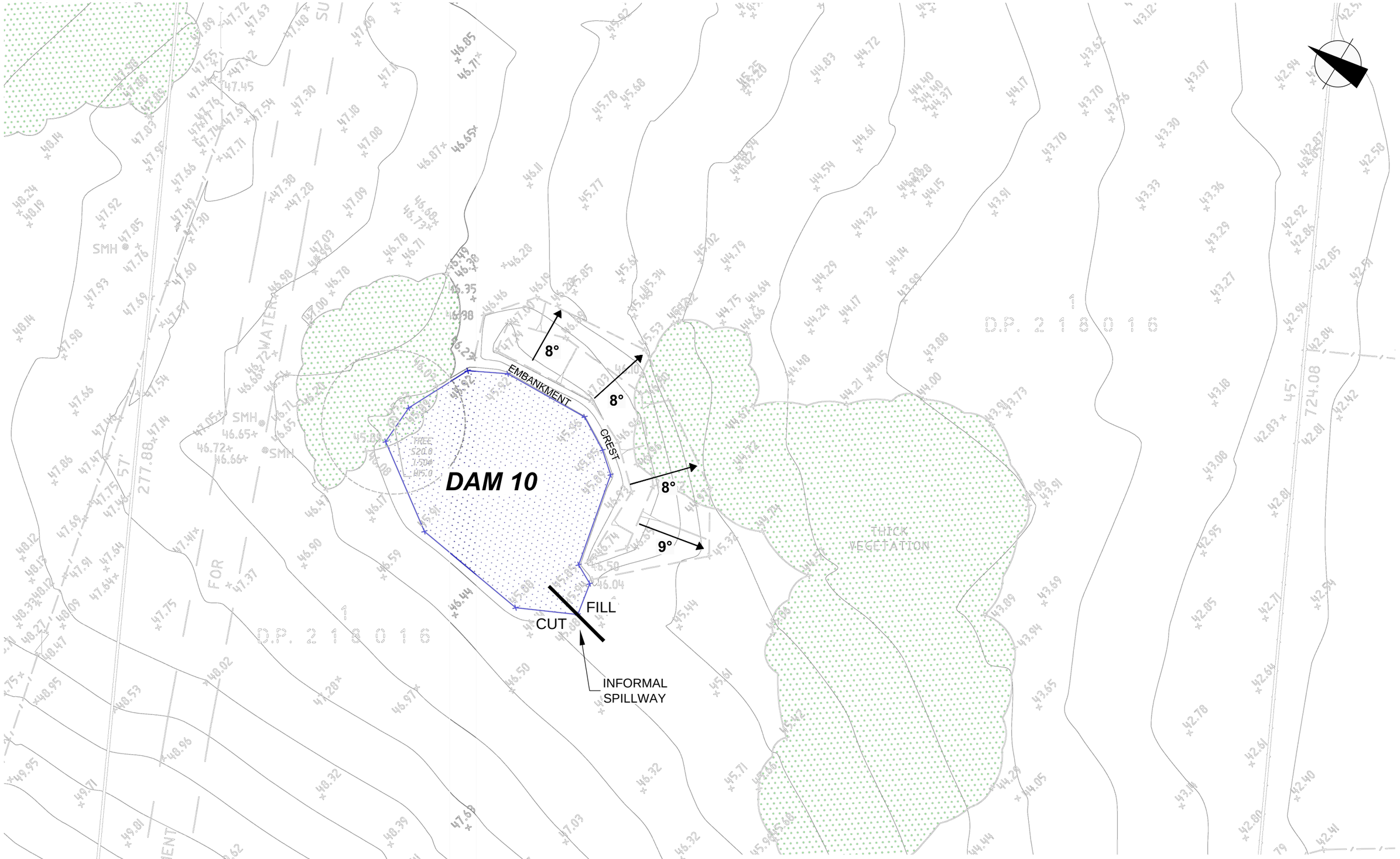

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This plan should be read in conjunction with the JK Geotechnics report.

Title: **GEOTECHNICAL SITE PLAN (DAM 10)**

Location: 166-176 ST ANDREWS ROAD
VARROVILLE, NSW

Report No: 30510ZA

Figure No: 11

JK **Geotechnics**

PLOT DATE: 10/01/2018 10:35:44 AM DWG FILE: S:\6 GEOTECHNICAL\6F GEOTECHNICAL JOBS\30000'S\30510ZA VARROVILLE\CAD\30510ZA.DWG

TOPOGRAPHY

Symbol *Ground Profile*

convex
concave
} well defined or angular break of slope

convex
concave
} poorly defined or smooth change of slope

breaks of slope
changes of slope
} convex and concave too close together to allow the use of separate symbols

sharp
rounded
} ridge crest

3 Cliff or escarpment or sharp break 40° or more (estimated height in metres)

15 Uniform Slope
10 Concave Slope
8 Convex Slope
} Slope direction and angle (Degrees)

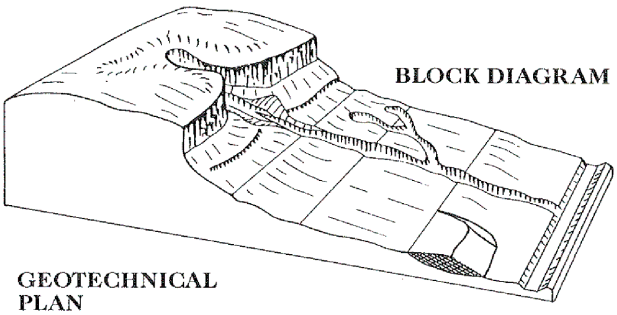
Top
Bottom
} Cut or fill slope, arrows pointing down slope

Hummocky or irregular ground

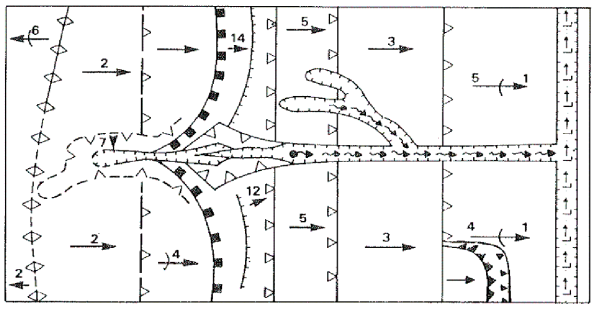
OTHER FEATURES

Boulder
Seepage/spring
Swallow hole for runoff
Natural water course
Open drain, unlined
Open drain, lined
Fenceline
Property boundary
Dry Stone Wall
J —— J 200 Major joint in rock face (opening in millimetres)
– T – T – 10 Tension crack (opening in millimetres)
Masonry or concrete wall
Ponding water
Boggy or swampy area

EXAMPLE OF USE OF TOPOGRAPHIC SYMBOLS:



GEOTECHNICAL PLAN



(After Gardiner, V & Dackombe, R. V. (1983), Geomorphological Field Manual; George Allen & Unwin).

Title:	**GEOTECHNICAL MAPPING SYMBOLS**	
Location:	166-176 ST ANDREWS ROAD VARROVILLE, NSW	
Report No: 30510ZA		Figure No: 12
J K **Geotechnics**		

This plan should be read in conjunction with the JK Geotechnics report.

APPENDIX A

Detailed Observations and Photographs of Each Dam

DAM 1

Looking south-west at Dam 1

Looking east at Dam 1

DAM 1 SPECIFIC OBSERVATIONS:

1. Dam 1 was constructed across a gully feature on a moderately sloping hillside, with the embankment on its southern side.
2. The embankment was up to approximately 3m high and about 65m long. The crest width ranged between 2.3m and 3.5m, but typically between 2.3m and 2.6m. The downstream shoulder graded between 20° and 35°. The upstream shoulder (above storage level) graded between 17° and 28°.
3. The storage area contained water, as well as some reeds. Surrounding the stored water were cattle tracks. The minimum observable elevation difference between the crest of the embankment and the water level on 29 May 2017 was 400mm.
4. There was no formal spillway or outlet structure. The dam appeared to spill over the lowest section of embankment at the south-western corner of the dam.
5. The crest and downstream shoulder contained a dense coverage of small to medium size trees and weeds. The profile of the downstream shoulder was generally uneven with some concave sections, indicating that previous trees in the shoulder had either toppled over or had been removed. A fence ran along the downstream toe. Our inspection of the downstream shoulder was limited by the dense vegetation and fence line.
6. The upstream shoulder was grass covered and contained scattered weeds.
7. The weeds extending several metres along the base of the gully, beyond the downstream toe of the embankment. Immediately downstream of the weeds, the base of the gully was moist under foot, indicating dam leakage.

DAM 2

Looking south-west at Dam 2

Looking south-east at Dam 2

DAM 2 SPECIFIC OBSERVATIONS:

1. Dam 2 was constructed across a gully feature on a moderately sloping hillside, with the embankment on its southern side.
2. The embankment was up to approximately 3m high and about 55m long. The crest width ranged between 3.0m and 4.5m. The downstream shoulder graded between 12° and 17°. The upstream shoulder (where could be seen above storage level) was sub-vertical.
3. The storage area contained water, as well as some reeds. Surrounding the stored water were cattle tracks. The minimum observable elevation difference between the crest of the embankment and the water level on 29 May 2017 was 700mm at the eastern corner of the dam.
4. There was no formal spillway or outlet structure. The dam appeared to spill over the lowest section at the cut to fill line on the eastern side of the dam. The discharge from this informal spillway appeared to drain along the downstream toe towards the base of the gully.
5. The crest and downstream shoulder contained a dense coverage of small size trees and weeds. Our inspection of the embankment was limited by the dense vegetation.
6. The base of the gully, immediately beyond the downstream toe of the embankment, was ‘boggy’ under foot, indicating dam leakage.

DAM 3

Looking west at Dam 3

DAM 3 SPECIFIC OBSERVATIONS:

1. Very small Dam 3 was constructed across a subtle gully feature on a gently to moderately sloping hillside, with the embankment on its southern side.
2. The embankment was up to approximately 0.6m high and about 15m long. The crest was approximately 0.9m wide. The downstream and upstream shoulders graded between 12° and 15°.
3. The storage area contained water, as well as some reeds.
4. There was no formal spillway or outlet structure. Discharge from the dam appeared to flow over the embankment and extend into the nearby creek, which drained into the lower lying, much larger Dam 4.
5. The embankment was grass covered, however, the cattle track along the crest was devoid of grass.
6. The downstream and upstream shoulders were 'boggy' under foot, indicating dam leakage.

DAM 4

Looking south at Dam 4

Looking east at Dam 4

DAM 4 SPECIFIC OBSERVATIONS:

1. Large Dam 4 was constructed across a gully feature within gently sloping topography, with the embankment on its southern side.
2. A small creek discharged into the northern end of Dam 4. There were stagnant pools of water within the creek. On the western side of the creek was a shallow 'dry' stormwater channel, which also discharged into Dam 4. The sides of both the creek and stormwater channel were incised.
3. The embankment was up to approximately 3.5m high and about 90m long. The crest width ranged between 2.2m and 3.2m. The downstream shoulder graded between 10° and 18°. The upstream shoulder (above storage level) generally graded between 12° and 22°, however, the 0.2m height above the water storage level was sub-vertical.
4. The storage area contained water. The minimum observable elevation difference between the crest of the embankment and the water level on 29 May 2017 was about 100mm at the south-western corner of the dam. Scattered small to large size trees surround the storage area, where the dam is in cut.
5. There was no formal spillway or outlet structure. The dam appeared to spill over the lowest section at the cut to fill line at the south-western of the dam. This informal spillway was 'dry' at the time of our inspection and had been disturbed and devoid of grass by cattle tracks. The discharge from this informal spillway appeared to drain along the downstream toe towards the base of the gully.
6. The crest and shoulders were grass covered, however, some areas were devoid of grass; at least partially due to cattle tracks. The central portion of the embankment contained a dense coverage of small to medium size trees and weeds. Some trees on the downstream shoulder had fallen out.
7. Six burrows were observed along the downstream shoulder (refer to photograph below), some of which appeared to be interconnected.
8. The base of the gully flanking the creek, immediately beyond the downstream toe of the embankment, was 'boggy' under foot and the creek itself contained pools of stagnant water (refer to photograph below), indicating dam leakage.

Burrows in downstream shoulder of Dam 4 embankment

Dam 4 embankment looking south-west

Stagnant water in creek beyond downstream toe of Dam 4 embankment

DAM 5

Looking south at Dam 5

Looking south-west at Dam 5 embankment

DAM 5 SPECIFIC OBSERVATIONS:

1. Large Dam 5 was constructed across a shallow gully feature on a gently sloping hillside, with the embankment on its south-eastern side.
2. The small creek on the downstream side of Dam 4 discharged into Dam 5.
3. The embankment was up to approximately 4.3m high and about 130m long. The crest width ranged between 3.0m and 3.4m. The downstream shoulder generally graded between 8° and 28°, but locally up to 45° towards the north-eastern end of the embankment. The upstream shoulder (above storage level) graded between 16° and 33°.
4. The storage area contained water.
5. There was no formal spillway or outlet structure. Towards the north-eastern end of the embankment, an approximately 8m wide informal spillway had been cut through the embankment (refer to photograph below). Here, the observable elevation difference between the informal spillway and the water level on 29 May 2017 was about 100mm.
6. The crest and shoulders contained a sparse grass cover, as well as a dense coverage of small to large size trees and weeds, particularly at the south-western end of the embankment. Cattle tracks and evidence of fallen trees had exacerbated the scour and erosion of the upstream and downstream shoulders. Our inspection of the embankment was limited by the dense vegetation.
7. Two burrows were observed along the toe of the downstream shoulder, in the vicinity of the base of the gully. Two ant hills were observed along the crest of the embankment (refer to photograph below).
8. The base of the gully, immediately beyond the downstream toe of the embankment, was ‘boggy’ under foot, indicating dam leakage.

Informal spillway at north-eastern of Dam 5 embankment, looking south-west

Ant hill on Dam 5 embankment crest

DAM 6

Looking south-west at Dam 6

Looking east at Dam 6 embankment

DAM 6 SPECIFIC OBSERVATIONS:

1. Large Dam 6 was constructed across a shallow gully feature on a gently sloping hillside, with the embankment on its southern side. This shallow gully was east of the shallow gully across which Dam 5 was constructed.
2. Discharge from the informal spillway on Dam 5 drained into the lower Dam 6.
3. The embankment was up to approximately 3m high and about 80m long. The crest width ranged between 2.5m and 3.0m. The downstream shoulder graded between 13° and 31°. The upstream shoulder (above storage level) generally graded between 18° and 31°, however, the 0.2m height above the water storage level was sub-vertical.
4. The storage area contained water.
5. The downstream shoulder descended into the storage area of the lower lying Dam 7. The difference in the water storage levels between Dam 6 and Dam 7 was about 1.7m. It appeared that the toe of the downstream shoulder, towards the centre of the Dam 6 embankment, had been locally steepened to accommodate the storage area of Dam 7.
6. There was no formal spillway or outlet structure. At the western end of the embankment, an informal shallow spillway/drainage channel descended down to Dam 7 (refer to photograph below). At the time of our inspection, the channel contained stagnant water.
7. The crest and shoulders were grass covered. The grass cover was devoid in areas due to cattle tracks. There were scattered small trees and weeds along the embankment, with a localised dense coverage on the downstream shoulder. Our inspection of some of the downstream shoulder was limited by this dense vegetation.
8. Five burrows were observed towards the western end of the embankment (refer to photograph below).

Informal spillway/drainage channel at western of Dam 6 embankment, looking south-west

Burrow at western end of Dam 6 embankment

DAM 7

Looking south-east at Dam 7

DAM 7 SPECIFIC OBSERVATIONS:

1. Large Dam 7 was constructed across a shallow gully feature on a gently sloping hillside, with the embankment on its south-western side.
2. Discharge from the Dam 6 informal spillway/drainage channel drained into the lower Dam 7. A shallow gully feature also discharged into Dam 7 on its eastern side.
3. The embankment was up to approximately 4.5m high and about 90m long. The crest width ranged between 3.0m and 3.7m. The downstream shoulder graded between 11° and 30°. The upstream shoulder (above storage level) graded between 22° and 29°.
4. The storage area contained water. The minimum observable elevation difference between the crest of the embankment and the water level on 29 May 2017 was about 100mm at the north-western end of the embankment.
5. There was no formal spillway or outlet structure. The dam appeared to spill over the lowest section at the cut to fill line at the north-western end of the embankment. The discharge from this informal spillway appeared to drain along the downstream toe towards the base of the gully.
6. The shoulders were predominantly grass covered. The crest was devoid of grass cover; most likely due to cattle tracks. The embankment was generally covered with small to medium size trees and weeds. Our inspection of the embankment was limited by the vegetation.
7. There were deeply incised erosion features along the downstream shoulder. They appeared to have been initiated by cattle tracks and/or previously fallen trees (refer to photographs below).

8. A burrow was observed towards the south-eastern end of the downstream shoulder. Ant hills were also observed towards the ends of the embankment (refer to photographs below).
9. On the south-eastern flank of the gully feature immediately downstream of Dam 7, was a deeply incised erosion rill along the downstream toe of the embankment.
10. At the base of the gully, the toe of the downstream shoulder was sub-vertical to a maximum height of about 1m (refer to photograph below). At one section, boulders had been placed up against the sub-vertical face.
11. The base of the gully, immediately beyond the downstream toe of the embankment, was 'boggy' under foot and contained pools of stagnant water, indicating dam leakage.

Erosion features on downstream shoulder of Dam 7 embankment

Burrow at south-eastern end of downstream shoulder

Ant hill at north-western end of Dam 7 embankment

Sub-vertical toe along downstream shoulder of Dam 7 embankment

DAM 8

Looking south at Dam 8

Looking along crest of Dam 8 embankment

DAM 8 SPECIFIC OBSERVATIONS:

1. Large Dam 8 was constructed across a shallow gully feature on a gently sloping hillside, with the embankment on its southern side.
2. The embankment was up to approximately 3.5m high and about 70m long. The crest width ranged between 2.7m and 5.3m. The downstream shoulder graded between 13° and 28°. The upstream shoulder (above storage level) graded between 17° and 35°.
3. The storage area contained water. The minimum observable elevation difference between the crest of the embankment and the water level on 29 May 2017 was about 300mm at the western end of the embankment.
4. There was no formal spillway or outlet structure. The dam appeared to spill over the lowest section at the cut to fill line at the western end of the embankment. The discharge from this informal spillway appeared to drain along the downstream toe towards the creek at the base of the gully. At the time of our inspection, the informal spillway was 'dry'.
5. The embankment was covered with an abundance of small to large size trees and weeds. There were numerous fallen trees on the embankment. Our inspection of the embankment was limited by the dense vegetation.
6. There were erosion features along the downstream shoulder. They appeared to have been initiated by cattle tracks and/or previously fallen trees.
7. Numerous burrows were observed along the crest and downstream shoulder of the embankment (refer to photograph below). An ant hill was also observed towards the eastern end of the embankment.
8. Towards the western end of the embankment, was a deeply incised, 0.8m deep erosion feature at the toe of the downstream shoulder. At the time of our inspection, this feature contained a stagnant pool of water; indicating dam leakage. Further downstream was a creek, which also contained stagnant water (refer to photographs below).
9. Approximately mid-length along the embankment, on the eastern flank of the gully, the ground surface immediately beyond the downstream toe was 'boggy' under foot and contained pools of stagnant water, indicating dam leakage. This width of this feature was approximately 10m.

Burrow in Dam 8 embankment

Deeply incised erosion feature at downstream toe of Dam 8 embankment

Stagnant water in creek beyond downstream toe

DAM 9

Looking south-west at Dam 9

Looking north at Dam 9 embankment

DAM 9 SPECIFIC OBSERVATIONS:

1. Large Dam 9 was constructed across a shallow gully feature on a gently sloping hillside, with the embankment on its southern/south-eastern side.
2. The embankment was up to approximately 3m high and about 150m long. The crest width ranged between 2.5m and 3.0m. The downstream shoulder graded between 16° and 31°. The upstream shoulder (above storage level) was predominantly sub-vertical.
3. The storage area contained water. The minimum observable elevation difference between the crest of the embankment and the water level on 29 May 2017 was about 500mm at the north-eastern end of the embankment.
4. There was no formal spillway or outlet structure. The dam appeared to spill over the lowest section at the cut to fill line at the north-eastern end of the embankment. The discharge from this informal spillway appeared to drain along the downstream toe towards the base of the gully. At the time of our inspection, the informal spillway was 'dry'.
5. The crest and downstream shoulder of the embankment were grass covered and contained scattered small to medium size trees, shrubs and weeds, particularly at the western end. There was also a dead large tree in the downstream shoulder (refer to photograph below), as well as a fallen large tree. Our inspection of the embankment was limited by the vegetation.
6. There were cattle tracks along the upstream and downstream shoulders. These tracks initiated localised scour and erosion of the shoulders.
7. A burrow was observed towards the north-eastern end of the embankment. An ant hill was observed towards the western end of the embankment.
8. The base of the gully, immediately beyond the downstream toe of the embankment, was 'boggy' under foot and contained pools of stagnant water, indicating dam leakage. This maximum width of this feature was approximately 50m; tapering in width in a downstream direction (ie, towards the lower Dam 10).

Downstream shoulder of Dam 9 embankment and dead large tree, looking west

DAM 10

Looking east at Dam 10

DAM 10 SPECIFIC OBSERVATIONS:

1. Dam 10 was constructed across a shallow gully feature on a gently sloping hillside, with the embankment on its south-eastern side.
2. The gully below Dam 9 discharged into Dam 10.
3. The embankment was up to approximately 2m high and about 40m long. The crest width ranged between 3.0m and 3.5m. The downstream shoulder typically graded between 8° and 9°, however along the central portion of the embankment, the downstream toe was sub-vertical to a maximum height of 1m. The upstream shoulder (above storage level) was predominantly sub-vertical.
4. The storage area contained water. The minimum observable elevation difference between the crest of the embankment and the water level on 29 May 2017 was pabout 300mm at the south-western end of the embankment.
5. There was no formal spillway or outlet structure. The dam appeared to spill over the lowest section at the cut to fill line at the south-western end of the embankment. At the time of our inspection, the informal spillway was ‘dry’.
6. The crest and downstream shoulder of the embankment contained a sparse grass cover, as well as small to large size trees (including one large dead tree) and weeds. The sub-vertical length of the downstream toe was covered in dense weeds, thus limiting our inspection.
7. Numerous burrows were observed along the downstream shoulder, some of which appeared to be interconnected (refer to photographs below).

Burrows in downstream shoulder of Dam 10 embankment