APPENDIX G

EASTERN AREA

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G1. EASTERN QUARRY FACE

Photo G1 shows the eastern quarry face, which is composed entirely of diatreme breccia.

Photo G1: Eastern Face of Quarry

The area above the quarry face is shown in Photo G2.

Photo G2: The Eastern Zone

The obvious geological features of the eastern face are the bedding surfaces in the breccia, forming what looks like a “bowl” structure. In fact detailed mapping of the bedding surfaced shows that the view in Photo G1 is akin to a slice throughout the side of a trumpet full of slumped material, as illustrated in Photos G3 and G4.

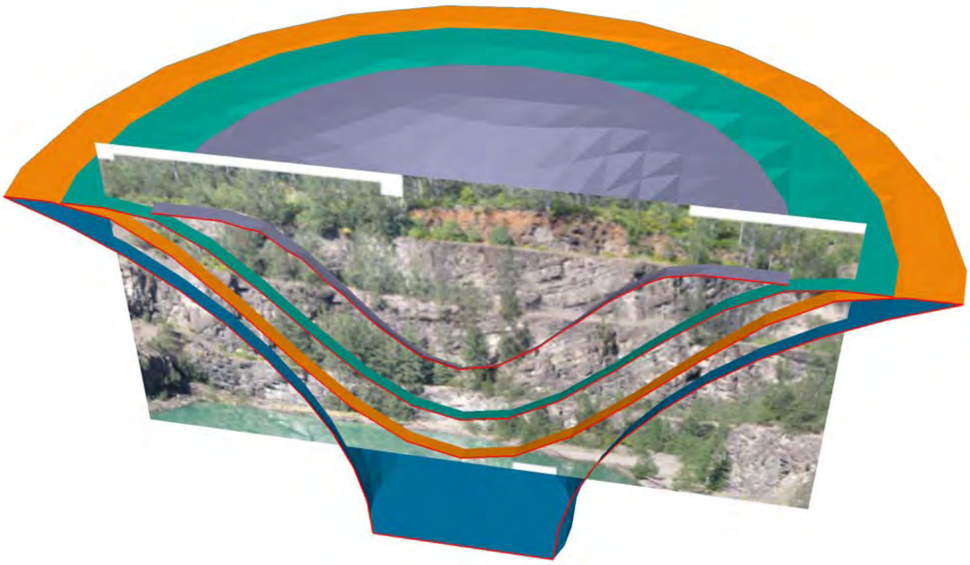

Photo G3: Face view illustration of eastern face in relation to “trumpet” shape of eastern diatreme body

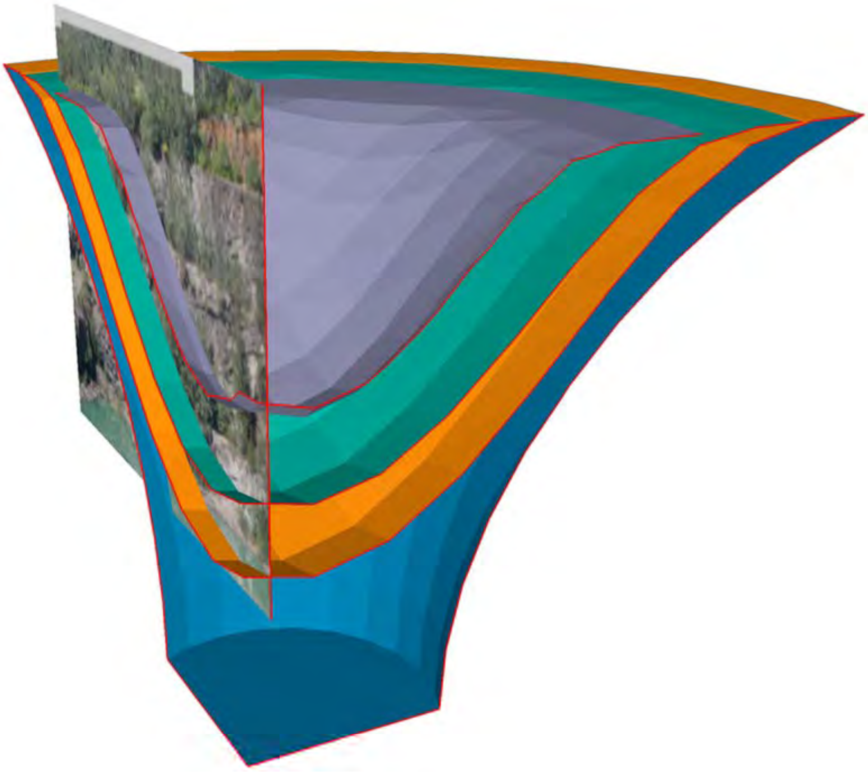

Photo G4: Side view showing interpretation of bedding

Alternative interpretations of the bedding orientations within the 'trumpet' are possible but the model adopted here is conservative from the viewpoint of stability assessment of the eastern face.

A scaled drawing of the eastern face is presented in Drawing PSM1059-15. This scaled drawing is based on field measurements of bedding orientations and on Photo P1.

Drawing PSM1059-7 shows a section (Section 2) at right angles to the face approximately midway within Photo G1. The bedding orientations interpreted in Drawing PSM1059-7 are based line mapping undertaken by Coffey in 1989 on the benches at RL 40m, RL 68m and RL90m, and on oriented core from boreholes BH101 and BH102. Other interpretations of the geology of the eastern face are possible, but the one given in Drawing PSM1059-15 accepts the core orientation data in BH101 and is relatively pessimistic from the viewpoint of overall slope stability. Notwithstanding this "pessimistic" interpretation the stability analyses of the eastern quarry face indicate high factors of safety against deep seated failure (see Appendix E), consistent with those normally required for civil engineering structures.

The diatreme/Hawkesbury boundaries shown on Drawings PSM1059-7 and PSM1059-15 are based on surface mapping and borehole BH103. The existence of a transition zone between the breccia and Hawkesbury is based on boreholes BH103 and PSM1.

As shown on Drawing PSM1059-15 a major slip occurred in the southern face of the quarry sometime during quarry operations. The slip surface was one of the bedding surfaces, at an angle of 65° to 70°.

The overall stability of this eastern face is dealt with together with the other faces of the quarry in Appendix E. The remaining parts in this Appendix deal with the land to the east of the face, namely the eastern development zone as shown on Drawing PSM1059-3.

G2. LAND ABOVE EASTERN QUARRY FACE

G2.1. Coffey Investigations 1989 and 1990

In 1989 and 1990 Coffey and Partners Pty Ltd (Coffey) undertook detailed geotechnical studies[1] of the area to the east of the eastern quarry face (see Figure G1). The work was directed at assessing slope stability and drainage issues in relation to existing fill areas (including the "playing field") and proposed extensions to the playing field area.

[1] Coffey and Partners Reports S8463/4-AD, May 1990 and S8463/3-AG, July 1990.

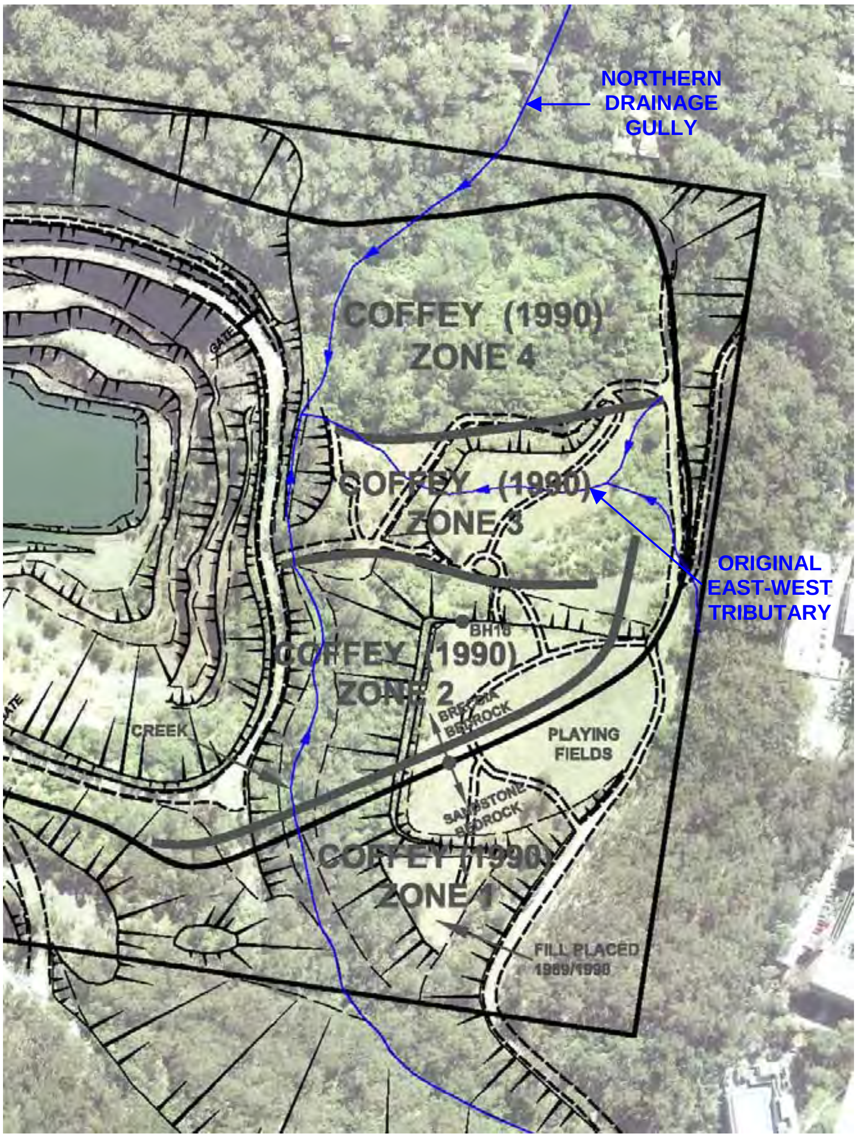

Figure G1: Eastern Development Area Zones

Substantial field investigations were conducted that included the following:

- 47 boreholes (including three very deep holes), with 37 fitted with standpipes,
- 11 test pits,
- mapping of the eastern face of the quarry, and
- laboratory testing of disturbed and undisturbed samples.

Since the time of the Coffey investigation there has been little change to the eastern area. Additional fill was being placed at the south of the existing "playing field" (see Figure G1) while Coffey were undertaking their field work. Since 1990 additional fill has also been placed in the gully area north of the playing fields (Coffey Zone 3 as discussed in detail in Section G2.2, below).

As part of the present study PSM excavated eight test pits within the eastern area. The results are detailed in Appendix A. In essence they confirmed the findings reached by Coffey in 1989 and 1990.

PSM has reviewed the Coffey reports S8463/4-AD and S8463/3-AG and is of the view that they provide an appropriate data source for the assessment of existing constraints on development of the land east of the quarry. Therefore, this section of the report gives PSM's recommendations regarding geotechnical constrains on developments in this eastern area based on the data in the Coffey report, supplemented from test pit and survey data obtained by PSM for this study.

G2.2. Geotechnical Zones

In 1990 Coffey divided the eastern part of the quarry into four zones, as shown in Figure G1. This subdivision remains valid. The zones are described in the following sub-sections.

Zone 1

This zone is underlain by sandstone and lies south of the breccia/sandstone boundary which passes NE-SW through the middle of the existing playing field. This zone consists of breccia fill, varying from zero to about 10 meters thick, overlying shallow residual sandy clays over weathered sandstone. No subsurface drainage was provided beneath the fill in this area. The eastern part of the playing field is cut into the natural Hawkesbury Sandstone profile (see Photo G5).

Photo G5: View of Zones 1, 2 and 3 of the Eastern Area from the North East. The road in the left corner of the photo loops up to the TAFE access road.

Controlled fill is reported by Coffey to have been placed at the SE corner of the playing fields (see Figure G1 and Photo G6). They also report that prior to fill placement in this latter area, subsoil drains were installed. This area is now a level, grassed triangular shaped piece of land, about 2m below the level of the "playing field".

The fill consists of a mixture of cobbles and boulders of breccia in a clayey sandy gravel matrix. The breccia boulders range in size up to about 0.5m across. The fines in the matrix are of medium plasticity. The sandstone underlying the fill is typically extremely weathered for approximately the upper 2.5m, below which highly to moderately weathered sandstone occurs.

Photo G6: Fill Area South East of "Playing Field"

The batters below the fill areas, which are part fill and part natural hillside, are moderately steep and are now densely overgrown. The stability of these slopes is discussed in Section G5.1, below.

Zone 2

The second zone extends northwards from Zone 1 to near an access roadway. In this zone, breccia underlies all but the easternmost part of the fill. The stratigraphy consists of breccia fill overlying the natural breccia land surface, again with no subsurface drainage provisions.

Coffey was given to understand from Hornsby Quarry personnel, that a "key trench", some 1.5m deep and 4.5m wide was excavated along the toe of the batter to the playing fields and backfilled with compacted fill. The dimensions or nature of this trench are unknown.

West and downslope of the fill batters, the northwards draining creek has incised deeply into the weathered breccia, giving steep sides to the creek, with the fill batter and creek slope forming a more or less continuous slope from the top of the fill to the flat floored sandy creek bed. The lower part of the slope exposed in the bank of the creek, consists of extremely to highly weathered breccia. There is alluvium along and either side of the natural creek bed. This is an area of quite "rugged" terrain, presently densely overgrown.

Zone 3

The third zone extends northwards from an access roadway to the east-west drainage course. In this zone breccia underlies all but the easternmost part of the fill. Up to about 20m of breccia fill overlies about 1.5m of residual sandy clay, before extremely to highly weathered breccia is encountered.

Prior to filling, a tributary creek ran from east to west in about the centre of Zone 3 (see Figure G1). Fill has been placed over this depression and the watercourse visible now is north of the natural one and marks the northern limit of the filling. It is understood that the drainage course was cleaned "to rock" prior to fill placement, although it has not been possible to confirm this. It is further understood that no attempt was made to provide any subsurface drainage measures in the depression.

Fill was continued to be placed in this Zone after the Coffey study of 1990. In the SE corner of this Zone there appears to have been random dumping of fill from an unknown source, and this area is quite chaotic. In the central part of this zone, where fill was placed from stripping of the north face of the quarry there are very steep batters extending down to the present drainage system (see Photo G7). The fill attains a maximum depth of about 20m along the line of the original east-west tributary (see Drawing PSM1059-20).

Alluvium associated with the creek system consists of sandy clay of low to medium plasticity and is approximately 1m thick. Underlying the alluvium is about a 1m thick layer of residual sandy clay which overlies weathered breccia.

Surface drainage in Zone 3 is very poorly controlled.

Photo G7: Telephoto View of Part of Eastern Area, taken from Upper North Face of Quarry.

Zone 4

The fourth zone comprises the area north of the east-west drainage depression (see Figure G1). This area is located on a ridge and is underlain by residual clays overlying weathered breccia. A borehole located on the ridge encountered about 6m of extremely to highly weathered breccia. A second borehole on the midslope showed residual soil and EW breccia to 4.5m depth and "rock" strength HW/MW breccia from about 5.5m depth. A third borehole at the base of the slope, showed "rock" strength breccia at about 4m depth.

Over most of the area, the residual sandy clay layer varies in thickness from about 0.6m to 1.3m.

To the north sandstone outcrops along the base of the northern drainage gully (see Figure G1), and to the east sandstone outcrops on the steeper hillside. To the west, a broad area of alluvium exists, through which the northern drainage gully has eroded, exposing the underlying weathered breccia. Located between the creek and the quarry haul road is a relatively thin ridge of weathered breccia.

The slightly weathered to fresh breccia occurs at about RL 90m in the quarry as shown on the geological cross-sections.

Approximate contours of fill thickness in the eastern area have been prepared, as shown in Figure G2, by comparing the 1961 and 2006 contour plans. On the basis of these contours the total volume of fill in the eastern area (Zones 1, 2 and 3) is calculated as approximately 370,000 cubic metres.

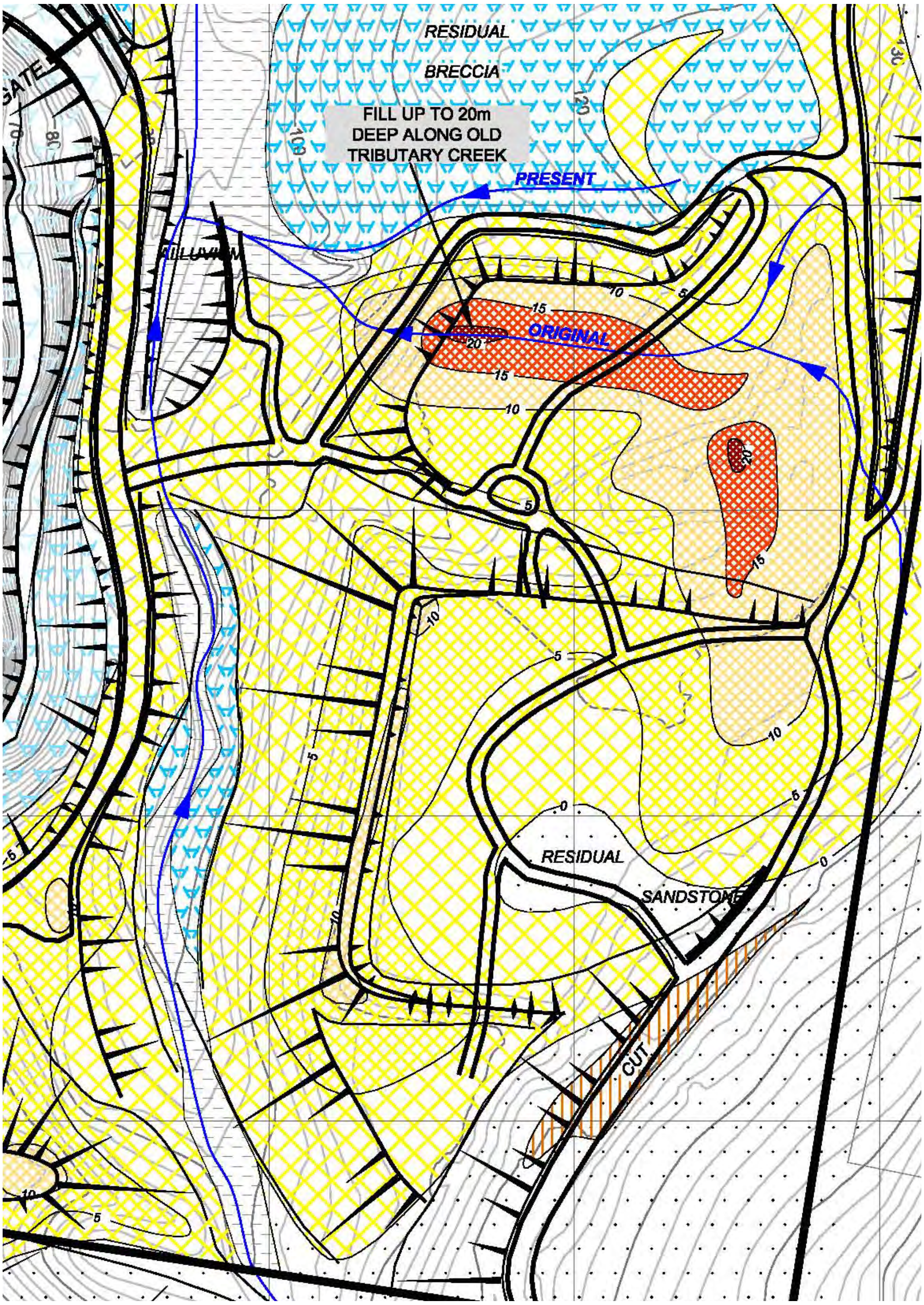

Figure G2: Isopachs of Fill Thickness in the Eastern Area

G3. MATERIAL PROPERTIES

The primary materials in the geotechnical zones 1 to 4 are:

- breccia fill
- residual soil derived from breccia
- extremely weathered (soil like) breccia
- highly weathered breccia
- Hawkesbury Sandstone.

The detailed laboratory test reports on samples of the above materials are given in Coffey report S8463/3-AG of July 1990 and are summarised in Table 1.

TABLE 1
SUMMARY OF EFFECTIVE STRENGTH, MOISTURE CONTENT AND PLASTICITY PARAMETERS

MATERIAL	BOREHOLE	DEPTH	DENSITY t/m^3	M/C INITIAL	COHESION kPa	FRICTION deg	LIQUID LIMIT %	PLASTIC LIMIT %	LINEAR SHRINKAGE
Residual	16	0.8-1.15	1.8	35.7	25	29	71	45	10
	26	0.7-1.0	1.83	40.0	11.5	29	66	37	17.5
	41	2.3-2.6	2.02	19.1	10	28	38	23	10.0
	TP1	0.4	1.99	21.6	0	41			
	BH6	1.5-1.85	2.09	15.0	4	29			
EW	33	0.7-0.95	1.74	30.5	21	20	51	20	11.0
	45	0.8-1.15	1.88	27.1	13.5	34.5	49	20	10.0
	46	2.4-2.7	1.87	23.3	0	33.5	37	22	9.0
	TP11-1	1.2-1.5	2.13	32.0	0	27.0			
	TP11-2	1.2-1.5	2.13	36.4	25	26.0			
	TP11-3	1.2-1.5	2.13	31.30	40	24.0			
	TP1	0.8	1.83	32.5	25	26			
	TP1	0.9	1.88	23.0	80	32			
	TP3	13	1.92	20.0	80	17			
EW/HW	TP10	1.0-1.3	2.20	-	28	39			
Fill	1-SE Field	-	1.96	20.7	0	35	44	22	10.5
	2-Stock-pile	-	1.98	19.7	15	29.5	46	22	10.5

Based on the test data and field inspections the respective materials are described as set out below.

Breccia Fill

The breccia fill consists of brown, clayey sandy gravel matrix, with boulders up to about 500mm (see Photo G8). The test results show the fine grained portion to be of medium plasticity with more plastic material in some places. The matrix material is moderately reactive in respect to shrink/swell potential.

Photo G8: Fill Excavated in “Playing Field”

Residual Breccia Soils

In its fresh condition the breccia is very strong. However, the weathered zone is of considerably lower strength and is of greater importance to the stability of the eastern fills.

On the sloping parts of the site the uppermost red clay soils are the result of insitu weathering of the breccia. These residual soils are all of soil strength and show little rock structure. Typically these soils are 1 to 1.5m thick and are underlain by extremely weathered breccia. These soils vary in plasticity from medium to high plasticity. The material is moderately to highly reactive.

The extremely weathered breccia has soil strengths but retains rock-like structure and has some pieces of weathered rock. As the depth increases the rock structure becomes more evident and the proportion of rock strength material increases until highly weathered breccia is encountered with essentially rock type strengths. This transition zone is of substantial thickness in the ridges. In some instances there is an ordered transition. However, at others there are a series of bands of material alternating between extremely and highly weathered material.

Extremely Weathered Breccia

Coffey found that testing of the extremely (EW) and extremely to highly weathered (EW/HW) breccia was difficult because of the rock-like structure. For this reason a number of large size shearbox tests were undertaken on block samples cut from test pits. There is a gradual change in the ground from the residual soil/extremely weathered breccia to highly weathered breccia, and this is reflected in the substantial scatter of the test results (see Table 1).

Hawkesbury Sandstone

The slopes along the eastern boundary of the site, which extend up to and beyond the TAFE building, comprise a shallow cover of residual sandy soil over typical Hawkesbury Sandstone. The residual soils have been stripped along much of the access track that descends from Quarry Road, and also within the south eastern part of the "playing field". In these areas there is sandstone at the surface.

As already discussed, part of the "playing field" area in Zone 1 comprises breccia fill placed over a natural Hawkesbury Sandstone profile. Typically the underlying profile comprises up to about 1m of residual soil, and 1m to 3m or extremely weathered sandstone, over less weathered sandstone with a typical unconfined compressive strength of greater than 15MPa.

The Hawkesbury Sandstone profile does not constitute a constraint on the stability of the existing fills in the eastern area. The constraints are created by the properties of the breccia fill and the underlying residual breccia soils.

Parameters for future designs of foundations, roads and retaining walls located within the Hawkesbury Sandstone footprint, may be taken from Table 2.

TABLE 2
ROCK MASS PARAMETERS FOR HAWKESBURY SANDSTONE

CLASS	SUBSTANCE			MASS STRENGTH			MASS		
	UCS (MPa)	σ^t (MPa)	E (GPa)	UCS (MPa)	c' (kPa)	ϕ' (°)	UNIT WEIGHT (kN/m^3)	MODULUS (MPa)	GSI (b)
Sandstone I / II	12-50	2-6	8-14	15-25	(a)	(a)	24	900-2500	65-75
Sandstone III	7-25	0.5-3	6-10	5-20	(a)	(a)	24	350-1200	45-65
Sandstone IV / V	1-7	0.1-0.5		<1-4	(a)	(a)	24	50-700	30-45

(a) The value of GSI which is included in the table can be used to obtain c' and ϕ' which are dependent on the in situ stress.
(b) Geological Strength Index defined by Hoek et al (1995).

G3.1. Design Parameters for Stability Analyses

The design parameters for stability analyses adopted by Coffey Partners in 1990, and supported by PSM is this review are set out in Table 3.

TABLE 3
SUMMARY OF EFFECTIVE STRESS PARAMETERS
FOR STABILITY CALCULATIONS

MATERIAL	COHESION kPa	ANGLE OF FRICTION DEGREES	TOTAL DENSITY TONNES/M^3
Fill	10.0	30.0	2.0
Residual	5.0	28.5	1.95
EW Breccia	20.0	25.0	1.95
EW/HW Banded (south end)	30.0	27.0	1.95
HW Breccia	28.0	39.0	2.0

G4. GROUNDWATER REGIME

G4.1. Field Observations

The original landform of this eastern area has been modified by the placement of significant volumes of fill, and infilling of drainage depressions. In particular, the east-west tributary was infilled and the drainage moved to the north.

Following periods of heavy rainfall, seepage emerges particularly near the fill/natural surface interfaces. During their 12 month field work programme Coffey noted significant flows at the following locations:

- near the toe of the fill batter on the line of the old east-west tributary, measured at 5 litres/sec, approximately 6 hours after rain had stopped;
- emerging along the western toe of the existing "playing field",
- emerging halfway along an access road located at the northern end of the playing field.

The surface runoff from the slope uphill (to the east) of the playing field is intercepted by roughly formed surface drains located along the base of the slope. These surface drains lead to a pipe which runs from about the centre of the site northwards. In 1990 it was observed during wet periods that almost all of the flow from the centre and southern slope disappeared into the fill before reaching the pipe.

G4.2. Piezometer Measurements

In report S8463/3-AG of July 1990, Coffey provide the results of monitoring of 37 standpipes during the period mid-December 1989 to mid-March 1990 (3 months). There is no record of these 37 standpipes having been measured after March 1989. However, as part of the present study PSM used a differential GPS system to pin-point the location of one of Coffey's deep piezometers (BH18, see Figure G1). The standpipe was found after excavating some fill, and re-measured. The water level was found to have been essentially at the same level as measured by Coffey in January 1990 (about 55m below the surface).

It is important to note that during the 3 months that Coffey monitored the standpipes there was a period of very heavy rainfall. In February 1990 some 430mm of rain was recorded at Wahroonga. This was the month when there was widespread landslip damage in Warringah and Pittwater Shires and the rainfall was of the order of a 1 in 100 year event. Of the 37 standpipes, 13 showed groundwater level rises, followed by similar falls, of between 0.5m and 3m. The rises did not represent a consistent pattern across the eastern area. While most responses were in standpipes located in the weathered breccia horizon (depths between about 8m and 16m), there were similar standpipes that showed no reaction to the heavy rainfall. Similarly three of the standpipes in fresh breccia showed rises of between 0.5m and 2.5m, but others in fresh breccia showed no reaction. This apparent lack of 'pattern' does in fact tell us much about the groundwater regime and associated design criteria, as discussed in Section G4.3, below.

G4.3. Interpreted Groundwater Regime and Design Criteria

As expected from geological considerations, the piezometer data show that there are two groundwater systems, namely;

- System 1: a shallow, perched groundwater system within the fills and underlying weathered breccia, and
- System 2: a deep level system within the fresh breccia, and surrounding Hawkesbury sandstone.

As illustrated in FigureG3 (reproduced from Coffey's 1990 report) System 1 (perched) is controlled by surface infiltration, and leakage through the lower permeability weathered breccia to the underlying jointed fresh breccia.

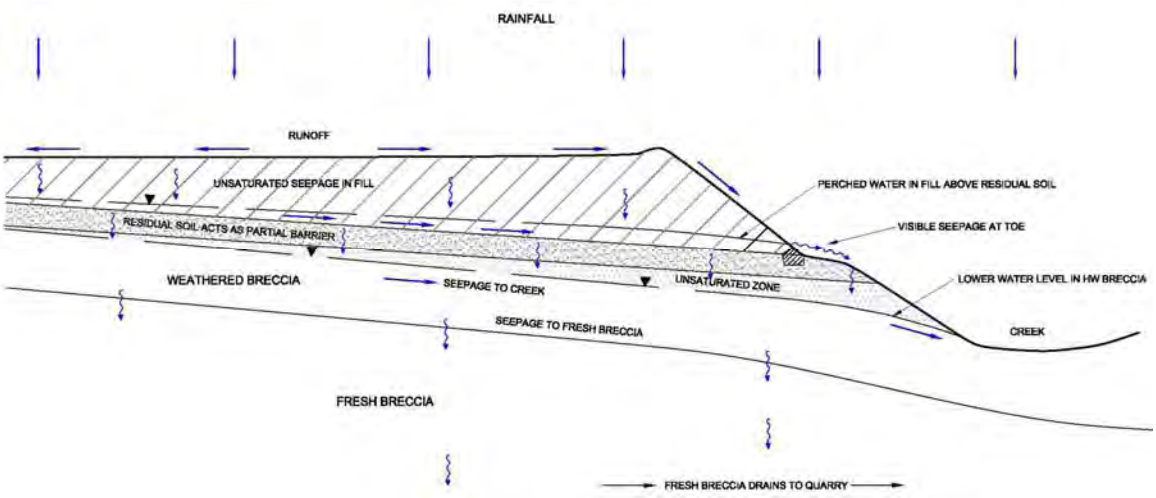

Figure G3: Groundwater Regime in Existing Playing Field Area

Input to System 2 is the downward leakage from System 1, and groundwater movement from the joints and bedding planes in the Hawkesbury Sandstone surrounding the diatreme. Output from System 2 is seepage into the quarry pit.

The groundwater in System 1 (perched) is stored both in the soil and fill pores and in fractures in the weathered breccia. The groundwater in System 2 is stored in the joints and bedding defects in the fresh breccia.

As demonstrated by the Coffey piezometer monitoring in 1989/1999, the fact that most of the groundwater in Systems 1 and 2 is within joints and bedding defects, and that downward seepage from System 1 is not uniform, means that there is a non-uniform response in groundwater pressures to heavy rainfall events.

If a particular standpipe intersects a particular joint that is connected to a location of ready recharge (surface to System 1, or leakage from System 1 to System 2), then that standpipe will show response to rainfall events. Conversely, if a nearby standpipe taps into joints that are shielded from ready recharge, little or no response to rainfall is measured. The importance of this understanding is that readings from individual piezometers, or even sets of piezometer, cannot be used to determine groundwater pressures for engineering design. It is necessary for a conservative view to be taken on the basis of a broad understanding of the groundwater model summarised above. PSM's recommendations are set out below and are based on finite element seepage analyses using conservative rock mass permeability values. These are consistent with those proposed by Coffey in 1990 for the design of extending playing field areas in the eastern area of the pit.

Zones 1 and 2 (existing playing field area)

Figure G4 shows the design groundwater regime for use as a starting point for slope stability assessment of any proposed development within the vicinity of the existing playing field. In essence this groundwater regime comprises:

- System 1: (Fill, residual soils, highly and extremely weathered breccia)
    - piezometer head at natural surface where no overlying fill, and controlled by a point 3m below the crest of the playing field for the fill zones.
- System 2: (fresh breccia)
    - piezometric level at RL 90m beneath playing field, falling linearly to pit water level (this RL 90m level is about 15m above the maximum measured water level in the fresh breccia).

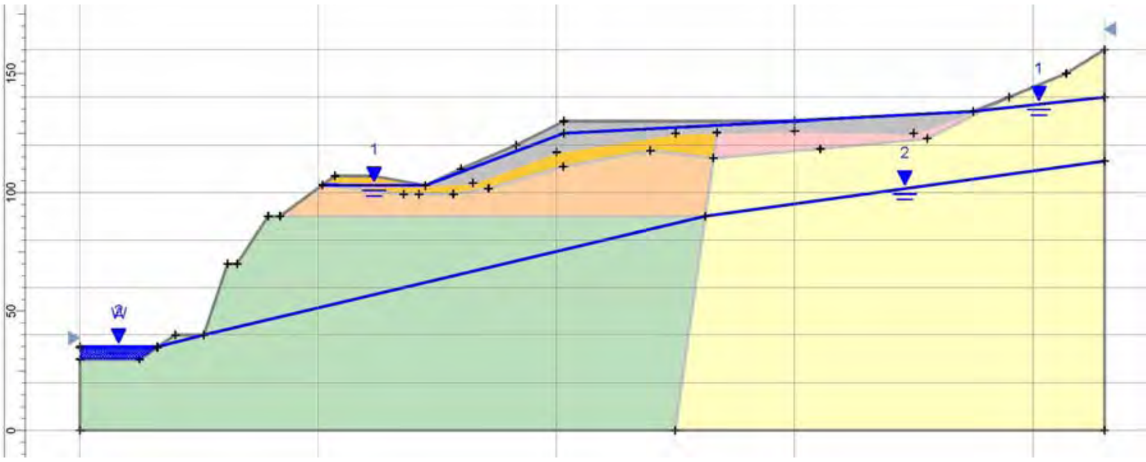

Figure G4: Recommended design piezometric surfaces for existing conditions in Zones 1 and 2

It must be noted that the above design criteria are for the ground as it exists at present. These groundwater pressures could be modified by drainage measures. Certain such measures were proposed by Coffey in 1990 for proposed extensions to the playing fields. Without such measures Coffey concluded that the safety factor (FOS) of the western batter of the playing field (including the natural slope down to the creek – see Figure G1), was about 1.3 (see Section 5.2 of Coffey report S8463/3-AG). To achieve the normal design requirement of FOS = 1.5, it was shown that it was necessary to implement certain drainage measures, and to construct a rockfill buttress against the natural creek bank, or flatten the western batter of the playing field. As far as PSM can determine from an examination of air photos and documentation provided by Council, none of this work was done.

Zone 3

The groundwater regime in this area is quite complex because of the infilled, east-west, drainage gully and the various zones of filling placed primarily during “stripping” of the upper north face of the quarry. Based on a study of air photographs this filling started about 1986 and ended sometime between 1993 and 1997. Therefore much of this filling post-dates the Coffey study of 1989.

It is interpreted by PSM, from the piezometer monitoring in 1989/1990, that groundwater levels in the old infilled east-west water course (see Figure G1) respond quite rapidly to rainfall events. Therefore it is concluded that this infilled water course must be taken as a “feeder” into the fill area. Therefore for Zone 3 the design recommendations are:

- System 1: piezometric level at ground surface
- System 2: piezometric level at RL 90m beneath the fill zone, falling linearly to pit water level.

Zone 4

No significant filling has occurred in this area. The design piezometric system is as given in Figure G5 and comprises the following:

- System 1: piezometric surface at ground surface in the slopes below RL 110m, and 2m below the surface in the upper slope above RL 120m

- System 2: at RL 90m about 150m from the top of the eastern quarry face, dropping linearly to pit water level.

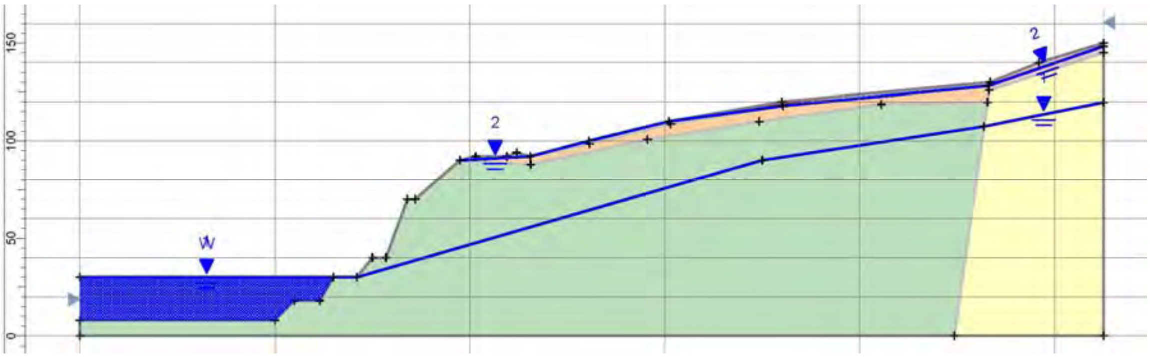

Figure G5: Recommended design piezometric surfaces for existing conditions in Zone 4

G5. CONSTRAINTS ON THE EASTERN DEVELOPMENT PART

The approximate 11 Hectare area comprising the Eastern Development Part could be developed in any number of ways, ranging from, say, a botanic gardens through to a high technology industrial park. Therefore, there could be buildings, roads, swimming pools, playing fields, picnic areas, school facilities, or any number of similar developments. New level areas of fill have been created over most of Zones 1 and 2 (see Photo G8), but, as discussed below, these fills cannot be relied upon as being “Controlled Fills”.

It is beyond the scope of this study to set out the detailed constraints on all possible developments. However, the principal constraints can be set out under the categories of:

- slope stability,
- surface and subsurface drainage,
- foundation conditions,
- earthworks.

It should also be noted that the terrain downslope of the three main fill platforms (see Figure G1 and Drawing PSM1058-3) is steep (best termed “rugged”) which constrains development of this portion of the 11 Hectares.

For certain developments, such as buildings, an economical solution could be to remove the fill and dump it back in the quarry void. At the other extreme a botanic gardens style development may only require re-contouring of the fill so as to improve discharge of the surface runoff.

Photo G8: "Playing Field" Area and Lower Fill Area to South East

G5.1. Slope Stability

Two cross-sections have been analysed to assess slope stability constraints, namely a section through the existing "playing field" (Coffey Zones 1 and 2), and a section through the natural hillside of Zone 4.

Playing Field Area

Figure G6 summarises the analyses of the existing playing field assuming the recommended design piezometric pressures set out above. The computed maximum safety factor is 1.2, which is slightly lower than the 1.3 obtained by Coffey in 1989 for slightly more optimistic water pressures. The normal requirement is for a safety factor of 1.5. Therefore the current analyses simply reinforce the recommendations made by Coffey in 1989 to the effect that, stabilisation works are necessary either in the form of a toe buttress to the existing playing field fill, or improved and maintained drainage measures. PSM recommends the toe buttress option because it is difficult to retrofit reliable subsurface drainage measures.

Given the similar geometry of the uncontrolled fill in Zone 3, to the north of the playing fields, it is certain that this area would also require buttressing, or recontouring to achieve a factor of safety of 1.5.

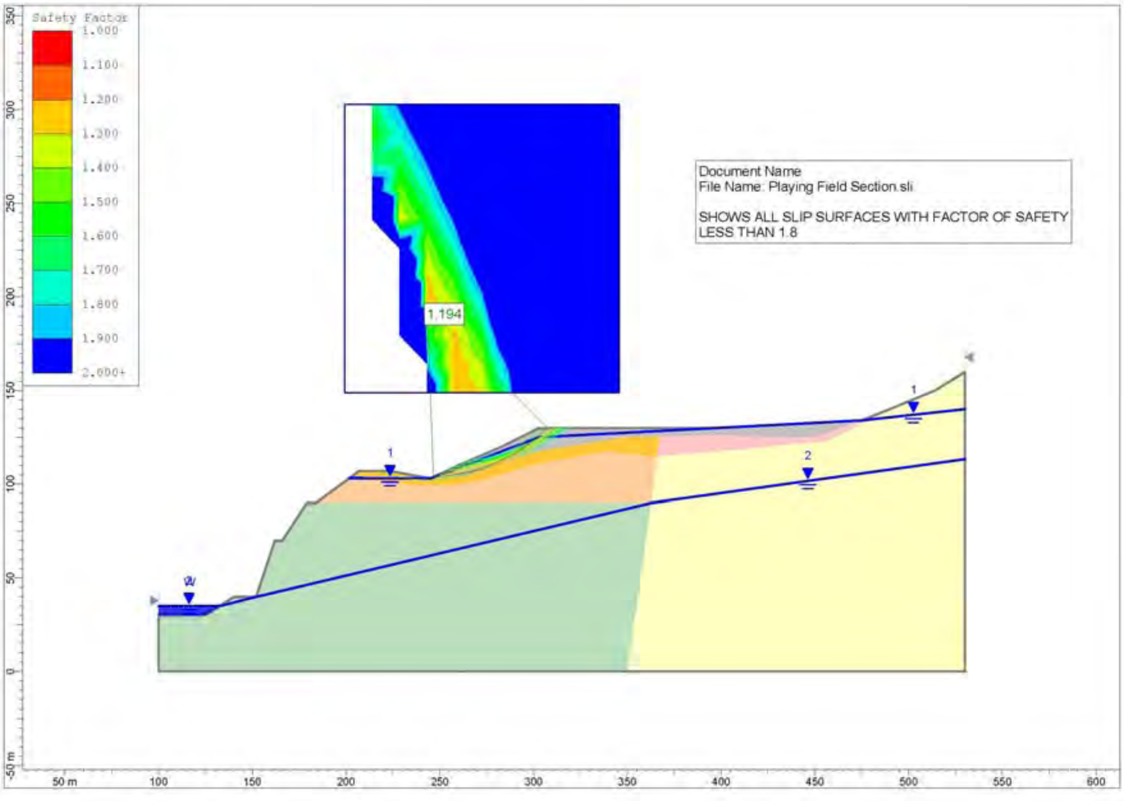

Figure G6: Stability analysis of existing playing field area using recommended design piezometric pressures

<u>Natural Hillside</u>

Figure G7 summarises the analyses for the natural hillside of Zone 4. The computed maximum factor of safety is greater than 2.0 so therefore there are no overall stability constraints on the development of this zone.

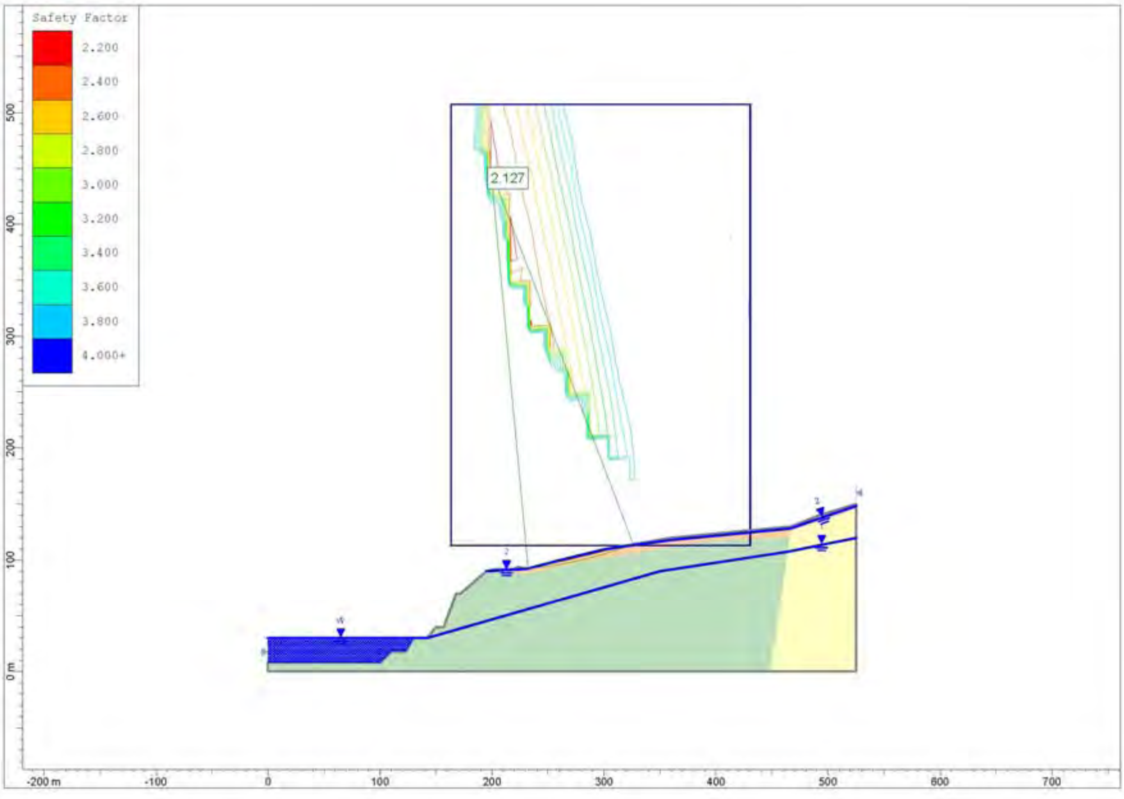

Figure G7: Stability analysis of natural slope in Zone 4

G5.2. Surface and Subsurface Drainage

The major issue with this eastern development area is that control of surface runoff is very poor. As part of any redevelopment of this area a complete surface drainage plan will have to be formulated.

The original west east drainage tributary in Zone 3 (see Figure G1) was infilled with waste material from the quarry. It is known that significant groundwater flows occur through this infilled creek following periods of heavy rain. In 1990 Coffey recommended (Report S8463/3 Figure 3) that a large rock drain be constructed within the old gully so as to control subsurface pressures. PSM have seen no evidence that this work was done. However, it is clear from airphotos that fill continued to be placed in this area by the quarry operators well after 1990. Therefore the assumption is made that surface and subsurface drainage works would have to be undertaken in this area, with the magnitude of such works depending entirely on the proposed development.

G5.3. Foundation Conditions

Zones 1, 2 and 3

Most of these zones contained uncontrolled fill up to 20m in depth, locally, although there are significant areas with sandstone close to the surface or with less than about 2m of fill that could be stripped (see Figure G2).

Buildings in these zones would mostly have to be supported on piles driven or drilled through to the underlying weathered breccia and weathered sandstone. However, there would be settlement issues (long term creep) with associated roads and services to the buildings. These issues could largely be dealt with by careful layout of the developments. However, it is likely that a development such as a high technology industrial park, or a school, would require substantial re-engineering of the existing fills.

Zone 4

There are no significant constraints on this zone other than the upper parts below Fern Tree Close are quite steep. The natural residual soils are moderately reactive but this can be easily dealt with by appropriate foundation designs.

G5.4. Earthworks

It is PSM's view that none of the existing fills in the eastern zone can, a priori, be relied upon as being properly engineered and controlled fills. In 1989 Coffey reported that fill then being placed to the south of the playing field was being controlled. However, PSM has seen no documentation covering this filling that would give confidence as to the suitability of this fill for structural support.

It is possible that detailed investigations for particular proposed developments may show that certain areas of fill can be used, as-is, for support of roads, parking areas etc. At this time such areas cannot be defined. Thus, while most of the existing fill materials are of suitable character for use in controlled fills, it should be assumed that excavation and re-compaction is necessary to achieve appropriate density and stiffness.

G6. REFERENCES

1. Hornsby Shire Council. Rock Mechanics Study, Hornsby Quarry, Old Man's Valley. Coffey & Partners Report S8463/4-AD May 1990.

2. Hornsby Shire Council. Old Man's Valley, Geotechnical Investigation. Coffey & Partners Report S8463/3-AG July 1990.