GEOTECHNICAL AND HYDROLOGICAL DESK STUDY REPORT

MONEYSTONE QUARRY, OAKAMOOR, STAFFORDSHIRE

Report 418040DS March 2011

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1. INTRODUCTION

On the instruction of Bolsterstone plc, on behalf of Laver Leisure, a desk study was carried out by Abbeydale Building Environment Consultants Ltd on a site to the north and south of Eaves Lane.

The site is located on the between the village of Whiston and Oakamoor Village and is centred within National Grid Reference square SK 044 459 between 110m to 240m AOD. See Fig 1. The site covers an area of approximately 170 hectares.

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Our desk study assessment has been divided into four separate reports, namely:-

Desk Study Report	418040DS dated March 2011
Factual Report	418040GR dated March 2011
Environmental Assessment	418040EA dated March 2011
Flood Risk Assessment	418040FR dated March 2011

This desk study report covers the physical geotechnical aspects of the ABEC site assessment and is based on factual data presented in the factual report and data referenced within the reports.

The comments and recommendations presented in these report are based on the findings of a review of available information. There may be other conditions prevailing on the site which have not been recorded by the available information and therefore have not been taken into account by this report. Responsibility cannot be accepted for unrecorded information.

When writing this report the proposed development was for an extreme activity holiday park with a hotel, lodges, lakes and lagoons. There will be potential to offer water sports including scuba diving, swimming, sailing, canoeing etc along with fishing. The park will also offer other outdoor activities such as mountain biking, nature trails, climbing, clay pigeon shooting etc. If there are changes to these proposals, then some modification to the comments and recommendations given may be required.

2. THE SITE

The proposed development is to be constructed on an irregular shaped parcel of land located between the River Churnet which bounds the southern extremity of the site and Rock Cottage which is located off Blakeley Lane approximately 100m to the north of the site. Eaves Lane runs between the site trending approximately east-west, separating the site into two areas. Blakeley Lane bounds the northern half of the site to the east, trending north-south. The site is accessed off the south side of Whiston Eaves Lane via a road which leads to the processing area and carparks.

The site can be broadly separated into six main areas, see Fig 2.

1. Quarry 1 - both east and west, located on the south side of Eaves Lane.
2. Quarry 2 - both east and west, located on the north side of Eaves Lane.
3. Quarry 3 - located on the south side of Eaves Lane, to the west of the site access road.
4. Eastern Area - Farmland associated with Crowtree Farm east of the quarry and production areas.
5. Western Area - Farmland located between the quarry and Whiston village.
6. Processing area which includes ancillaries such as conveyors, fuel tanks, storage sheds, workshops, offices and a materials laboratory.

To the south of the processing area, in the far south of the site, is a disused railway sidings, beyond which is the River Churnet which flows in a meandering channel towards the east.

The land surrounding the site is rural with scattered villages, cottages and farms. The primary land use is grazing and hay cutting which has resulted in some herb rich pasture and meadows. The site is directly adjacent to, or contains within, several areas of potentially sensitive landscape features as given below;

- Adjacent to the southwest boundary of Quarry 3 is Whiston Eaves Site of Special Scientific Interest (SSSI). The SSSI comprises a series of species rich meadows, managed as grazing pasture or hay meadows. Within the SSSI there are three water courses namely streams A, B and C. As well as the channeled water courses there are several water seepages and springs. Directly north of the SSSI and to the west of Quarry 3 is a Site of Biological Importance (SBI) which is principally improved grass land by grazing cattle.

- To the south and east of the site are areas of ancient woodland, the majority of which are replanted. The ancient woodland encroaches into the southern part of Quarry 1 and represents both semi-natural and replanted types.

3. PREVIOUS REPORTS

Numerous reports and letters have been produced for / about this site since the quarry started production in the early 1960s. Those available have been examined are listed in Appendix A. The three main reports utilised in the writing of this report are:-

1. Moneystone Quarry, Oakamoor, Quarries Regulations 1999, Geotechnical Assessment 2003 (issue date September 2004) Report Ref M0201/08/R11F. (*Reference No. 50*).
2. WBB Minerals - Moneystone Quarry Oakamoor, Quarries Regulations 1999, Geotechnical Assessment 2007. October 2008. Report Ref M0201/08/R85F (*Reference No. 1*)
3. Desk Study and Phase 1 Geo-Environmental Assessment. Moneystone Quarry, Staffordshire, Version 01 - June 2008 (Draft). (*Reference No. 49*).

The Geo-Environmental desk study (*Reference No. 49*) combines much of the information held by the quarry and was written with a restored quarry end use in mind, not the current proposal of a holiday park. The report deals with environmental issues, and provides details of the sites history, its production process and any potential sources of contamination including a risk assessment and recommendations.

The Geotechnical assessments (*Reference No. 1 & 50*) are a combination of a large number of different letters and reports which brings together the history of the various quarry areas, lagoons and tips. They go into some detail about the potential geotechnical risk of each feature. See also Report 418040EA, Appendix C.

The many letters and reports produced by the quarry have been produced to assist the development of the quarry and deal with changes and failures that have occurred. See listed documents in Appendix A. They record the history of the various quarry areas, lagoons, tips and production areas to a much greater detail than usually available in a desk study report. As part of the quarry regulation requirements, the potential geotechnical risk to the quarrying activity of each feature has been undertaken, for the quarry on a biannual basis and have been utilised where appropriate in preparing this document for the proposed development.

4. HISTORY

The history of the site has been varied and complicated with large amounts of information held by the quarry itself, which would not necessarily be picked up by historic maps. The history given below has largely been summarised from *Reference No. 49*, which as well as the geotechnical issues being considered, also gives detail on environmental aspects covered separately within ABEC Report 418040EA. The historic Ordnance Survey maps of the site and surrounding area, appended to ABEC Report 418040EA, have been obtained from a Landmark Envirocheck report, dated 5 October 2010.

Due to the complex nature of the site history, it has been necessary to divide the site into six main areas given in Section 2 and give the history of each of the areas separately.

Quarry 1 East (Q1E)
Active large scale quarrying started in the late 1950s in Quarry 1 and continued on until the early 1970s. The quarry sides were generally near vertical with one or two benches. The quarry floor is reported to be between 150m to 160m AOD, 25m to 35m below Eaves Lane. After quarrying had ceased the excavation was used for tailings and acidic liquor disposal between 1974 and 1978, referenced as Lagoon L4. The lagoon was initially contained within the walls of the excavation on the northern, eastern and southern sides reaching levels of around 164m AOD in 1981. On the western side the lagoon was retained from 1975 by a rock spur and in part by an earth dam made of rock fill with 45 degree slopes and 2m compressed tailings seal on its back slope. This failed in June 1975 at the junction of the dam and rock spur. It appears never to have been fully resolved until after excavation ceased in Q1W, when it was also used as a lagoon, so equalising the groundwater flows between the two sides of the quarries central dam.

Solid waste tipping commenced in 1981 to cap L4 and was later referenced as Tip T7. The tipped material comprised of sand cyclone fines, reject product and some domestic refuse from the works. The maximum height of tipped material is approximately 4m, resulting in surface levels of between 168m to 171m AOD. After tipping of solid waste ceased the area was used to stockpile topsoil and sands. In 2006 these stockpiles were removed and a 5m to 8m high bund was constructed around the limits of the former excavation to allow for further tailings disposal. This new lagoon is still named Lagoon L4 and to date has received a 3.5m to 4.5m thickness of tailings.

The existing bunds are sparsely vegetated. However, the northern flanks of the original quarry have been populated with trees to screen the quarry's high wall on its northern and eastern sides.

Quarry 1 West (Q1W)
Active large scale quarrying started in the late 1950s and continued on until the early 1970s. As with Q1E quarrying was achieved by blasting forming a benched excavation down to 155 to 165 m AOD. After quarrying had ceased the excavation was used for tailings and acidic liquor disposal to a level of 169m AOD between 1979 and 1987, referenced Lagoon L5. The life of the lagoon was prolonged by construction of a tailing dam at the low southern side. The tailings were overtipped from March 2001 with overburden and reject material, resulting in approximately 80% of the lagoon covered with about 2m of solid material. Remnants of Lagoon L5 remain in the southwest corner of Q1W, this is an uncovered area of tailings with approximately 1m of water which acts as a sump for the area.

The land areas were topsoiled with surface material from other areas of the quarry and has subsequently naturally vegetated with grass and small shrubs. Additionally trees were placed along its northern flanks to screen the remaining high wall along the quarry's northern and western side.

Quarry 2 East (Q2E)

Small scale quarrying is noted on the 1879 map in the northeast corner, this extraction was most probably for local building stone. Quarrying then recommenced in the late 1950s, with the southern part of Q2E completed by the late 1970s. Excavation of the northern half was largely finished by the late 1990s with battering back of the northern slopes in early 2000s. The excavation reached down to 182m AOD along its southern side adjacent to Eaves Lane with vertical benched sides with its crest located about 15m from the highway. The excavation floor then rose, along with the underside of the sandstone outcrop, to around 215m AOD at its northern extent. The lower southern half of the excavation was used for tailings and acidic liquor disposal between 1987 and 1999, referenced Lagoon L6. The lagoon was then overtipped with solid material. Subsequently further solid waste from the removal of overburden from Q3 was used to landscape and re-profile the Q2E area.

Tip T3 is located at the northeastern corner of Q2E and comprises of rock, coarse sand and sandy overburden from Q2E and Q2W to a material height of 19m. Tipping commenced in 1968 and ceased in 1984. The tip is well vegetated with grass and trees.

In 1981 concern was raised about the northwestern side slopes of Q2E when sandstone blocks toppled and slid into the northern extent of excavation. This was attributed to the Crowtrees Fault which downthrows the bedrock on its eastern side, removing the sandstone from the surface sequence east of the fault. The fallen sandstone blocks remain as part of the landscaped area and no further quarrying was undertaken on the eastern side of the fault.

Quarry 2 West (Q2W)

Excavation commenced in 1985 and was completed in the southern half of the excavation, in the mid 1990s and then continued towards the north and northwest until late 2000. As with Q2E quarrying started along its deeper southern side down to 170m AOD (35m below Eaves Lane) using vertical sides and blasting technique until 1970, when mechanical ripping and excavation was used for the remainder of the excavation works. Quarrying extended to the base of the sandstone which rises to 215m AOD at the quarry's northern extent. Quarrying was also extended eastwards sometime after about 1983, when Blakeley Lane was closed. The southern half of the excavation was used for tailings and acidic liquor disposal from 1997 and is currently ongoing, referenced as Lagoon L7. It is recorded that neutralised process water has been discharged into the lagoon via a flume at the northern limit from 2003. More recently a flume has been cut into the underlying shale along the east side of the lagoon and acidic liquor is discharged northwards along the flume to enter the L7 at its northern side. Lagoon water is then transferred back to the plant by submersible pumps or syphons via pipelines located on its eastern flanks.

Tip T4 (Black Plantation) is located at the north of the site beyond Q2W and comprises of rock, coarse sand and sandy overburden from Q2 to a maximum height of 5m. Tipping commenced in 1970 and ceased in 1982. The tip is well vegetated with mature shrubs and trees.

There is a tunnel that passes under Eaves Lane and connects Q1 with Q2. The tunnel is approximately 50m long, 4.7m wide and 4.3m high. The floor of the tunnel falls about 4m (5 degrees) from north to south. The tunnel was originally driven in 1963, widened in 1983 and again in 1994 to allow larger machinery to pass through. As part of the tunnel widening, individual sandstone blocks in the roof of the tunnel have been secured by rock bolting and a survey of the fracturing of the rock was undertaken. See *Reference 4*.

Quarry 3 (Q3)
Excavation started in 2001 by stripping off the overburden to the whole quarry area. This overburden was used in other parts of the quarry as previously discussed or stockpiled on the shale floor at the northern extent of Q2W. Overburden and topsoil was also used to form noise and sight bund along the north and west sides of the quarry. These have subsequently been vegetated and form a green fringe around the quarry edge. In the eastern half of the quarry the excavated overburden included Coal Measures mudstone which increased from less than a metre thickness to a depth 10 to 15m along the south boundary. With the subsequent deepening of the quarry the Coal Measures showed signs of movement which required side slopes to be slackened to maintain slope stability.

Initial sandstone quarrying was above groundwater level in Q3's eastern half. In September 2003 a small seepage of acidic water was noted in the northeastern corner of Q3 at about 163m AOD. A further seepage occurred in March 2004 in the same area of the quarry. The seepage volume was reported to be varied, but has always been recorded as small. To remedy this the mudline discharge in L7 (Q2W) was moved from the south to the north of the lagoon, with no further reports of acidic water seepage.

Q3 was extended by ripping and mechanical excavation westwards with side slopes of around 1:2 (v:h).

By 2008 the quarry had been deepened below the water table to around 140m AOD in the eastern area to, requiring continuous pumping. However, the excavation depth was limited to 2m above the sandstone base to maintain the stability of the 30m to 50m wide landbridge between Q2W and Q3 along which Eaves Lane runs. In the latter half of 2010 the quarry was being extended westwards at the lower level, which with benching, has relatively steep quarry sides, ranging in slope angles from 45 to 52 degrees from the horizontal. Additionally from 2008 a tailings lagoon occupied the eastern end of the deepened quarry, formed by a bund crest at 154m AOD across the central section of the quarry. The tailings had reached a level of around 152m AOD in December 2010, when quarrying activity ceased.

Since 2003 groundwater has been pumped from Q3. As the quarry was deepened pump rates increased to an average of around 150,000 litres per day in 2008 when the quarry floor reached its 140m floor. Since then pumping rates have been less, ranging between 50,000 to 120,000 litres per day. Pumping of water from the base of the quarry stopped in December 2010 and groundwater levels are beginning to rebound. A flood outfall was constructed as part of the initial phase of development at 159m AOD into the top of Stream A. However, water flow through this outfall has never occurred.

Eastern Area

The proposed development area includes the area to the south of Crowtree Farms and east of Q1E and the production area. This land consist of several fields which have remained in cultivation since the earliest 1887 maps examined. The fields are shown surrounded by hedges with woodland in the lower ground to the south.

Western Area

West of Q3, fields and copses of trees are shown in the rolling countryside towards Whiston village. There are a number of farm buildings and Whiston Grange either side of Eves Lane. Incised valleys flowing to the south are recorded as fenced woodland.

The Processing Area

The processing area has been in place since at least 1960 and comprised of numerous buildings, including two large metal clad buildings mill buildings. Also present is a large chimney on the east side of one of the mill buildings, a conveyor is located to the north of the buildings with a stockpile beneath. To collect waste from the production Lagoon L1 and Lagoon L2 were constructed in the lower ground to the south of the production area. Both L1 and L2 are reported to have been constructed by excavating approximately 6m to 7m below existing ground (siltstone and mudstone) and forming bunds with excavated material to give a depth of about 10m.

By the 1970s much of the processing plant was in place including both No. 1 and No. 2 clarifiers, the acid leaching plant and the clay body plant. Structures were located in the areas of current acid tanks and diesel tank, it is believed these are earlier versions of both. A conveyor was also in place, extending from the processing plant to the railway sidings in the valley to the south of the site.

Lagoon L1 was receiving slurry between 1960 and 1969. In September of 1963 L1 was increased in size (up to 24.38m deep), creating **Lagoon L3** (Key Wood) by clearing and enlarging the bed of an existing water course, with a retaining embankment on the southern end. The existing water course was diverted into the lagoon and over a spillway. This appears to have caused some instability difficulties in the dam in 1960, when run-off caused the water level behind the dam to rise close to its crest and to leak. Subsequently a rock blanket was placed at the base of the dam, the crest was raised and a lower spillway formed. Solid material was tipped over the tailings between 1973 and 1984. However, sink holes were recorded adjacent to the crest of the dam in 1985, together with water ponding in the lagoon area. Following that report the weir was reduced to 164.86m AOD and a channel cut into the lagoon area to drain. The water course that originally flowed in the valley, flows on top of the tipped material on its western side. Inspection of the lagoon area indicates a slight fall of the ground to the stream in the west. It is reported that trees were planted across the area, however, only a few of them have survived, as most of the area's vegetation is limited to a sparse covering of short grass, cropped by rabbits. However, in a more wooded and wet area close to the dam some Himalayan Balsam was identified.

Settlement pond SP1, which is located directly south of L3, was constructed in the early 1960s as an overflow pond for L1 and then L3. The pond was excavated in mudstones and marls and had a capacity of about $1000m^3$. The pond receives surface water from L3 and road drainage from the quarry. Settlement ponds SP2 and SP3 are located to the south and thus downstream of SP1, with SP2 being the larger of the three ponds. The ponds continue to be used to take surplus water from the production area, which after passing through the ponds is channeled to an area of reeded marshland on the Churnet River flood plain, before finding its way to the river by no defined channel, south of the railway sidings, upstream of the quarry's pump house.

Lagoon L2 received tailings between 1961 and 1976 and was subsequently over tipped with solid reject material between 1976 and 1979. Tip T2 (Frame Wood Clay) is located directly east of L2 and to the southeast of the Clay Body Plant. The tip started to receive material in 1969 until 1979, with the bulk of the fill being clay. The material was placed in a shallow valley to a maximum depth of 15m. The existing stream in the valley was cleaned out and filled with coarse granular material to allow the flow path to continue, fill material was then over tipped on top of the granular material. To the north of T2 and L2 and to the east of the clarifiers an Oxide Pond is recorded on a plan dated 1968 (*Reference 10*). The volume of the pond is indicated to be approximately 11500 m^3.

Settlement pond SP5, located to the south of L2 and T2, was constructed as an overflow pond for L2 and was formed in the mudstones and marls. The pond is currently obsolete, and stagnant, as it only receives surface water from within its own footprint. However, a further unnamed pond further south receives surface water from the slope above and with a small outfall has become naturalised.

5. GEOLOGY

The Geological Survey maps of the area, BGS Sheet 124 and SK04NE and SK04NW along with memoir of the area have been examined. Information has also been gained from Geotechnical Assessment (*Reference No.* 1 and 50) and Geo-Environmental Desk Study (*Reference No. 49*). The site is shown to be underlain by the Rough Rock Sandstone of the uppermost unit of the Upper Carboniferous Millstone Grit (Namurian) Series, which is overlain by Upper Carboniferous Coal Measures mudstones and siltstones. See Fig 3.

The Rough Rock Sandstone is fine to medium grained and is composed largely of quartz grains. The sandstone is normally hard and well cemented. However, it does contain beds and lenses of uncemented and poorly cemented weak sandstone. Also present are thin beds or lenses of shale, along with beds of very hard white siliceous sandstone. The sandstone has an on site maximum thickness of 35m, with an average dip of 5 to 7 degrees and up to 12 degrees south - southwest.

Shale underlies the sandstone and is approximately 2m to 4m below the base of Q1E, Q1W and Q3. See Fig 3. In Q2 the sandstone was generally removed to the top of the shale which includes beds of siltstone and sandstone.

The site is not underlain by drift deposits whilst residual soil is recorded to be approximately 0.5m thick. Made ground associated with the infilling of the quarry voids is in excess of 20m thick and largely comprises of clay slurry with a cap of 2m to 4m of solid mainly granular quarry waste.

The nearest fault is lies near to the eastern boundary of the site called Crowtrees Fault. The fault is trending north - south and has downthrown strata approximately 20m to the west, resulting in the sandstone being uneconomic in this area. A further fault lies to the southeast of Q3, its location being highlighted by a valley through which Stream B flows. The strata is downthrown to the southwest.

6. MINING

Other than the extraction of sandstone there is no known record of any other underground mining methods being employed on the site. Previous report (*Reference No. 49)* indicates that searches by Peter Brett Associates and Ove Arup & Partners mining review data indicate that the site is located in an area of no recorded mining activity. However, historic maps do show shallow coal mining has occurred in Coal Measures south of the site, north of the River Churnet, on the west side of what is now known as Key Wood. See Landmark 1879 OS map Page 2 in our Report 418040EA, Appendix B.

7. ENVIRONMENTAL ENQUIRY

A full assessment of our environmental enquiries is given within our report 418040EA dated March 2011.

A Landmark Envirocheck report, dated 5 October 2010, appended to 418040EA, indicates that there is one recorded licensed landfill site within the site boundary (Map ID 13). The location of this landfill site is shown to be in Q1E and Q1W, the licence holder was British Industrial Sand, with the waste source having no known restrictions. The licence has now lapsed or has been cancelled. Previous report *Reference No. 49* indicates that the licence for the landfill site detailed above was obtained for the disposal of effluent from the pottery industry. The plan was to dispose of the effluent in the lagoons on site. However, information supplied by WBB minerals (now Sibelco UK) indicates that although the licence was obtained no tipping of third party waste occurred at the site.

It is recorded that within Tip T7 in Q1E some domestic refuse from the quarry was tipped. Although the quantities and type of materials are not recorded, volumes are thought to have been small. Any arisings from demolished buildings within the site's history are also thought to have been placed via end tipping within the capping materials on site. Locations, quantities and exact types of material are unknown.

Waste from the Clay Body Plant was tipped in T2, the bulk of this material is recorded as being clay or clay based.

All of the tailings lagoons other than L1, L2 and L3 have the potential to be acidic in nature, with anecdotal evidence suggesting a pH range of 2.5 to 6.5. Test results of the tailings and lagoons has been undertaken and provided within 418040EA.

8. FIELDWORK

A total of 110 exploration records have been located from the quarry's archive in various formats and detail. From the more recent records 23 groundwater monitoring standpipe records are available. The larger investigations were generally carried out to establish the depth of the sandstone / shale (described correctly as mudstone and siltstone) interface and also to establish water inflow rates within the sandstone and the underlying shales. Additionally a number of smaller investigations have been carried out through the quarry's history to evaluate particular areas of the site to establish ground conditions where changes or failure of past structures needed investigation. A list of the exploration logs is given in the factual report 418040GR, whilst their locations are shown in Report 418040GR on Fig 3. Because the original logs are produced in many different formats, including both metric and imperial scales the available exploration records for the proposed development have been reproduced in a unified ABEC log format in the factual report 418040GR. However, if the data being sort is critical, the original logs should be examined.

In December 2010 it was agreed that a series of pH tests should be carried out on the existing lagoon water and tailings around the site. These results from these surface sampled tests are presented and considered considered further within the Environmental Assessment report 418040EA.

9. LABORATORY TESTING

Geotechnical testing carried out over the last 30 to 40 years has been summarised in the factual report 418040GR. The materials tested include lagoon tailings, sandstone, siltstone / mudstone and shale. The results have been reproduced in good faith and where known the original reports have been attributed to the individual test results. If these results are critical to design or development proposals the original result sheets should be examined.

There has been very little reported chemical testing carried out on the site of either lagoon waters, tailings, solid capping materials or groundwater (perched within lagoons or natural). The only reported chemical testing undertaken was for Streams A, B and C. This consisted of 12 monthly sampling rounds in 1998/99 of which the minimum, maximum and mean results were reported. Also tested were two water samples in 1996, one from a newly drilled borehole, located in what is now Q3 and one from the junction of Streams A, B and C in Ashbourne Hey. Both sets of results are appended in Report 418040EA.

10. GROUND CONDITIONS

General

A considerable amount of ground investigation data that has been collected by the quarry over its 50 years operation are reproductions of previously obtained information. Often the original investigation has not been retained resulting in only parts of the investigation records being appended to subsequent reports. Much is specific to the requirements of the quarry at the time, but remain useful to obtain an overview of the ground conditions present. Once more detailed development requirements are known we would anticipate further more detailed ground and testing information will be required to develop the site.

Stratigraphy

Where not removed by quarrying activity, residual soil cloaks the bedrock strata

As discussed in Section 5, the site is underlain by the Rough Rock Sandstone of the uppermost unit of the Upper Carboniferous Millstone Grit (Namurian) Series, which is overlain by Upper Carboniferous Coal Measures mudstones and siltstones. The borehole records allow the base contours of the sandstone to be mapped out across the quarried areas. See Fig 3. The sandstone has an on site maximum thickness of 35m, with an average dip of 5 to 7 degrees and up to 12 degrees south - southwest.

Shale underlies the sandstone. The BGS geological maps do not define this boundary, instead include the shale sequence in with the overlying sandstone and show them to extend to the top of the watershed in the north. The shale consist mostly of mudstone interbedded with thin beds of siltstone and sandstone, which outcrop north of the quarried areas and following the regional trend, dip under the remainder of the site to the southwest.

As depicted on Fig 3, the Crowtrees Fault trends from north to south and bounds the east side of the quarried area. A northwest to southeast trending fault cuts through the geological sequence along the line of Stream B, to the southwest of the quarried area. Further minor faulting has been identified during quarrying activity, which weaken and fracture the surrounding bedrock and have been exploited by past streams and gullies. This is particularly noticeable at the west end of Q3 where in part the sandstone has weathered to unbound sand.

Quarried Areas

In the quarry areas both the residual soil and sandstone have been removed. South of Eaves Lane Q1 and Q3 have been excavated to within 2m of the shale layer. The base of the sandstone being retained to maintain stability of the landbridge on which Eaves Lane is on. North of the lane, Q2 has had the sandstone fully exploited such that at the north end of the quarry the shale beds are now exposed at the surface.

The production of silica sand products has resulted in around 25% waste. This was initially deposited in lagoons and tips in stream gullies southeast and southwest of the production area. Since the 1970's, when the southern lagoons and tip were full and Q1 had been excavated, the quarries have been used in sequence to dispose of the waste both in liquid (tailing) and solid form.

Material Properties

Solid Capping and Bund Materials

The type of dry bunding and capping fills used by the quarry has been dependent on what material was available at the time it was required. The bulk of the material will have come from the residual soil and unsuitable weathered bedrock removed as part of the initial quarrying activity. The remainder is mostly dry waste from the production process. As most was derived from the sandstone, the waste is mainly free draining and granular in nature. However, there are some notable exceptions. For example in the north of Q2 there is a stockpile of dark grey shales. We understand from the quarry this was derived from the stripping off of Q3 on its southern side where in places the overlying Coal Measure shale was up to 15m thick. Similar material was also used to thicken the cap on Q2W.

Examination of the past report have only found one set of laboratory test data for this material.

Tests	Units	Min	Avg	Max	No.
Moisture	%		24		1
Plastic Limit	%		26		1
Liquid Limit	%		44		1
PI	%		18		1

Clearly the single test result on this material is not representative of the whole, although the result is not untypical of weathered mudstones from Coal Measures strata it is anticipated it was derived from.

Tailing Infill

Tests	Units	Min	Avg	Max	No.
Moisture	%	15	66	145	37
Plastic Limit	%	30	40	47	4
Liquid Limit	%	50	66	87	4
PI	%	20	26	40	4
Bulk Density	Mg/m^3	1.470	1.646	1.940	20
SG		2.69	2.71	2.75	5
Clay	%	15	19	23	3
Silt	%	50	61	67	3
Sand	%	10	19	30	3
Gravel	%	0	0	0	3
Mv	m^2/kN	0.00012	0.00216	0.0077	20
Cv	m^3/yr	13	271	2,600	20

The tests carried out on Q1E tailings soon after they were capped show moisture contents well over the liquid limit directly below the capping. (*Reference 2 & 51*). Graphical representation of the moisture and strength results against depth in Figs 5 and 6 show how with depth and loading the moisture content of the tailings decrease whilst the strength increases. With time these moistures would be expected to reduce to, at / or close to the plastic limit. It is only when this has been achieved that the tailings can be considered to be stable without being confined or having lateral support.

Residual Soil

No engineering testing of the residual soil has been identified within the reports examined. Soil testing on the proposed Q4 extension area shows that where underlain by the sandstone much of the soil is granular and sandy in nature. However, on the shales and Coal Measures above and below the central sandstone belt the residual soil would anticipated to be typically firm becoming stiff cohesive soils.

Coal Measures

No engineering testing of the residual soil has been identified within the reports examined. The Coal Measures are exposed over the sandstone on the south face of Q3 at its eastern end above the quarry access ramp. Enquiries with the quarryman have established that when removing the overburden (material not able to quarry) from Q3 a wedge extending 6m bgl on the quarry's south side was removed. Consisting mainly of friable mudstone it was re-used to over cap Q2E and stockpile on the north base slope of Q2W. See test result for capping. Initially it was cut back at 1:1.5 (v:h). However, following instability of the slope it was trimmed back to 1:3 and 1:4 (v:h) and vegetated. Although some localised, shallow movement is evident adjacent to the access track, vegetation has matured over most of this slope, with no significant signs of further movement.

Sandstone

The Rough Rock Sandstone is fine to medium grained and is composed largely of quartz grains. The sandstone is normally hard and well cemented. However, it does contain beds and lenses of uncemented and poorly cemented weak sandstone. Also present are thin beds or lenses of shale, along with beds of very hard white siliceous sandstone.

The upper 15m of the medium-bedded to massive sandstone is generally pale coloured containing 0.15% iron oxide. The lower beds are red in colour due to iron oxide coating on the sand grains (0.3 - 0.5% iron oxide). Iron ore is clearly visible in the paler rocks, with chromite also recorded to be present.

Examination of the quarry faces has revealed three sets of discontinuities, two joint sets striking east-west separated by 0.5m to 2m and a third set parallel to bedding. These three set form cubic and tabular blocks of about 0.3m to 1m in size. The bedding planes and joints in the quarry face appear open, possibly due to loosening by quarrying. The exposed rocks in the tunnel have been less disturbed and indicate bedding planes to be partially open. See tunnel exposure log and steriographic projections in Appendix F, from *Reference 4*.

The bedding planes and joints will result in allowing preferential flow paths for groundwater.

Shales
The contact between the sandstone base and the underlying shale have been examined in detail in the base of Q2E. Trial Pit Q2E was excavated 6m below the base of the sandstone to evaluate the potential of lateral movement of the quarry sides into the open excavation in 1984 (*Reference No. 2*). The excavations were carried out following movement that had occurred along the west side of the quarry adjacent to a known fault.

Tests	Units	Min	Avg	Max	No.
Moisture	%	11	18	28	4
Plastic Limit	%		22		1
Liquid Limit	%		57		1
PI	%		35		1
Bulk Density	Mg/m^3	2.270	2.320	2.350	3

11. HYDROGEOLOGY

The main physical hydrological features of the site and the surrounding area are discussed in the hydrogeology baseline assessment provided in Appendix B. Issues relating to contamination are discussed in more detail within ABEC Environmental Desk Study report 418040EA, dated March 2011, whilst issues relating to flood risk have been covered separately within our report 418040FR, also dated March 2011.

General
The Environment Agency (EA) indicate the site to be located on a Secondary A aquifer (formally minor aquifer). The aquifer material is largely impermeable. However, fractures, joints and bedding planes will allow the movement of groundwater. Although Secondary A aquifers do not produce large quantities of water, they are important for local supplies and in supplying base flows to rivers. The soils on site can be split up into two soil types, generally to the north of Eaves Lane soils have a high leaching (H3) potential due to their coarse texture, whereas on the south side of Whiston Eaves Lane soils have a low leaching potential.

The nearest named surface water feature is the River Churnet running in the valley floor on the southern extent of the site, at a level of 110m AOD. The quarry abstracts water from the River Churnet, at a maximum daily rate of abstraction rate of $341m^3$. The abstracted water is used to wash the sand and to remove the fines, which settle in tailing lagoons formed in the previously worked quarries. The water is then returned to the production area to be used again in the washing process, with a proportion of the water overflowing back to the river. The quarry estimate around 37 million m^3 (8 million gallons) of water is being used in the quarry and production process at any one time.

The watershed covers an area of just under 3 million m^2, extends from the quarry areas at 160m to 280m AOD, rising to 290m AOD around Blakeley Farm, to the north. The area is drained by five unnamed streams which flow southwards to the River Churnet. Previous reports have named the three streams affected by Q3 excavation, Streams A, B and C which combine southwest of Q3 before flowing through Ashbourne Hay to the river. Similarly, streams flowing south of the production area into the River Churnet have been named Streams D and E. See Fig B5a.

Where not quarried, the watershed is mostly covered by farmed grassland and woodland. The underlying geology splits the watershed into three distinct areas. The highest northern part of the watershed is underlain by interbedded siltstone and shale with a low permeability. In the sandstone areas a higher proportion of the rainfall and run-off will soak into the sandstone aquifer which dips gently to the southeast. Consequently much of the rainfall, together from the collected surface water from the shale runs through the sandstone, with groundwater east of the quarry entrance running to Streams D and E, whilst the remaining flow enters Streams A and B, and possibly C in the areas of exposed sandstone just upstream of their confluence.

South of the quarries, the Coal Measures strata rests above the sandstone and has relatively low permeability resulting in limited infiltration. Run-off is therefore more immediate and drains directly to the four streams directed by the slope of the ground. See Fig 4.

As discussed further in Appendix B quarrying has redistributed the flow of run-off and groundwater between Streams A, B, C, D and E. See Figures B5a to c. With the development of Q3, the run-off from the higher ground to the north will have been increasingly diverted into the quarry. Consequently water being pumped from Q3 will, having first been used in the production process, drain down to Stream D. This is artificially supplemented by 200 to 340 m^3/day of water extracted and returned to the river Churnet for the production washing process. This will have reduced the flow of Stream A & C and possibly B. However, continued flow from the groundwater within the sandstone have kept flows running above the reduced flows required by the EA before needing them to be artificially recharged.

The underlying shale that outcrops to the north and Coal Measures mudstone which cap the sandstone to the south will each have a low permeability. With the influence of faulting and fractures, most of the groundwater flow is currently directed into the five streams as springs below the quarries and production area.

Site of Special Scientific Interest (SSSI)

Streams A, B and C pass through a SSSI located to the southwest of the Q3 consisting of a series of species-rich meadows managed as grazing pasture and hay meadows. The majority of this area is directly underlain by Coal Measures strata and therefore the impact to changes in groundwater from quarrying will be limited to the flow of water in the stream. Details about the SSSI are given in the Bowland Ecological Survey Report.

Influence of Proposed Development

The proposed development involves the flooding of Q3 to form an activity lake, the development of the production area into an activity centre hub and the construction of lodges in the other quarry areas and parts of the surrounding land. To meet the quarry's commitments Eaves Lane Farm is to be reconstructed on land to the west of Q3, together with some linear development on the fringe of Whiston village.

When the quarrying and production works cease Q3 would naturally fill with both surface run-off from the north and groundwater from the surrounding sandstone. The baseline groundwater monitoring and modelling indicate seasonal changes in standing level would range between 156m AOD and the current quarry outfall to Stream A set at 159m AOD. As a 3m difference in level is undesirable for an amenity lake setting, it is proposed the outfall to Stream A is reduced to between 156m and 157m AOD. The proposed development will therefore partly restore the groundwater flows of Streams A, B and potentially C and return seasonal surface flow to the top of Stream A.

Comparing the proposed development to the baseline before Q3 quarrying given in Appendix B, the run-off above Q3 will be ponded in Q3 lake before outfalling into Stream A, rather than the previous flash flows that would have occurred after heavy rain. Not reflected by the changes to run-off area figures given in Table B3 is the proportion of water flowing into Q3 which will natural seep through the sandstone bedrock and form the baseloads of Streams A, B and possibly C. By maintaining the lake level at 156 to 157m AOD, close to the previously monitored groundwater levels in the quarry standpipes, it is anticipated that groundwater flow into Streams A, B and possibly C, will be returned to pre-2006 base flows.

The proposed lodge areas are to be developed sympathetically to their ecological surroundings. The existing fields and landscaped quarries are to have a high proportion of their areas covered by natural grassland and heath land habitat, as discussed in more detail within the Bowland Ecological report. Similarly roof run-off, from the lodges will not be collected, but drained onto the surrounding ground and allowed to run across the ground, and where necessary directed by ditches into the proposed streams and ponds. The proposed ponds and meandering of the water flow around the development will reduce the flashy nature of the existing run-off. With the development located at the top of the watershed, this will reduce the risk of flash flooding further down and therefore can only reduce the risk of flooding in the river system below. For further details see 418040FR.

As part of the development options some of the surface water flow from the old quarry areas can either be diverted into the Q3 lake or down Stream D.

One of the factors which will need to be addressed is the affect of the proposed changes to the SSSI through which Streams A, B and C flow through. The current excavations of Q3 will have reduced the stream flows of Streams A and C, although Stream B will be less affected. Changes to Stream D's flow will however be more greatly influenced by the closure of the production plant and no longer the need to continually discharge back to the River Churnet via Stream D. None of the proposals should affect the current flow of Stream E.

12 ENGINEERING CONSIDERATIONS

12.1 General

An outline plan of the proposed development was being prepared when completing this report. It has been assumed that lodges are to be constructed on the capped tailing lagoons as well as on previously undisturbed ground around the quarry areas. A number of larger buildings are proposed in the hub, currently occupied by the quarry's production area. Houses are to be constructed at or close to existing ground levels in areas of open ground adjacent to Whiston Village. The proposed ground loadings were not known, but for the purpose of this report are assumed to be less than 100 kN/m. If there are any changes to these proposals, then some modification to the comments and recommendations given may be required.

During quarry operations the risk from physical failure was largely addressed by restricting access to areas of moderate or high risk. This allowed the quarry to operate at levels of risk much greater than would be considered acceptable where public access is permitted, such as being proposed for the development. At the outline stage of development detailed design for ways of reducing these risks is not required. To meet planning requirements an evaluation and quantitative assessment of the risk has been presented in Table 1. However, with further understanding and more detailed assessment, alternative methods to reduce risk may be found and will need to be considered.

12.2 Mining

No deep or shallow coal or non-coal mine workings have been identified in the site area. However, quarrying to over 45m bgl has occurred in the past 60 years, which have mostly been infilled with tailings, together with a number of separate spoil heaps. Additionally two incised streams south of the production area have been dammed and infilled with tailings in the 1960's and 70's.

12.3 Slope Stability

The initial analysis was undertaken on existing slopes which had been previously analysised by the quarry engineer to determine whether we concurred with the previous analysis undertaken. For the desk study assessment six critical sections have been examined and the resultant analysis has been presented and summarised in Appendix C.

As part of the quarrying activity a number of steep sandstone slopes and cliffs have been formed. With the infilling of the quarries a large proportion of these slopes have been covered over. However, significant slopes remain, particularly on the north sides of the quarries where the natural slope rises and within the most recent, unfilled, quarry Q3. Generally stability of slopes have been maintained at just above unity, the relatively low safety factors being justified by the fact that limited, controlled, access was maintained by the quarry operation. With the proposed development the levels of risk are going to need to be reduced as the access to the general public increases.

Consequently, the stability of slopes will need to be improved to levels acceptable for public access, which for highways are generally 20% to 30% above unity (Factor of Safety (FoS) of 1.2 to 1.3). Therefore, prior to developing the various sections of the quarries will need to have the slope stability assessed to evaluate the safety of the development users and to assess where improvement in stability may be required.

In the region of the proposed hotel in Q3 the quarry previously identified that there was a risk that slide failure may occur of the landbridge between Q2W and Q3 slide along the shales at the base of the sandstone being quarried. Following analysis the quarry limited their excavation to within 2m of the base of the sandstone to provide passive resistance to movement. Initial analysis for this desk study would suggest that a FoS in excess of 1.3 can be achieved provided the existing profile and groundwater conditions are not worsened.

Examination of the existing quarry face at the quarries west end shows that some of the steep 45 to 52 degree quarry face is formed of highly weathered sandstone, in parts completely weathered to sand. Wetting of a weakly cemented sandstone will result in a reduction of its cohesive strength, particularly where unconfined. Consequently with the flooding of the quarry our observations would suggest the over steep quarry side faces will decay and cause localised instability into the lake. Analysis would suggest that instability would not initially affect the ground beyond the quarry crests, but if unchecked this might be a concern, although, provided it is not removed, slipped debris in the lake floor would have the effect of improving the stability of the side slopes. Although this scenario may be acceptable in a quarry setting where public access is limited, in an area developed for lake activities and lodges on the quarry sides, localised slipping could not only affect the areas of movement, but displaced water in the lake might be expected to surge in a wave across the lake and endanger lakeside activities.

To develop the lake there is a desire to have shallow water, to limit the amount of cold deep water. Therefore, if as proposed, the west end was part infilled say to 1.5m to 2m below proposed lake level the steep quarry faces at the west end would be confined. As shown in Appendix C this would increase the side slope stability above the minimum 1.3 FoS required.

During a period of flooding in the mid 1960's the quarry records would suggest the dam supporting lagoon L3 came close to failing which as speculated at the time could have resulted in the water and tailings contained behind the dam flooding down Stream D through the railway sidings and into the River Churnet valley. Since the 1960's we would anticipate the tailings in L3 will have consolidated and become firmer. This in turn will reduce the pressures on the dam so reduce the risk of failure. However, with time the dam construction could have weakened as water flow through its structure continued. Consequently the dams stability remains a concern so will require investigation, further analysis and probably drainage measures in the lagoon and weir areas to improve stability and its future durability.

In the northern areas of Q2E & Q2W there are several areas where localised instability may be a concern depending on detailed design proposals. These will need to be addressed as part of the detailed design.

From the analysis given in Appendix C it can be concluded that the proposed development can be undertaken in a safe manner providing certain precautions are undertaken.

12.4 Quarry Rock Faces.

For planning purposes the risks associated with quarry face failures have been assessed in Table 1.

Until the early 1990's the quarry sandstone was removed by blasting resulting in near vertical quarry sides in Q1 and all but the north side of Q2. Since then the majority of these faces have been covered by tailings with only the top terrace of Q1 north and eastern faces, and the top of faces on the western and central southern faces of Q2 remain.

A walkover survey of these remaining faces would suggest their overall stability, over most of their length, have been stable since they were exposed and there is no reason to suspect large scale failure will occur in the near future. However, many of the faces are made up of individual blocks of sandstone which, particularly in the upper parts of the face, are prone to spalling. Commonly such faces are particularly prone to spalling following frosty weather when blocks are pushed out from the face by the ice and then release when thawing takes place.

Where public access is required within a distance equal to the height of the exposed face we would recommend further assessment is undertaken. We would also anticipate that inspections at regular intervals would need to be undertaken during the life time of the development in sections of the face where the risk is considered to be moderately high or high.

For most of the quarry face lengths the risk could be reduced to low by restricting access to the crest or base of the face. Currently the quarry achieves a reduced risk by fencing and the use of difficult to penetrate vegetation along the top of the faces and by a scree slope and vegetation and the current limited access at the face base. The proposed development currently shows no development which would increase the access to the upper sections. However, there are proposals to use some faces for climbing which will need particular attention. On the lower side of the faces the vegetation could be further extended and thickened where space allows. In other areas protection specific to the location, such as face dressing and rock nets, may need to be considered.

12.5 Tunnel Stability

To provide access between Q2 and the production area without using public highways a tunnel was excavated in 1963 under Eves Lane in the central part of the north face of Q1. The tunnel has been enlarged on two occasions in 1983 and 1994, and as part of the last widening mesh and rock bolts were installed into the roof of the tunnel to limit the risk of falling blocks.

Quarry records (*Reference 4*) show the stability of the tunnel has been evaluated on several occasions in the past. Except on limited occasions, to limit the risk to quarry operators access through the tunnel has been restricted to vehicles with roof protection. Also traffic lights have been installed to limit the flow of traffic to a single direction at any one time.

During development earthmoving vehicle access is going to be required. During this period it would be best to maintain the measures use by the quarry to limit the levels of risk to acceptable levels. It is our understanding when the northern section of the development is operational the tunnel is required for pedestrian, bike and possibly on-site vehicle access. Because of the limited width of the tunnel, public vehicle access is unlikely to be a practical option without the tunnel being widened.

In the short term consideration could be given to providing a timber framed structure within and extending from the portals of the tunnel to support mesh to prevent stone larger than the mesh falling onto those using the tunnel. As this will require regular inspections and the removal of spoil, an alternative approach may need to be considered over the longer term. This could be in the form of a solid concrete or Armco tunnel lining with infill placed between the lining and existing tunnel sides.

12.6 Earthworks

Earthworks requirement may change depending on development requirements and time scales. As an example of earthworks that may be required an earthworks assessment to use on site materials to infill the base of Q3 and cap existing lagoons is given within Appendix D. Before development takes place these suggested proposals will need to be further developed and modified to meet development requirements.

12.7 Foundations

Before development, investigation of the ground conditions present is recommended to confirm suitable founding strata and available bearing pressures. For the outline stage the following assessment has been made.

Development on areas on Natural Ground.

On areas not affected by past quarrying and tipping and for the light small scale lodge and associated buildings proposed for development strip footings founding into the stiff residual clay or bedrock could be considered. Minimum founding depths will range between 750mm and 1m bgl depending on the shrinkability of the residual clay (where present). Also some footings for permanent structures may need to be deepened due to trees and where past disturbance has occurred. Some thickening of unsuitable founding strata should be anticipated in the valley floors and where past hedges and ditches have been present. Assuming an acceptable settlement of 25mm a net allowable bearing pressure of 100 kN/m^2 should be available where founding at least 250mm into the stiff clay or bedrock.

Capped Tailing Lagoons

As discussed in Section 9, Q1 and Q2 have been infilled with tailing which generally increase in depth to the south west. When depositing the tailings a considerable amount of water is entrapped between the particles. With time, the weight of overlying material reduces the moisture content of the tailings and so increases the strength. Consequently with time the potential further settlement will reduce.

As discussed in more detail in Appendix E foundations in the tailing lagoon areas will require to cope with settlement in the order of 100mm in the first year, reducing to less than 10mm/yr after 10 years. For the individual lodges proposed, the concern will be differential movement, as if the whole structure moves down with the ground surface by the same amount, little tangible evidence of the movement will be seen. Differential movement would be most noticeable around the areas of quarry high wall and where significant changes in the depth of tailings has occurred. There are ways of reducing or speeding the settlement process up, but where being applied over large areas could be prohibitively expensive to undertake.

Where practical the remaining lagoons should be drained and as soon as a suitable crust has been able to be formed, capped. In this respect Q1W and Q2E have already been capped, as have L2 and L3. Q1E is formed of a 3m to 4m thick layer of tailings over a cap, over a further 9m to 15m thickness of tailings. If this area was prepared by removing the upper tailings layer it would be expected that the tailings below the existing concealed cap will have consolidated since its investigation in 1981, and will therefore exhibit less settlement than the previous investigation would suggest. See *Reference 51*. The quarryman past experience suggest the initial drying process will take about 2 years. However, some encroachment of capping spoil onto its dryer southern side of L7 may be possible to allow stockpiling of capping material to take place. This would allow material to be brought into this area as and when they become available.

Before development a ground investigation and monitoring will need to be undertaken to determine when development can start and the differential loadings available. Even with all these measures in place some preparation of the capping fill under lodge positions will be required. At this stage we would suggest it is assumed a 0.5m regulatory layer is compacted in place, extending at least 1m beyond the lodge and decking footprint. This should be reinforced with one or possibly two layers of Geo-Grid. The base construction could then be placed over the regulatory layer. Although the lodge manufacturers recommend a concrete slab, concrete paving may better suit the lagoon locations as they are less likely to crack if differential movement occurs and can be re-laid if required.

Hub Area

In the hub areas higher ground loadings are anticipated. No ground investigation records are available for the production area. Most of the existing production appears to be located over an area where residual soil is anticipated over mudstone bedrock. However records show the clay body plant to have been partly built over tipped material, and other similar situations may occur, particularly at the fringes of the existing production area. Also existing and past substructures underlie the production area and could result in areas of deep fill when removed, if existing levels are to be maintained. For most structures founding on the underlying residual soil or bedrock shallow strip footings can be considered. Where loads in excess of $150kN/m^2$ are required or if vibratory loading is anticipated then founding on the underlying bedrock will be required.

12.8 Floor Slabs

Ground bearing floor slabs may be considered for areas where undisturbed residual soil overlies bedrock. Where the ground has been previously developed or over infilled quarry areas suspended or integrated floors will need to be considered.

12.9 Highways & Hardstanding

Except in the hub are the current proposals are that highways around the site will be formed unbound construction which can be re-laid where required. Where highways and hardstanding will need to be constructed on re-engineered material, for design purposes a CBR of 2.5% may be assumed provided the formation is proof rolled and soft spots are removed or reinforce with Geo-Grids. Geo-Grid may also need to be considered where crossing quarry highwalls or where significant changes to the formation occur. In areas of undisturbed ground higher design CBRs may be available, but without ground investigation we would recommend that the same design criteria is applied.

12.10 Drainage & Excavatability

Some difficulties in excavation of trenches for sewers and foundations in the bedrock should be anticipated, partially where sandstone bedrock underlies the development. Consideration should be given to providing safe temporary support of excavations within made ground or where greater than 1.2m deep.

Soakaways may be suitable for this site in the areas underlain by sandstone. In infilled quarry areas and other areas underlain by the shale and Coal Measures mudstone surface drainage will need to be considered. See Flood Risk assessment report 418040FR. If soakaways are to be considered it is recommended that soakaway tests are carried out at proposed soakaway locations to determine the size of soakaway required. These should be placed at least 5m from proposed or existing properties.

12.11 Chemical Precautions

The available testing in the sandstone and quarry areas indicate some areas might have high sulphate levels. At this stage we would recommend that all sub-surface concrete is sulphate resistant as in accordance with BRE Special Digest 1:2005 . It should also be assumed that water supply pipes should be leachate resistant in at least the production area.

12.13 Ground Source Heating

A fuller assessment of heating proposals is to be given within the WSP report.

Providing building heat and hot water using ground source heating could be considered for this site. The quartzitic lagoon tailings would be particularly suitable as their thermal conductivity and volumetric heat capacity will be relatively high. Depending on investigation findings ground source heating loops installation costs might be expected to be significantly reduced if the loops could be driven, rather than drilled into position.

Installing ground loops into the ponds and lakes proposed is not recommended as the flow to and from these water bodies are not anticipated to be high. The use of loops could result in the water bodies freezing in colder periods, and a reduction in their bio-diversity and suitability for fish.

13. REGULATORY APPROVAL

The recommendations given in this report are based on the findings of the site investigation of others, and supporting desk study, undertaken as described. The conclusions cannot be guaranteed to gain regulatory approval, should the report be required as part of a planning application. If it is required as such, it should therefore be passed to the appropriate authorities for comment and approval, prior to undertaking any remediation or development work.

14. DISPOSAL OF SOILS

Any wastes arising from remediation and/or development of the site, such as excess spoil or material deemed unsuitable for retention on site, should be disposed of in accordance with the Duty of Care Regulations. Additional Waste Acceptance Criteria (WAC) analysis may be required to determine the most appropriate disposal facility for the waste, in accordance with the requirements of the current Landfill Directive.

15. FURTHER INVESTIGATION

As indicated throughout the report ground investigation will be required prior to the commencement of groundworks for the development. The methods and extent of investigation will vary depending on the investigation and development requirements. Initially some general investigation to evaluate the potential variability of the strata and materials present. We would also recommend that the potential geotechnical hazards are re-assessed where they could potentially change the way the development is undertaken. For example by knowing the state of the existing tailing lagoons would be useful in determining the levels of settlement that might be expected, and whether alternative methods of founding or improving the ground can be considered. Another concern is the current states of some on the supporting structures, such as L3 dam, and whether an alternative approach to development need to be considered in such areas.

16. SUMMARY

- Abbeydale BEC Reports 418040GR, 418040EA and 418040FR should be read in conjunction with this report. This report covers geotechnical and hydrogeological issues related to the proposed extreme activity holiday park.

- The site in underlain by Coal Measures over the Mill Stone Grit sandstone and shale which dip 5 to 12 degrees to the southwest.

- Shallow mining is reported south of the site, but not within the site boundaries.

- On natural ground traditional foundations can be considered. In tailing filled quarries, flexible and light structures with measures to combat differential settlement proposed.

- Further slope and rock face stability assessment and remediation required, at locations identified in Table 1.

- Further assessment of tunnel and remediation required before used for public access.

- Recommend that Q2 is not developed until Q2W lagoon (L7) has been capped and made safe. Until then public access should be limited.

- Earthworks to stabilise and make safe Q3 quarry's sides slopes proposed. Also to provide shallow bathing and beach areas.

- Soakaway drainage can be considered into the sandstone in the central, eastern and western areas. In quarries and other areas, surface drainage into streams and ponds proposed.

For and on behalf of Abbeydale BEC Ltd.

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Senior Geologist
Report 418040DS March 2011.

TABLES

Quarry Area	Risk Ref.	Description of Risk	Walkover Assessment	Who is at risk	Time of Risk	Potential to cause harm	Probability Factor	Risk Factor	Action Required	Investigation Required	Reduction in Risk	Resultant Risk
Q1	1.1	Exposed Quarry Face instability	No signs of past large scale movements visible from top and bottom of faces	Site users	Highest risk in winter but could occur any time.	2	2	4	Remove any recently moved or loose blocks	Inspect and photograph key locations for signs of movement each spring	3	1
Q1	1.2	Localised block failure from exposed quarry face	2m to 3m high scree slope at base of exposed quarry face. Small scale block failures will continue to occur, particularly in upper sections following frost action	Site users	Highest risk in winter but could occur any time.	1	4	4	Limit public access at base of slope. Area equal to half height of face should be fenced off, signed and thorny vegetation planted. Regularly remove any recently moved or loose blocks where public access is closer to face.	Remove any recently moved or loose blocks	3	1
Q1	1.3	Faces not suitable for free climbing. However, face could be prepared for controlled supervised climbing	Existing brambles cover deters pedestrian access onto scree slope.	Climbers & supervisors	Highest risk whilst next to rock face	2	4	8	Chosen section of Rock Face will need to be scaled of loose material, including the removal of the residual soil and heavily weathered rock in top 2m to 3m from crest. Reinforced concrete slab to be placed at top of face to limit frost action and physical erosion. Also to provide anchor for abseil ropes etc.	Rock face will need to be inspected to find most suitable sections for climbing	4	4
Q1	1.4	Accidental fall over quarry face	Tops of quarry faces currently protected by a combination of walls, wire fencing, signs and impenetrable vegetation	Site users and general public where close to highway or footpaths	Any time but highest risk when visibility is poor.	2	2	4	Existing restrictions should be maintained and improved, particularly where areas above quarry faces are to have increased use.	A methodical examination of the existing restrictions.	3	1
Q1	1.5	Sink hole forming and migrating to the surface	Sink holes next rock face	Proposed structures & site users.	Potential to occur any time	1	3	3	Highest risk is within approx 10m to 20m from the edge of the infilled quarry. Therefore development in this zone needs to be relocated or measures put in place such as geo-grids within the capping layer to minimise the effects should a sink hole form.	Any surface movements need to be investigated to determine the cause.	2	1
Q1	1.6	Q1E Dam holding L4 tailings (2nd Stage)	Historic instability. None currently observed	Site users & developer	Highest risk whilst water behind dam	2	3	6	Remove upper level of L4 tailings to old capping layer	Investigate by S& A existing dam and tailings and compare with 1984 logs. Monitor groundwater	4	2

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Geotechnical Risk Assessment

Client: Laver Leisure

Project: Moneystone Quarry, Oakamoor

Number: 418040

Table 1

Quarry Area	Risk Ref.	Description of Risk	Walkover Assessment	Who is at risk	Time of Risk	Potential to cause harm	Probability Factor	Risk Factor	Action Required	Investigation Required	Reduction in Risk	Resultant Risk
Q1	1.7	Soft tailings in bottom of Q1W pond	Naturalised lake, estimated depth 1m with reeds around	Site users & developer	Any time	2	1	2	Place signs around lake to discourage swimming/paddling	Probe base of lake	1	1
Q2E	2.1	Penetration of capping exposing underlying tailings	A 2m plus cover of dry waste applied to this area which has subsequently been vegetated. Stream running through centre of old lagoon to west.	Proposed structures, plant used to excavate.	During development	2	2	4	Excavation into capping should be limited to 1m bgl.	SI investigation recommended to establish depth and state of cap and tailings	3	1
Q2E	2.2	Existing bunds around south and west side of quarry lagoon	The capping and bunding along the south side of quarry have become one and are difficult to distinguish	Proposed structures, plant used to excavate.	During development	2	2	4	Development plans should not remove the bund material without further investigation	SI investigation recommended to establish depth and state of cap and tailings	3	1
Q2E	2.3	Toppled blocks and unstable quarry edge 300m east	Toppled blocks form feature east of track down face	Site users	During development	2	1	2	Restricted development along the north eastern side of the quarry in areas of past instability. Recommend 15m building buffer	Investigate extent of instability where development proposed within 50m	2	0
Q2E	2.4	Groundwater flow from base of sandstone onto exposed underlying shale	Moss growing on shale quarry floor	Slope instability.	During development	2	3	6	Install drains along break of slope to limit groundwater flow across shale	Investigate extent of seepage and determine line of drainage trench required	4	2
Q2W	3.1	L7 tailings lagoon infill southern 2/3 of quarried area	Lagoon still in use. Nearly full	Site users	Before capping	3	4	12	Area needs a strategy to protect public from entering area of lagoon until capped and developed complete	Investigate state of tailings and agree time when capping can proceed.	9	3
Q2W	3.2	Flume in trench around east and north side of lagoon	Liquid waste colourful due to lime neutralising of acidic water from production plant	Site users, surface waters and groundwater	High risk before capping	4	2	8	The neutralisation of the flume to be agreed on completion of the production processes.	Investigate resultant treatment of flume area to confirm restoration to agreed condition	6	2
Q2W	3.3	Exposed Quarry Face instability	No signs of past large scale movements visible from top of faces	Site users	Highest risk in winter but could occur any time.	2	2	4	Limit access to plant with hard cabs until capping complete	Investigate when capping of L6 complete	3	1
Q2W	3.4	Localised block failure from exposed quarry face	Base of cliff faces on west side currently with L6 tailings lagoon below so no access available	Site users	Highest risk in winter but could occur any time.	1	4	4	Limit access to plant with hard cabs until capping complete	Investigate when capping of L6 complete	3	1

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Geotechnical Risk Assessment

Client: Laver Leisure

Project: Moneystone Quarry, Oakamoor

Number: 418040

Table 1

Quarry Area	Risk Ref.	Description of Risk	Walkover Assessment	Who is at risk	Time of Risk	Potential to cause harm	Probability Factor	Risk Factor	Action Required	Investigation Required	Reduction in Risk	Resultant Risk
Q2W	3.5	Accidental falls over quarry face	Tops of quarry faces currently protected by a combination of walls, wire fencing, signs and impenetrable vegetation	Site users	Any time but highest risk when visibility is poor.	2	2	4	Existing restrictions should be maintained and improved, particularly where areas above quarry faces are to have increased use.	A methodical examination of the existing restrictions.	3	1
Q2W	3.6	Consideration for suitability should be deferred until L6 capping in place	Investigate when capping of L6 complete	Site users	Highest risk whilst next to rock face	2	4	8	Chosen section of Rock Face will need to be scaled of loose material, including the removal of the residual soil and heavily weathered rock in top 2m to 3m from crest. Reinforced concrete slab to be placed at top of face to limit frost action and physical erosion . Also to provide anchor for abseil ropes etc.	Rock face will need to be inspected to find most suitable sections for climbing	4	4
Q2W	3.7	Existing bunds around south and west side of quarry lagoon	Bunds have been formed at two low points along Q2W face allowing tailing infill above Eaves Lane	Public and developers	During development	4	1	4	Development plans should not remove the bund material without further investigation	Investigation of bund and tailings recommended before capping	3	1
Q2	3.8	Sink hole forming and migrating to the surface	Sink hole recorded in NW corner of Q2E and small scale sink holes observed in south of Q2W.	Proposed structures & site users.	Potential to occur any time	1	3	3	Highest risk is within approx 10m to 20m from the edge of the infilled quarry. Therefore development in this zone needs to be relocated or measures put in place such as geo-grids within the capping layer to minimise the effects should a sink hole form.	Any surface movements need to be investigated to determine the cause.	2	1
Q3	4.1	Landbridge failure between Q2W and Q3	The existing slopes of Q3 range from 1:2 at the top to 1:1 at the quarry base. Evidence of the 2m retained sandstone is evident on the quarry floor sloping into L8.	Mass movement of landbridge into Q3 lake	Most at risk during or after Q3 fills with water	4	2	8	Slope support or buttressing may be required	monitor quarry slopes during infilling and after lake infilling for signs of movement	6	2
Q3	4.2	Steep north slope with weakly cemented sandstone near base	Existing slope stable. However wet western slope has been reduced to 1:3 to counter localised instability	Concern that localised base instability could result in mass movement into Q3 lake	Most at risk during or after Q3 fills with water	4	3	12	Slope support or buttressing required below water level	monitor quarry slopes during infilling and after lake infilling for signs of movement	10	2

Quarry Area	Risk Ref.	Description of Risk	Walkover Assessment	Who is at risk	Time of Risk	Potential to cause harm	Probability Factor	Risk Factor	Action Required	Investigation Required	Reduction in Risk	Resultant Risk
Q3	4.3	Steep south slope with weakly cemented sandstone near base	Existing slope stable. However wet western slope has been reduced to 1:3 to counter localised instability	Concern that localised base instability could result in mass movement into Q3 lake. Dip of strata into slope and open ground at crest makes risk slightly less than north side However risk remains high	Most at risk during or after Q3 fills with water	4	2	8	Slope support or buttressing required below water level	monitor quarry slopes during infilling and after lake infilling for signs of movement	7	1
Q3	4.4	Steep slopes around lake	Existing slopes form rocky crags which can be walked over with care	Plant, equipment and personnel falling down slope	During development and after	3	1	3	Place temporary barrier below areas of working and movement	H&S inspection of area prior to working	2	1
Q3	4.5	Steep slopes around lake	Existing slopes form rocky crags which can be walked over with care	Site users	Potential to occur any time	3	1	3	Place bunds or fences between path / track and slope. Encourage bushes and shrubs to grow on slope to limit fall.	Hydro-seed slope with drought resistant plants and grass to build up soil layer.	2	1
Q3	4.6	Acidic water / tailings	Initial tests indicate that acidity rapidly reduces as river /rain water flows over and through tailing areas	Low pH which will adversely affect lake user, fish and ecology.	During development	3	1	3	Prior to construction investigate and monitor surface water, tailings and groundwater to determine pH. Post construction monitor pH regularly.	Investigate quarry water before and after production has ceased to confirm acidity has been neutralised	3	0
Q1/2	5.1	Localised block failure around Tunnel under Eves Lane Entrance	Existing tunnel portals protected from cliff rock falls. Existing portal protection in poor state of repair. Requires replacing	Site users	Highest risk in winter but could occur any time.	3	4	12	Assessment of potential rock size and design of new portals	Detailed logging of portal rock face	10	2
Q1/2	5.2	Risk of minor rock falls in Tunnel under Eves Lane	Existing tunnel roof rock bolted to limit risk of large rock fall	Traffic or pedestrians passing through tunnel	Any time.	3	3	9	Inspect and photograph key locations for signs of movement on an annual basis. Alternative is to provide tunnel with a new lining and infill void between.	Test rock bolts and re-logging of rock faces in tunnel	6	3
Q1/2	5.3	Risk of major collapse of tunnel under Eves Lane	Tunnel reported to have been stable throughout its life. No signs of major movement within or around tunnel	Traffic or pedestrians passing through tunnel	Any time.	4	1	4	Inspect and photograph key locations for signs of movement on an annual basis	Place movement indicators/ targets into tunnel wall and roof and regularly survey	3	1

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Geotechnical Risk Assessment

Client: Laver Leisure

Project: Moneystone Quarry, Oakamoor

Number: 418040

Table 1

Quarry Area	Risk Ref.	Description of Risk	Walkover Assessment	Who is at risk	Time of Risk	Potential to cause harm	Probability Factor	Risk Factor	Action Required	Investigation Required	Reduction in Risk	Resultant Risk
L2	6.1	Tailing lagoon south east of production area	Area of flat ground with floor slab of clay body plant at northern end.	Differential settlement of building on lagoon	During development and after	1	2	2	Building to be limited to flexible structures or piles/stone columns in differential movement unacceptable	Investigate tailings in area of proposed structures	1	1
L3	6.2	Potential collapse of dam supporting L3 tailings if surface water ponding on L3 area	Lagoon capped and grass and scrub tree cover. Dam covered by trees. No signs of any movement on main slope. Area above SP1 may be a concern.	A dam failure would cause the lagoon slurry to liquefy causing the loss of anything constructed on it. Also there is a risk the collapse could extend down into the valley below.	Dam was given 50 life which has passed. Blockage of drains could trigger future collapse.	4	3	12	Determine whether tailings need to be under drained by horizontal pipes or whether surface drainage sufficient	Investigate by S& A existing dam and tailings and compare with 1968 logs. Monitor groundwater	9	3
L2/3	6.3	Penetration of capping exposing underlying tailings	A 2m plus cover of dry waste applied to this area which has subsequently been vegetated. Stream running through area to south	Destabilisation of cap causing differential movement	During development and after	2	2	4	Excavation into capping should be limited to 1m bgl	SI investigation recommended to establish depth and state of cap and tailings	3	1
SP 1, 2 & 3	6.4	Silt ponds in valley below dam	Running sand and deep water in pond areas	Site users	During development and after	3	2	6	Cut into dams to reduce depth of water retention	Investigate dams to determine suitable location for lowering water levels	5	1
L2 / T2	6.5	Dam supporting L2 tailings and T3 backfill could fail	Lagoon capped and grass and scrub tree cover. Dam covered by trees. Signs of any movement obscured. Stream E flows out of stone blanket in valley floor.	A dam failure would cause the lagoon slurry to liquefy causing the loss of anything constructed on it. Also there is a risk the collapse could extend down into the valley below.	During development	4	2	8	Watercourse beneath tip T2 needs monitoring for signs blockage. Given the time since it was covered over and the method, the flow capacity / potential will diminish with time.	Investigate dam, tailings and groundwater in base of old valley	7	1
P1	6.6	Unknown	Many structures & tanks	Various	Whilst structures remain	4	4	16	If not being removed before development, place secure fencing around until removed or made safe	Separate risk assessment by structural engineer required if to be retained.		

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Geotechnical Risk Assessment

Client: Laver Leisure

Project: Moneystone Quarry, Oakamoor

Number: 418040

Table 1

FIGURES

N

THE SITE

Reproduced from the Ordnance Survey map with permission of the Controller of Her Majesty's Stationery Office Crown Copyright 2000. Licence No. 100002140

Measurements should not be scaled from this plan

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KEY PLAN

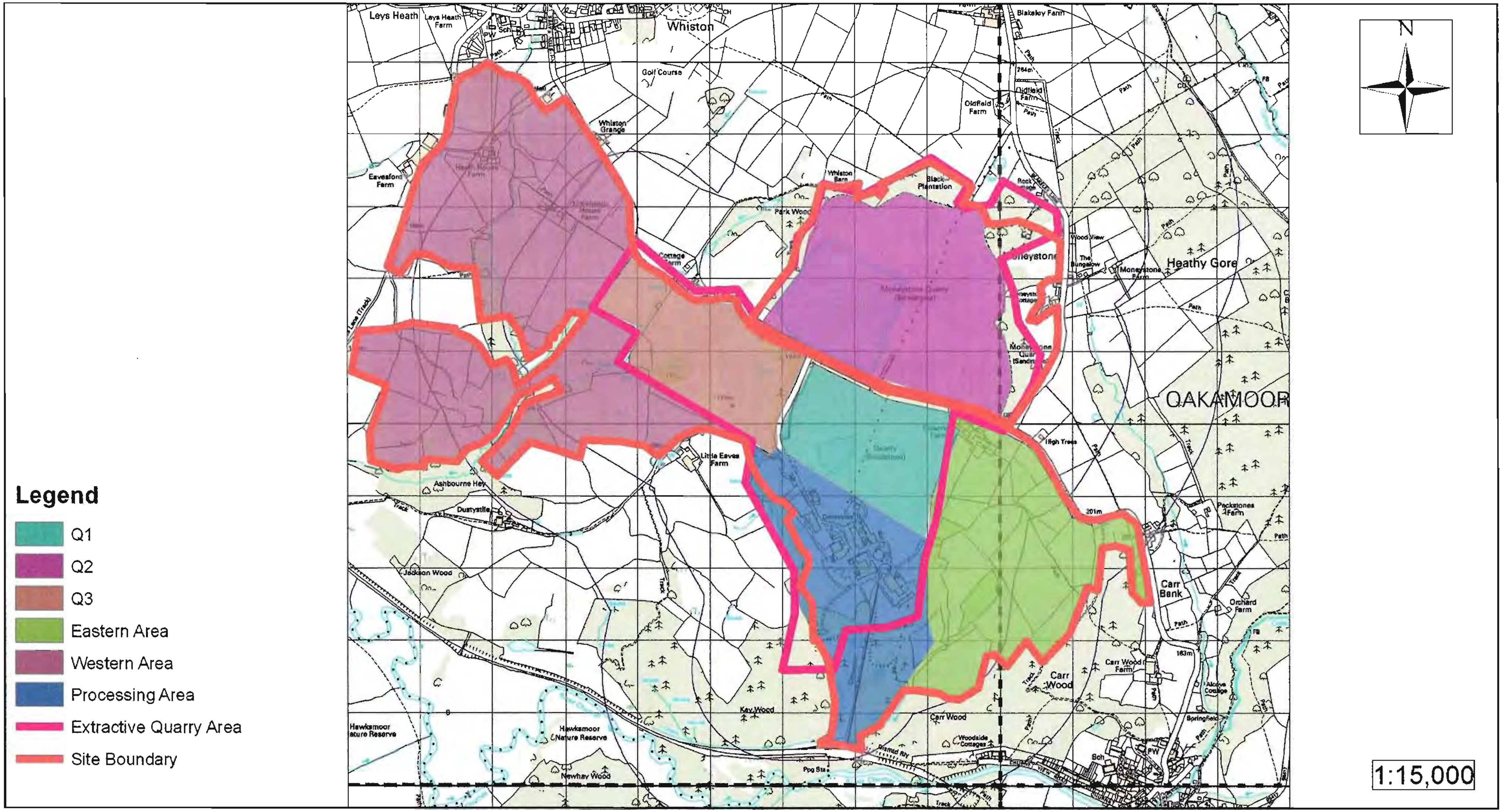
Client: Laver Leisure

Project: Moneystone Quarry, Oakamoor

Number: 418040

Fig 1

*FIG 1 KEY PLAN 418040.GPJ ABEC TEMPLATE.GDT 11/3/11



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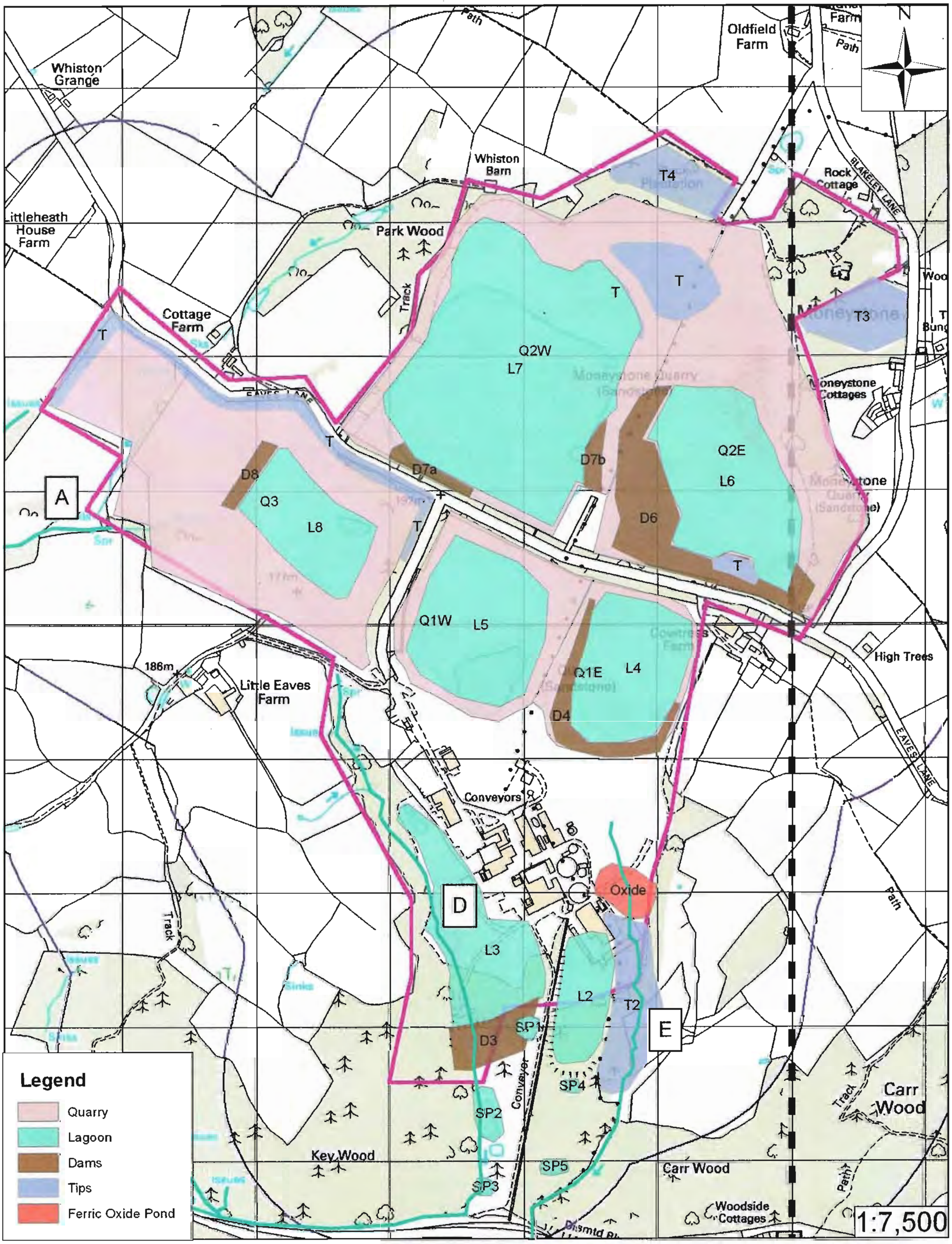
Quarry Area Plan

Project: Moneystone Quarry Oakamoor
Job No: 418040
Client: Laver Leisure
March 2011

Fig 2a



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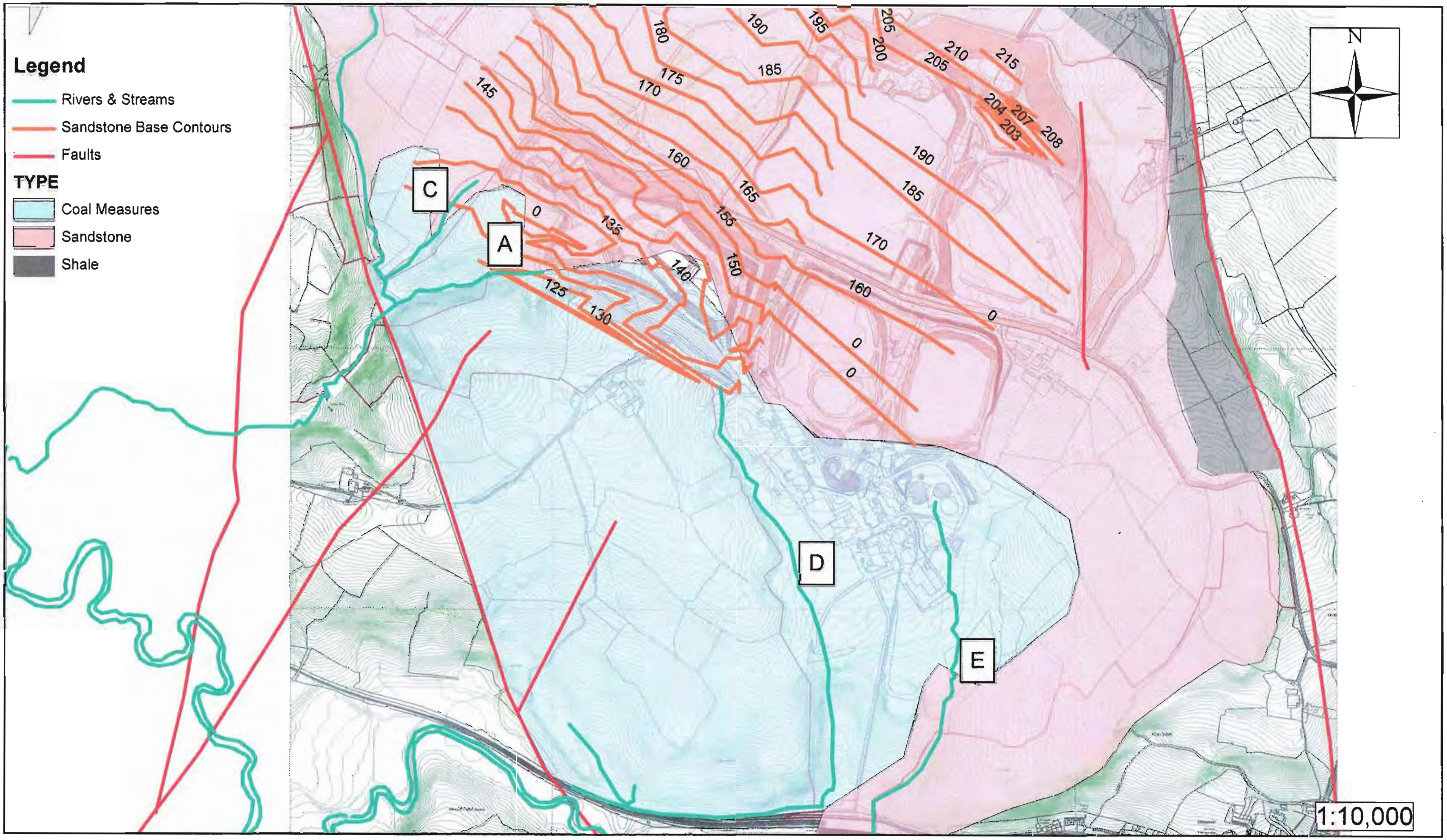
Quarry Features

Project: Moneystone Quarry Oakamoor
Job No: 418040
Client: Laver Leisure
March 2011

Fig 2b



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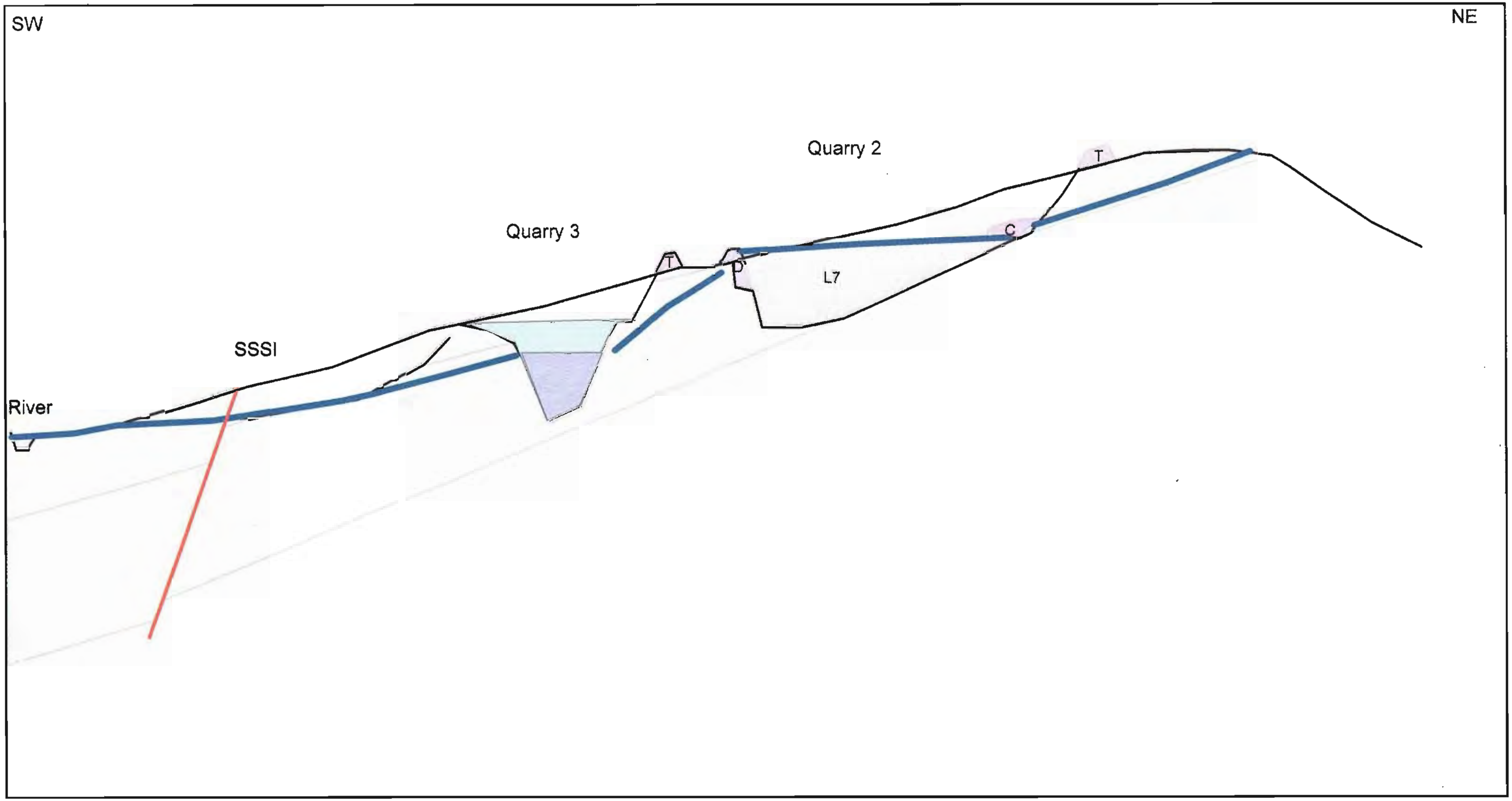
Geological Plan

Project: Moneystone Quarry Oakamoor
Job No: 418040
Client: Laver Leisure
March 2011

Fig 3



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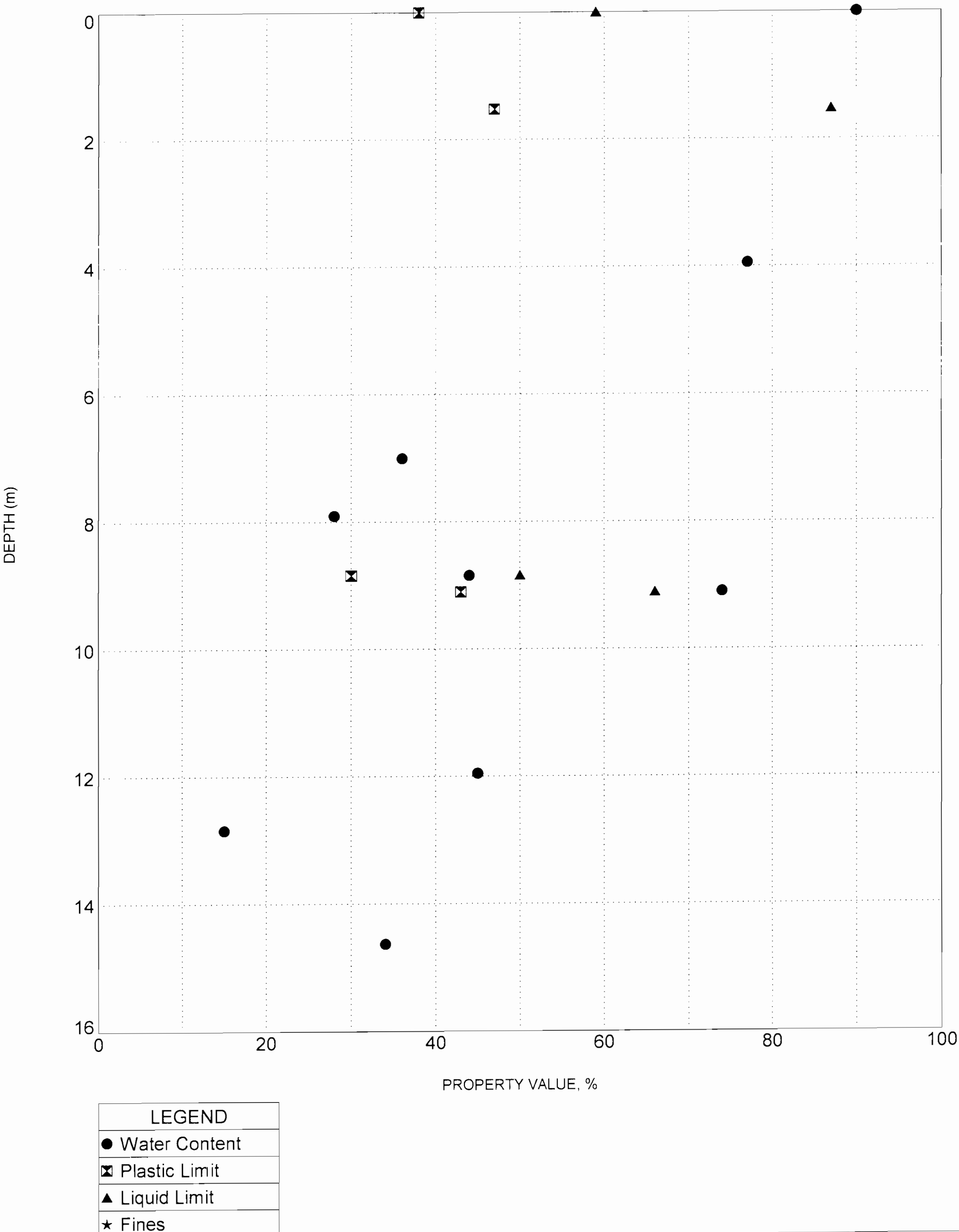
Not to Scale

Typical SW to NE Section

Project: Moneystone Quarry Oakamoor
Job No: 418040
Client: Bolsterstone plc
September 2010

Fig 4



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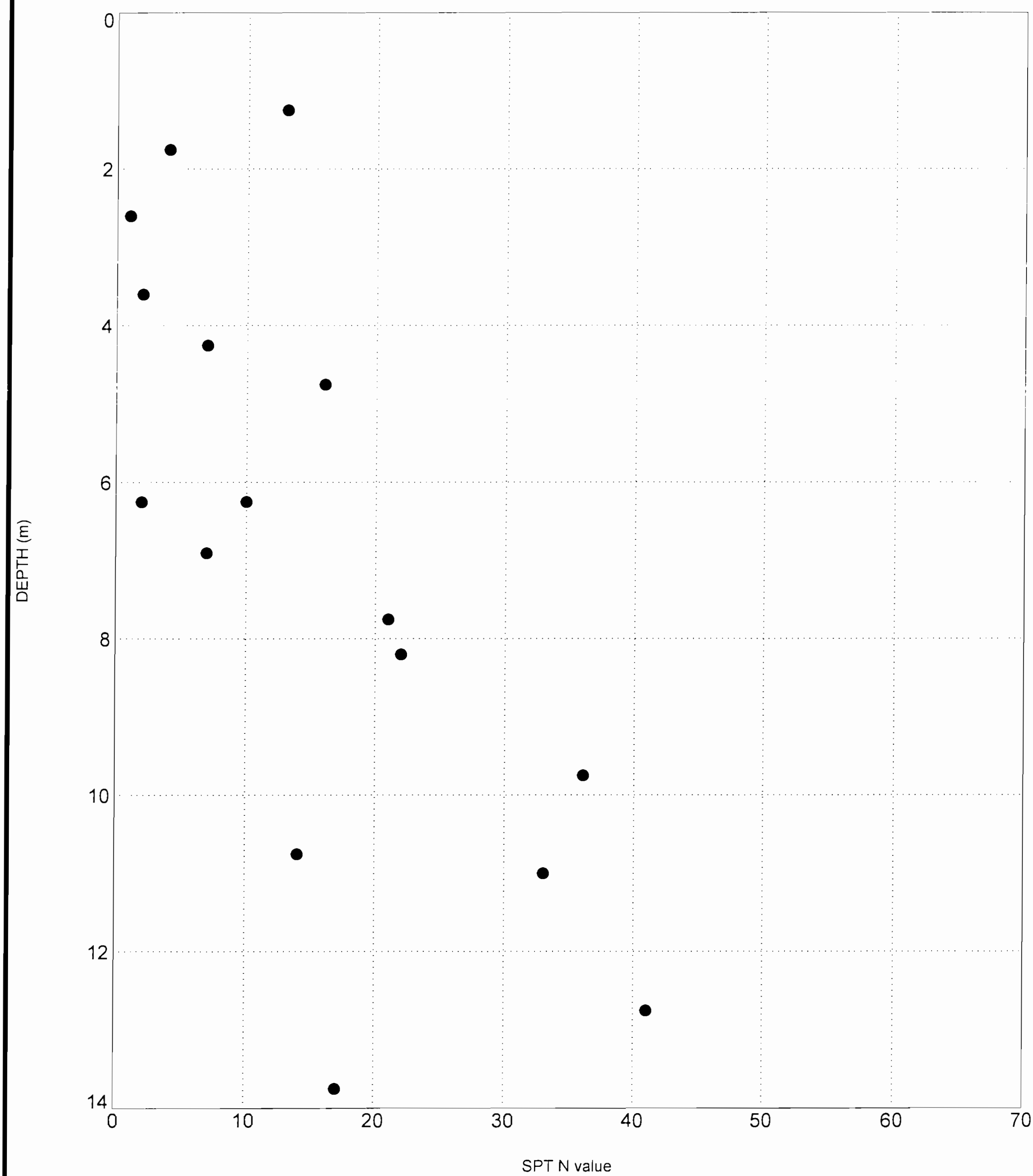
TAILINGS MOISTURE VERSUS DEPTH

Client: Laver Leisure

Project: Moneystone Quarry, Oakamoor

Number: 418040

Fig 5



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TAILINGS STRENGTH VERSUS DEPTH

Client: Laver Leisure

Project: Moneystone Quarry, Oakamoor

Number: 418040

Fig 6

APPENDIX A

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APPENDIX B

Hydrogeology Baseline Assessment

APPENDIX B

Hydrogeology Baseline Assessment

As part of a planning application by WBB in 2007, for the extension of Q3 and the excavation of Q4 proposed to the northwest of the existing quarries, a baseline study of the groundwater flow around and through the quarry area was undertaken. As this baseline hydrological data remains relevant to the proposed development it has been used as the baseline data for this report. In preparing the baseline data the three streams draining the Q3 area were monitored using three 'V' notch gauges located just before the confluence of the three streams A, B and C. See Fig B1. It should be noted that Stream C flows into Stream B above the level of Stream B's weir, and consequently Stream C's flow forms a part of Stream B's flow. The monitoring records are given in Table B4 and shown in graphical form in Fig B2. Additionally groundwater levels from standpipes in the sandstone are given in Table B5 and Figs B3, whilst the Moneystone monthly rainfall data from 1984 is given in Table B2 and in Fig B4. In addition to Streams A, B and C, named in the previous report, this report identifies two further unnamed streams, running south from the Production Area, as Streams D and E.

Rainfall

Monthly rainfall data was collected by the quarry since 1984 and presented in 418040GR. A monthly summarised is given in Table B1 below.

Table B1	Monthly Rainfall (mm)		
Month	Min	Avg	Max
January	12	91	180
February	8	68	134
March	13	70	146
April	11	75	147
May	9	59	115
June	14	77	150
July	27	71	192
August	25	81	299
September	12	71	155
October	30	97	178
November	53	98	214
December	38	103	186
Annual Rainfall	700	960	1,202

The annual rainfall shows some marked variations between the dry years of 1991, 1995-97 and the wet years of 2000 and 2002. Although rainfall, on average, has been increasing in the winter months, the highest peaks of rainfall have occurred during the summer months.

Monthly potential evaporation (PE) data were obtained for the original WBB baseline study from the Met Office for MORECS square 115 and were used to estimate recharge to groundwater.

Run-Off

Where not quarried, the watershed is mostly covered by farmed grassland and woodland. The underlying geology splits the watershed into three distinct areas. The highest northern part of the watershed (46%) is underlain by interbedded siltstone and shale with a low permeability and consequently relatively high run-off. Collected by a number of shallow south flowing gullies, run-off flows into the quarry area and onto the sandstone which outcrops east to west centrally across the watershed. In the sandstone areas (35%) a higher proportion of the rainfall and run-off will soak into the sandstone aquifer which dips gently to the southeast. Consequently much of the rainfall, together from the collected surface water from the shale runs through the sandstone, with groundwater east of the quarry entrance running to Streams D and E, whilst the remaining flow enters Streams A and B, and possibly C in the areas of exposed sandstone just upstream of their confluence.

Table B2		Area of Watershed (m^2)			
Period	Stream	Shale	Sandstone	Coal Measures	Total
Pre Q3	A	169,500	284,700	106,200	560,400
	B	458,400	26,200	75,000	559,600
	C	457,600	246,100	18,300	722,000
	D	359,800	173,200	411,200	944,200
	E				192,400
Current Q3	A	0	11,100	88,900	100,000
	B	458,400	26,200	75,000	559,600
	C	0	13,400	18,300	31,700
	D	987,000	679,400	428,500	2,094,900
	E				192,400
New Development	A	987,000	548,800	88,900	1,624,700
	B	458,400	26,200	75,000	559,600
	C	0	13,400	18,300	31,700
	D	0	141,700	428,500	570,200
	E				192,400

Forming the lower ground, south of the quarries, the Coal Measures strata rests above the sandstone and has relatively low permeability resulting in limited infiltration. Run-off is therefore more immediate and drains directly to the four streams directed by the slope of the ground.

With quarrying the run-off from the watershed has been redistributed between Streams A, B, C and D. Initially the landforms prior to Q2 show run-off was split between Stream A and D, whilst Q1 and the production area was wholly drained by

Stream D and E. Table B2 along with Figs B5a, B5b and B5c shows the proportion of land the five streams drain, in the period prior to Q3, currently, and after, the proposed development.

Before the excavation of Q3, all of Q2s run-off had been collected by Stream D as part of the production washing process. With the development of Q3, the run-off from the higher ground to the north will have been increasingly diverted into the quarry. Initially surface water running into Q3 will have soaked into the sandstone quarry floor, which will have fed the background groundwater flows of Streams A and B, possibly C. With Q3 being deepened to below the groundwater table along with its extension westwards the groundwater flow and surface water were collected in a sump and then used to supplement the water used in the production process. See pump records Fig D6. Consequently water being collected from Q3 will, having first been used in the production process, drain down to Stream D. This is artificially supplemented by 200 to 340 m^3/day of water extracted and returned to the river Churnet for the production washing process.

Groundwater Flow

The baseline data indicates some significant flow of groundwater through the sandstone bedrock. The permeability of the sandstone has been previously investigated and field tests record the permeability of the sandstone to range between $4.3x10^{-3}$ to $4.3x10^{-1}$ m/sec. These results are quite high and probably represents flow through heavily fractured zones. Typical permeability of the medium to fine sandstone found at this site would be in the order of 10^{-5} m/sec. A calculated permeability based on rainfall data, catchment areas and lag time to peak stream flows indicates an average permeability in the range of $8x10^{-5}$ to $2x10^{-4}$ m/sec.

The underlying shale that outcrops to the north and Coal Measures mudstone which cap the sandstone to the south will each have a low permeability ($<1x10^{-7}$m/s). These therefore form aquacludes above and below the southwest dipping sandstone. However, artesian pressures reported below Q3 from the more permeable sandstone bands within the lower shales does suggest small flow through this lower strata may occur.

Streams A, B & C

South of Q3 the streams are in incised valleys cutting through the overlying Coal Measures strata which form the valley sides. However, the stream base over most of their length, before combining, is on the top of the underlying sandstone. This results in a number of springs forming in the valley floor of all three streams until they reach levels of 143, 145 and 146 respectively. Additionally Stream B follows the line of a NW to SE trending fault which downthrows the strata to the southwest and so will limit flow of groundwater further to the southwest.

Between 1996 and 2005 WBB monitored Streams A, B and C which flow southwest of Q3 using 'V' notch gauges located before the Streams A and B combine to flow into Ashbourne Hey. See Fig B1.

Table B3	Stream Flow (1996 to 2005) m^3/day		
Stream	A	B	C
Min Flow	109	109	55
Avg Flow	502	1,074	190
Max Flow	4,113	4,113	832
Notes	1. Stream C flows into Stream B above it gauge. 2. The maximum gauge flows of Streams A and B occurred when the gauges were overtopped.		

It was concluded from the WBB baseline study that Streams A, B and C flow was influence by the short flashy nature of the run-off and a slower flowing baseloads from the sandstone spring waters.

As Stream D was outside the remit of the WBB report, it's hydrology was not covered in their baseline report. However, since its current flow and its flows since quarry production started in 1960 has largely been influenced by the outfall of water from the production washing process, it has not been coincided practical to provide a supplementary baseline for this stream other than provide a brief outline of its setting.

Stream D

Stream D currently drains run-off from the quarry areas and production area which is channelled through the production area to a point at where a dismantled conveyor belt met the access road down to the railway at 153m AOD. The stream is then culverted down the side of the access road to a settling pond SP1 on the track's west side. From time to time silt is removed by excavator from this pond. The pond is also joined by surface water that flows down the west side of a tailings dam, draining the wooded area of the site to the southwest of the production area. The stream then steeply descends, in pipe, to settling pond SP2 at 125m AOD and SP3 at 115m AOD. Again the stream enters a series of culverts and marshy areas before entering the River Churnet at 110m AOD, south of the disused railway.

Stream E

Stream E originally flowed in an incised valley east of the production area and outfalls with Stream D into the River Churnet. Between the start of quarrying in the 1960's and about 1979 the valley was gradually infilled. To allow groundwater outflow to continue the stream was stone filled and part culverted. Currently water flows from a stone headwall just north of the railway sidings, and runs in culvert and channel to the River Churnet.

Two further ponds have been identified within the woodland area to the east of the access track. Both ponds are artificially constructed and were previously used by the production works for settling fines before releasing water to the river. The upper pond at about 145m AOD has limited inflow and when inspected was stagnant with its outfall 2m to 3m higher within a dam on its south and west sides. Historic records would suggest it was used when the now capped L2 was in operation. The second pond at 123m AOD, again had no defined inflow other than receiving run-off from the slope above. However, with a small outflow it has become naturalised with a rich wildlife.

Licensed Abstractions

The quarry has an abstraction license to pump water from the River Churnet just above the outfall of Stream E, while in December 2011 they had licenses to discharge of water to Streams A, B and C as well as to the River Churnet. We understand it was agreed the quarry would rescind their right to discharge to Streams A, B and C when quarrying ceased in December 2011. Copies of the various abstraction and discharge licenses are attached.

Moneystones Quarry, Oakamoor
Stream Flow from 1996

Table B5

Date Measured	Flow (m3/d)					Rainfall (mm/month)
	A	B	C		A+B	
07/03/1996	256	539	50		**795**	**71**
08/03/1996	256	483	50		**739**	**71**
11/03/1996	220	539	50		**760**	**72**
13/03/1996	295	1322	55		**1616**	**72**
15/03/1996	295	731	55		**1025**	**71**
18/03/1996	256	878	50		**1134**	**71**
22/03/1996	295	1043	55		**1337**	**70**
25/03/1996	295	802	50		**1097**	**68**
30/03/1996	256	483	41		**739**	**69**
01/04/1996	173	401	32		**574**	**68**
04/04/1996	146	337	27		**482**	**64**
09/04/1996	127	295	23		**422**	**59**
12/04/1996	233	539	43		**773**	**58**
15/04/1996	173	401	32		**574**	**58**
19/04/1996	209	483	38		**692**	**58**
22/04/1996	165	382	30		**547**	**59**
26/04/1996	165	382	30		**547**	**61**
29/04/1996	165	382	30		**547**	**60**
03/05/1996	209	483	38		**692**	**57**
06/05/1996	127	295	23		**422**	**55**
10/05/1996	111	256	20		**366**	**54**
13/05/1996	95	220	18		**316**	**52**
17/05/1996	95	220	18		**316**	**49**
20/05/1996	90	207	16		**297**	**47**
24/05/1996	111	256	20		**366**	**43**
28/05/1996	127	295	23		**422**	**42**
31/05/1996	165	382	30		**547**	**41**
03/06/1996	69	159	13		**227**	**40**
07/06/1996	64	148	12		**212**	**39**
10/06/1996	47	109	9		**156**	**39**
14/06/1996	47	109	9		**156**	**38**
17/06/1996	43	100	8		**143**	**38**
21/06/1996	51	118	9		**169**	**37**
24/06/1996	42	96	8		**138**	**36**
28/06/1996	74	170	14		**244**	**36**
01/07/1996	104	241	19		**346**	**36**
05/07/1996	42	96	8		**138**	**34**
08/07/1996	39	91	7		**130**	**33**
12/07/1996	188	91	48		**279**	**33**
15/07/1996	159	91	37		**249**	**32**
19/07/1996	159	91	37		**249**	**31**
22/07/1996	188	91	39		**279**	**31**
26/07/1996	148	132	44		**280**	**30**
29/07/1996	194	132	39		**326**	**30**
02/08/1996	142	132	42		**275**	**32**
05/08/1996	164	107	36		**271**	**36**
08/08/1996	220	153	38		**373**	**38**
12/08/1996	227	148	37		**375**	**40**
16/08/1996	137	122	40		**260**	**41**
19/08/1996	159	109	44		**267**	**42**

Moneystones Quarry, Oakamoor
Stream Flow from 1996

Table B5

Date Measured	Flow (m3/d)				Rainfall (mm/month)
	A	B	C	A+B	
23/08/1996	170	164	43	**334**	**42**
27/08/1996	159	201	40	**359**	**42**
30/08/1996	153	159	44	**312**	**43**
02/09/1996	132	159	37	**291**	**41**
06/09/1996	234	188	39	**422**	**35**
09/09/1996	148	159	37	**306**	**33**
13/09/1996	132	153	37	**285**	**32**
16/09/1996	132	170	39	**302**	**32**
20/09/1996	220	170	28	**390**	**31**
23/09/1996	142	153	35	**296**	**32**
27/09/1996	153	170	38	**323**	**33**
30/09/1996	159	170	37	**329**	**32**
04/10/1996	127	176	32	**303**	**44**
07/10/1996	153	159	36	**312**	**53**
11/10/1996	118	176	39	**294**	**56**
14/10/1996	159	176	39	**335**	**57**
18/10/1996	148	287	42	**434**	**60**
21/10/1996	159	401	46	**560**	**62**
25/10/1996	127	176	39	**303**	**60**
28/10/1996	159	295	41	**453**	**60**
01/11/1996	188	539	40	**727**	**65**
04/11/1996	188	731	57	**919**	**74**
08/11/1996	170	345	40	**515**	**83**
11/11/1996	159	256	39	**414**	**86**
15/11/1996	153	182	42	**335**	**93**
18/11/1996	234	731	46	**965**	**99**
22/11/1996	303	690	50	**992**	**108**
25/11/1996	1131	3367	204	**4498**	**113**
29/11/1996	894	4113	190	**5007**	**116**
02/12/1996	483	1758	75	**2241**	**112**
06/12/1996	421	1302	78	**1723**	**102**
09/12/1996	263	773	50	**1037**	**98**
13/12/1996	214	528	40	**741**	**96**
16/12/1996	207	391	38	**598**	**95**
20/12/1996	878	4113	219	**4991**	**94**
23/12/1996	363	910	62	**1273**	**95**
03/01/1997	148	382	37	**530**	**83**
06/01/1997	182	391	38	**573**	**73**
10/01/1997	148	328	40	**476**	**67**
13/01/1997	194	1095	45	**1289**	**63**
17/01/1997	164	505	40	**670**	**54**
20/01/1997	182	401	38	**583**	**47**
24/01/1997	153	505	45	**658**	**40**
27/01/1997	188	391	38	**579**	**36**
30/01/1997	164	421	42	**585**	**35**
03/02/1997	170	337	37	**507**	**42**
07/02/1997	164	663	52	**827**	**53**
10/02/1997	207	539	48	**746**	**55**
14/02/1997	494	1642	75	**2136**	**56**
17/02/1997	303	731	45	**1033**	**57**

Moneystones Quarry, Oakamoor
Stream Flow from 1996

Table B5

Date Measured	Flow (m3/d) A	B	C	A+B	Rainfall (mm/month)
21/02/1997	441	1665	134	**2106**	**58**
24/02/1997	295	1060	95	**1354**	**55**
28/02/1997	599	2558	126	**3157**	**53**
03/03/1997	303	1113	60	**1416**	**52**
07/03/1997	241	788	50	**1029**	**45**
10/03/1997	214	587	42	**801**	**44**
14/03/1997	201	451	46	**652**	**45**
17/03/1997	182	421	47	**603**	**46**
21/03/1997	194	431	41	**625**	**48**
24/03/1997	159	382	46	**541**	**52**
04/04/1997	109	256	37	**364**	**51**
07/04/1997	159	271	35	**430**	**51**
11/04/1997	142	263	37	**406**	**50**
14/04/1997	159	227	36	**386**	**48**
18/04/1997	148	248	44	**396**	**45**
21/04/1997	153	194	32	**347**	**42**
25/04/1997	148	401	49	**549**	**37**
28/04/1997	159	271	39	**430**	**36**
02/05/1997	132	263	40	**396**	**40**
06/05/1997	287	1224	92	**1511**	**48**
12/05/1997	483	2005	95	**2488**	**52**
19/05/1997	176	401	28	**577**	**57**
27/05/1997	137	279	41	**416**	**61**
02/06/1997	188	248	40	**436**	**70**
09/06/1997	142	220	50	**363**	**92**
16/06/1997	214	382	43	**596**	**102**
23/06/1997	802	4113	274	**4916**	**115**
30/06/1997	256	1131	134	**1387**	**121**
07/07/1997	176	319	41	**495**	**98**
14/07/1997	127	256	54	**383**	**95**
21/07/1997	176	256	50	**432**	**93**
28/07/1997	113	279	47	**392**	**99**
04/08/1997	94	188	42	**282**	**95**
12/08/1997	137	194	36	**331**	**94**
18/08/1997	159	188	36	**347**	**86**
26/08/1997	241	271	40	**512**	**72**
01/09/1997	256	663	51	**919**	**72**
08/09/1997	142	328	38	**470**	**61**
16/09/1997	182	220	38	**402**	**59**
23/09/1997	153	182	38	**335**	**57**
29/09/1997	142	337	39	**479**	**57**
09/10/1997	220	2135	67	**2356**	**63**
13/10/1997	194	354	39	**548**	**63**
21/10/1997	194	382	39	**576**	**61**
27/10/1997	170	263	39	**433**	**58**
03/11/1997	176	248	45	**424**	**65**
11/11/1997	214	1043	55	**1256**	**77**
18/11/1997	401	2412	81	**2813**	**85**
24/11/1997	295	1445	150	**1739**	**91**
01/12/1997	539	1758	95	**2297**	**95**

Moneystones Quarry, Oakamoor
Stream Flow from 1996

Table B5

Date Measured	Flow (m3/d) A	B	C		A+B	Rainfall (mm/month)
08/12/1997	234	587	49		**821**	**96**
15/12/1997	271	847	51		**1118**	**99**
22/12/1997	303	942	53		**1245**	**104**
05/01/1998	1424	4113	337		**5537**	**108**
12/01/1998	401	1531	95		**1932**	**108**
19/01/1998	1131	3918	209		**5049**	**108**
26/01/1998	539	817	55		**1357**	**107**
02/02/1998	441	663	60		**1104**	**100**
09/02/1998	431	663	52		**1094**	**78**
17/02/1998	287	483	55		**770**	**68**
26/02/1998	271	472	52		**743**	**61**
04/03/1998	1186	4113	204		**5300**	**69**
10/03/1998	731	1688	138		**2419**	**80**
23/03/1998	401	802	75		**1203**	**77**
30/03/1998	599	2189	126		**2788**	**76**
06/04/1998	802	1735	126		**2537**	**81**
14/04/1998	650	1113	102		**1763**	**86**
20/04/1998	1806	2412	130		**4218**	**95**
30/04/1998	431	958	89		**1389**	**105**
05/05/1998	411	817	95		**1228**	**84**
11/05/1998	421	745	89		**1165**	**71**
18/05/1998	382	637	83		**1019**	**61**
26/05/1998	363	612	89		**975**	**53**
01/06/1998	337	599	83		**936**	**54**
08/06/1998	373	894	142		**1266**	**85**
15/06/1998	337	745	92		**1081**	**89**
22/06/1998	363	802	92		**1166**	**92**
29/06/1998	337	759	95		**1095**	**89**
06/07/1998	311	717	89		**1028**	**77**
13/07/1998	311	599	92		**910**	**73**
20/07/1998	319	599	81		**919**	**80**
19/08/1998	227	494	72		**721**	**82**
24/08/1998	431	2412	119		**2843**	**74**
01/09/1998	287	731	86		**1017**	**73**
08/09/1998	295	483	55		**778**	**82**
14/09/1998	373	958	89		**1331**	**86**
21/09/1998	279	575	83		**853**	**92**
28/09/1998	248	575	67		**823**	**96**
05/10/1998	319	731	81		**1050**	**115**
12/10/1998	295	817	89		**1112**	**127**
19/10/1998	441	1382	99		**1823**	**139**
28/10/1998	4113	4113	358		**8226**	**147**
02/11/1998	731	2005	194		**2735**	**141**
09/11/1998	1782	3367	224		**5149**	**116**
16/11/1998	575	1322	134		**1897**	**111**
23/11/1998	539	1043	112		**1582**	**109**
30/11/1998	563	1131	126		**1694**	**108**
07/12/1998	516	894	105		**1410**	**109**
14/12/1998	910	2803	194		**3712**	**104**
21/12/1998	676	1322	150		**1998**	**92**

Moneystones Quarry, Oakamoor
Stream Flow from 1996

Table B5

Date Measured	Flow (m3/d) A	B	C		A+B	Rainfall (mm/month)
04/01/1999	1282	3692	224		**4974**	**128**
11/01/1999	878	1322	112		**2200**	**131**
18/01/1999	1224	2709	246		**3934**	**125**
25/01/1999	1186	2866	209		**4052**	**115**
01/02/1999	1224	1711	209		**2935**	**112**
08/02/1999	1077	1782	269		**2859**	**94**
15/02/1999	759	1531	257		**2289**	**91**
22/02/1999	1077	3027	393		**4105**	**88**
01/03/1999	3195	4113	722		**7308**	**88**
08/03/1999	1025	2327	393		**3352**	**93**
15/03/1999	703	1531	344		**2234**	**90**
22/03/1999	773	2056	408		**2830**	**85**
29/03/1999	759	1642	439		**2401**	**80**
06/04/1999	650	1342	386		**1992**	**87**
12/04/1999	599	1403	416		**2002**	**89**
19/04/1999	1642	2709	446		**4351**	**95**
26/04/1999	1168	4113	512		**5281**	**101**
04/05/1999	599	1322	393		**1921**	**91**
10/05/1999	637	1466	423		**2103**	**80**
17/05/1999	563	1149	372		**1712**	**75**
24/05/1999	599	1131	393		**1730**	**72**
01/06/1999	483	1131	57		**1614**	**71**
07/06/1999	759	1929	423		**2688**	**85**
14/06/1999	539	1149	365		**1689**	**86**
21/06/1999	483	1043	337		**1526**	**86**
28/06/1999	516	1382	324		**1899**	**81**
05/07/1999	663	1362	324		**2025**	**73**
12/07/1999	494	958	274		**1452**	**67**
19/07/1999	483	1224	299		**1707**	**68**
29/07/1999	575	731	171		**1306**	**73**
03/08/1999	539	802	67		**1342**	**75**
09/08/1999	441	1322	251		**1763**	**81**
16/08/1999	373	788	199		**1160**	**79**
25/08/1999	441	1424	209		**1865**	**73**
30/08/1999	345	745	158		**1090**	**73**
07/09/1999	391	731	162		**1122**	**81**
13/09/1999	354	663	146		**1017**	**84**
20/09/1999	431	1531	185		**1961**	**91**
27/09/1999	1095	1362	146		**2457**	**96**
04/10/1999	731	2109	150		**2840**	**99**
11/10/1999	421	1131	142		**1552**	**100**
18/10/1999	345	663	134		**1008**	**102**
25/10/1999	1424	4113	401		**5537**	**105**
01/11/1999	431	1186	150		**1617**	**103**
08/11/1999	528	1362	176		**1890**	**89**
15/11/1999	354	863	109		**1217**	**85**
22/11/1999	411	1025	109		**1436**	**80**
29/11/1999	401	958	109		**1359**	**79**
08/12/1999	494	1263	158		**1757**	**96**
13/12/1999	1077	3438	219		**4515**	**98**

Moneystones Quarry, Oakamoor
Stream Flow from 1996

Table B5

Date Measured	Flow (m3/d) A	B	C	A+B	Rainfall (mm/month)
20/12/1999	483	1131	86	**1614**	**100**
10/01/2000	505	1186	119	**1692**	**74**
14/01/2000	663	1711	146	**2374**	**73**
24/01/2000	528	328	109	**856**	**74**
31/01/2000	650	1758	150	**2408**	**71**
08/02/2000	539	1043	105	**1582**	**88**
14/02/2000	587	1282	138	**1869**	**88**
21/02/2000	650	1642	167	**2292**	**85**
29/02/2000	1186	3195	240	**4381**	**79**
06/03/2000	676	1531	180	**2207**	**71**
13/03/2000	587	1043	138	**1629**	**68**
20/03/2000	1362	863	105	**2225**	**71**
03/04/2000	539	1131	130	**1671**	**76**
10/04/2000	505	802	109	**1308**	**76**
18/04/2000	690	2005	162	**2694**	**72**
27/04/2000	1322	4113	240	**5435**	**64**
02/05/2000	703	1113	150	**1816**	**65**
16/05/2000	505	802	134	**1308**	**67**
23/05/2000	505	958	180	**1463**	**69**
30/05/2000	539	1224	154	**1764**	**69**
05/06/2000	612	1424	167	**2036**	**70**
12/06/2000	483	759	146	**1242**	**71**
19/06/2000	441	745	119	**1186**	**71**
26/06/2000	472	878	126	**1351**	**71**
03/07/2000	505	1224	150	**1729**	**68**
10/07/2000	451	1043	123	**1494**	**62**
17/07/2000	401	745	112	**1146**	**60**
08/08/2000	373	599	115	**972**	**59**
21/08/2000	345	703	109	**1048**	**56**
04/09/2000	354	624	112	**979**	**73**
18/09/2000	462	2031	240	**2492**	**104**
02/10/2000	759	4113	209	**4872**	**121**
16/10/2000	483	1466	209	**1949**	**143**
31/10/2000	1322	3367	235	**4689**	**166**
13/11/2000	1243	2470	219	**3714**	**185**
27/11/2000	1552	2866	230	**4418**	**196**
18/12/2000	1445	2271	487	**3716**	**172**
03/01/2001	1854	3729	776	**5583**	**156**
22/01/2001	1205	2189	671	**3394**	**103**
29/01/2001	958	2109	358	**3067**	**94**
12/02/2001	1575	3918	776	**5493**	**101**
17/07/2001	528	1224	305	**1752**	
30/07/2001	599	1043	337	**1642**	
13/08/2001	483	1224	358	**1707**	
03/09/2001	382	847	246	**1229**	
17/09/2001	373	878	180	**1251**	
31/10/2001	337	910	130	**1246**	
05/12/2001	975	4113	293	**5088**	
15/01/2002	421	1008	351	**1429**	
07/03/2002	575	1008	171	**1583**	

Moneystones Quarry, Oakamoor
Stream Flow from 1996

Table B5

Date Measured	Flow (m3/d) A	B	C		A+B	Rainfall (mm/month)
04/04/2002	483	731	81		**1214**	
14/05/2002	295	731	81		**1025**	
17/06/2002	295	731	55		**1025**	
22/07/2002	295	483	150		**778**	
15/08/2002	220	878	81		**1099**	
10/09/2002	220	1879	112		**2099**	
11/10/2002	220	382	112		**602**	
12/11/2002	599	1879	246		**2478**	
23/12/2002	1642	2709	832		**4351**	
14/01/2003	731	1424	112		**2155**	
13/02/2003	1224	1224	150		**2448**	
13/03/2003	599	1424	150		**2023**	
09/04/2003	3729	1224	150		**4953**	
15/05/2003	382	878	194		**1260**	
25/06/2003	1642	599	150		**2241**	
25/07/2003	295	599	81		**894**	
15/08/2003	220	483	81		**704**	
08/09/2003	382	599	81		**981**	
20/10/2003	159	483	81		**642**	
28/11/2003	220	483	55		**704**	
22/12/2003	483	1424	112		**1907**	
22/01/2004	731	3367	305		**4098**	
25/02/2004	295	731	55		**1025**	
15/03/2004	220	599	798		**820**	
20/04/2004	483	1424	81		**1907**	
13/05/2004	382	878	81		**1260**	
04/06/2004	220	599	81		**820**	
01/07/2004	159	599	55		**758**	
20/08/2004	382	1043	112		**1424**	
22/09/2004	731	1879	194		**2610**	
10/10/2004	1043	4200	194		**5243**	
11/11/2004	483	4200	150		**4683**	
22/12/2004	1043	4200	150		**5243**	
07/03/2005	731	4200	821		**4931**	
10/06/2005	483	599	81		**1082**	
09/08/2005	159	382	55		**541**	
28/10/2005	878	1424	18		**2302**	
04/01/2006	382	1043	55		**1424**	
20/04/2006	382	1879	112		**2261**	
06/07/2006	220	382	55		**602**	
21/07/2006	159	382	46		**541**	
21/08/2006	295	878	55		**1173**	
21/09/2006	483	2412	112		**2896**	
31/10/2006	295	878	46		**1173**	
12/12/2006	382	1879	81		**2261**	
08/01/2007	599	2709	112		**3309**	
06/02/2007	483	731	55		**1214**	
08/03/2007	1043	4113	246		**5156**	
12/04/2007	295	599	55		**894**	
01/05/2007	382	731	81		**1113**	

Moneystones Quarry, Oakamoor
Stream Flow from 1996

Table B5

Date Measured	Flow (m3/d) A	B	C		A+B	Rainfall (mm/month)
11/06/2007	295	483	46		**778**	
04/07/2007	731	3027	246		**3758**	
28/08/2007	159	483	55		**642**	
13/09/2007	159	483	55		**642**	
11/10/2007	295	599	55		**894**	
22/11/2007	295	731	55		**1025**	
03/12/2007	483	3027	112		**3511**	
31/01/2008	220	599	112		**820**	
26/02/2008	93	878	46		**971**	
27/03/2008	599	1224	194		**1823**	
17/04/2008	599	1043	150		**1642**	
29/05/2008	731	1424	246		**2155**	
27/06/2008	220	878	46		**1099**	
31/07/2008	159	164	46		**322**	
29/08/2008	109	236	37		**345**	
16/09/2008	382	236	37		**618**	
31/10/2008	731	254	46		**985**	
27/11/2008	731	273	55		**1003**	
22/12/2008	599	273	55		**872**	
30/01/2009	382	291	64		**673**	
26/02/2009	295	254	55		**549**	
18/03/2009	295	236	46		**531**	
14/04/2009	382	236	55		**618**	
01/05/2009	382	254	55		**636**	
01/06/2009	295	254	46		**549**	
01/07/2009	220	291	46		**511**	
01/08/2009	159	309	55		**467**	
01/09/2009	159	291	55		**449**	
01/10/2009	220	291	46		**511**	

Moneystone Quarry, Oakamoor

WATER MONITORING BOREHOLES

Table D5

BOREHOLE NUMBER	80003	80004	83001	92010	92017	92029	92032	95009	95011	95012	95013	95014	95015
NORTHING	346058	346082	346146	346297	346022	346092	346364	346540	346114	345921	346170	346427	345776
EASTING	404774	404777	404494	404295	404206	403898	403914	404350	404409	404336	404029	403774	404506
SURFACE LEVEL (m.AOD)	201.56	203.90	181.70	188.01	181.19	166.55	170.38	199.90	185.15	169.12	161.61	171.69	164.70
Tip Set at (m.A.O.D)	172.33	172.19	165.03	157.51	157.95	134.90	143.88	183.90	155.81	136.32	140.37	137.27	127.70
Date read													
29-Mar-85	N.R.	N.R.											
17-May-85	N.R.	172.90											
17-Jun-85	N.R	173.00											
21-Nov-85	N.R.	173.20											
15-Oct-86	173.13	174.67											
28-Jan-87	173.13	174.68											
14-Jun-88	174.46	176.80											
15-Dec-89	173.81	175.95											
09-Jul-91	173.46	174.95		N.I.		N.I.							
04-Dec-92	N.R.	N.R.		163.22	N.I.	147.89	N.I.						
29-Jan-93	N.R.	N.R.		164.24	170.31	147.20	161.80						
24-Jan-94	172.71	174.55		N.R.	N.R.	N.R.	N.R.						
04-May-94	N.R.	N.R.		167.90	168.38	149.13	165.39						
21-Jul-94	N.R.	N.R.		167.54	166.88	149.26	164.55						
22-Sep-94	N.R.	N.R.		166.50	166.53	149.09	163.63						
17-Nov-94	N.R.	N.R.		165.67	167.63	149.35	162.97						
01-Mar-95	N.R.	N.R.		166.89	166.96	149.50	165.35						
26-May-95	N.R.	N.R.		167.95	168.66	148.79	165.08						
29-Sep-95	173.09	175.00		166.87	167.55	147.11	162.78						
24-Oct-95	N.R.	N.R.		165.39	167.34	147.25	162.28						
30-Oct-95	172.86	174.76		165.26	167.30	147.21	162.09	N.I.					
23-Nov-95	172.71	174.57		164.82	167.10	147.08	161.66	188.48	N.I.				
19-Dec-95	172.62	174.38		164.40	167.00	147.00	161.28	188.45	156.65	N.I.			
30-Jan-96	172.47	174.11		163.64	167.78	146.56	160.72	188.05	156.08	141.56	N.I.	N.I.	N.I.
05-Mar-96	172.57	174.28		163.17	168.93	146.56	160.44	187.99	156.27	141.34	152.42	160.29	135.70
04-Apr-96	172.46	174.11		162.73	168.80	146.11	160.05	188.24	156.50	141.25	152.43	159.87	135.48
03-May-96	172.57	174.35	NR	162.37	168.81	145.92	159.76	188.54	156.47	141.00	152.19	159.61	135.23
31-May-96	172.97	175.89	167.52	162.21	168.64	145.98	159.53	189.69	156.43	140.78	151.96	159.39	134.99
12-Jul-96	173.39	175.44	167.51	162.00	168.50	145.96	159.22	188.62	156.43	140.48	151.73	159.11	134.83
05-Aug-96	173.15	175.13	167.57	161.87	168.23	146.09	158.87	Blocked	156.39	140.45	151.61	158.97	134.71
02-Sep-96	173.13	175.16	167.60	161.71	168.23	146.09	158.87		156.36	140.29	151.44	158.79	134.53
01-Oct-96	173.09	175.13	167.63	161.61	168.11	146.12	158.73		156.31	140.16	151.29	158.63	134.48
04-Nov-96	173.18	175.26	168.50	161.47	167.99	146.23	158.54		156.24	140.06	151.17	158.43	134.65
02-Dec-96	173.15	175.18	167.54	161.38	169.56	146.36	158.49		156.29	140.16	151.16	158.39	135.38
06-Jan-97	172.90	174.77	167.47	161.31	168.92	146.57	158.37		156.30	140.47	151.13	158.29	135.69
31-Jan-97	173.01	174.96	167.37	161.25	169.08	146.44	158.22		156.27	140.29	150.99	158.10	135.40
03-Mar-97	172.93	174.93	167.54	161.14	169.19	146.48	158.27		156.26	140.19	150.99	158.19	135.50
07-Apr-97	Dry	173.53	166.43	161.11	169.60	145.99	158.14		156.26	140.16	150.86	158.05	135.23
06-May-97	Dry	172.89	167.06	160.57	169.62	146.19	158.13		156.15	139.85	150.79	158.02	134.45
02-Jun-97	Dry	172.90	167.78	161.28	169.72	145.74	158.40		156.00	139.55	150.61	158.29	134.24
07-Jul-97	172.77	174.88	170.44	161.88	169.97	144.96	158.66		156.62	139.36	150.71	158.55	133.69
12-Aug-97	172.81	174.56	171.29	162.91	169.70	144.97	158.93		156.96	139.57	150.83	158.80	133.78
01-Sep-97	172.19	173.90	171.50	163.41	169.64	145.39	159.03		157.00	139.71	150.93	158.93	133.65
09-Oct-97	172.42	173.36	171.77	164.22	169.62	145.43	159.33		157.17	139.96	151.19	159.19	133.63
03-Nov-97	172.36	173.17	171.90	164.56	169.61	145.20	159.41		157.25	140.14	151.29	159.25	133.60
01-Dec-97	172.36	172.98	171.22	164.61	171.07	144.37	159.56		157.42	140.22	151.15	159.45	133.31
05-Jan-98	172.36	173.03	171.15	164.95	172.51	144.39	160.38		157.48	140.48	152.27	160.20	133.83
09-Feb-98	DRY	172.68	171.72	165.41	169.85	145.70	161.26		156.59	141.04	152.71	161.06	133.68
10-Mar-98	DRY	173.42	171.77	165.82	170.56	145.70	162.25		157.45	141.25	153.42	162.00	134.79
30-Mar-98	DRY	173.49	171.83	166.35	169.70	145.98	162.66		157.61	141.44	153.72	162.47	135.02
30-Apr-98	DRY	173.40	171.80	167.04	169.72	145.98	163.53		157.58	141.75	154.17	163.31	135.28
26-May-98	DRY	173.28	172.06	167.73	169.51	146.27	164.07		157.79	142.12	154.51	163.85	135.45
29-Jun-98	DRY	172.99	172.32	167.99	169.45	146.34	164.10		157.97	142.22	154.59	163.87	135.21
24-Jul-98	DRY	172.91	172.38	168.21	169.42	146.35	164.00		158.18	142.30	154.51	163.75	135.11
24-Aug-98	DRY	173.03	173.16	168.55	169.41	146.36	163.74		158.54	142.38	154.46	163.48	134.91
28-Sep-98	DRY	173.11	173.47	168.84	169.63	146.41	163.34		159.06	142.64	154.32	163.07	135.11
28-Oct-98	DRY	172.99	173.74	168.94	172.22	146.59	163.89		159.42	142.93	154.77	163.57	135.62
23-Nov-98	DRY	173.16	173.55	169.07	170.46	146.72	163.44		159.40	143.33	154.59	163.14	136.36
22-Dec-98	DRY	173.13	173.54	169.21	171.08	146.86	163.69		159.32	143.57	154.82	163.41	136.51
25-Jan-99	DRY	173.29	173.23	169.70	171.61	147.24	164.55		159.32	143.94	155.42	164.26	136.97
22-Feb-99	DRY	173.86	173.18	170.04	171.05	147.40	164.78		159.29	144.16	155.65	164.53	137.17
29-Mar-99	172.80	174.79	173.91	170.72	170.85	147.66	165.18		159.87	144.57	155.96	164.96	137.75
26-Apr-99	172.91	175.36	173.08	170.87	171.29	147.81	164.66		160.22	144.86	155.37	165.11	138.20
24-May-99	172.05	175.54	172.76	170.68	170.31	147.93	165.18		159.77	145.18	156.09	164.89	138.39
28-Jun-99	172.45	174.19	174.00	170.84	169.82	147.93	164.93		160.23	144.54	156.01	164.68	138.05
19-Jul-99	172.65	174.51	173.75	171.07	168.63	147.81	164.71		160.68	145.21	155.82	164.52	138.05
25-Aug-99	DRY	173.91	173.80	170.62	168.98	147.65	164.21		161.00	144.96	155.61	164.09	137.27

Moneystone Quarry, Oakamoor

WATER MONITORING BOREHOLES

Table D5

BOREHOLE NUMBER	80003	80004	83001	92010	92017	92029	92032	95009	95011	95012	95013	95014	95015
NORTHING	346058	346082	346146	346297	346022	346092	346364	346540	346114	345921	346170	346427	345776
EASTING	404774	404777	404494	404295	404206	403898	403914	404350	404409	404336	404029	403774	404506
SURFACE LEVEL (m.AOD)	201.56	203.90	181.70	188.01	181.19	166.55	170.38	199.90	185.15	169.12	161.61	171.69	164.70
Tip Set at . (m A.O D)	172.33	172.19	165.03	157.51	157.95	134.90	143.88	183.90	155.81	136.32	140.37	137.27	127.70
Date read													
27-Sep-99	DRY	173.21	175.10	171.16	168.04	147.43	164.15		161.07	145.17	155.57	163.61	137.75
25-Oct-99	DRY	173.54	174.70	171.19	172.50	147.85	163.99		161.32	145.48	155.61	163.68	138.35
29-Nov-99	DRY	173.53	174.55	171.11	170.44	147.60	163.48		162.37	145.80	155.40	163.14	138.55
20-Dec-99	DRY	173.67	174.56	170.98	170.89	147.55	163.38		162.30	145.54	155.29	163.06	138.43
31-Jan-00	DRY	173.73	174.32	170.96	169.89	147.91	163.50		161.30	145.73	155.38	163.14	138.79
29-Feb-00	DRY	174.08	174.40	171.41	170.36	149.20	163.96		161.57	146.06	155.84	163.64	139.17
20-Mar-00	172.44	174.30	174.64	171.38	170.09	148.12	163.98		161.57	146.02	155.76	163.69	140.28
27-Apr-00	172.46	174.30	174.23	171.41	172.73	148.33	164.66		161.27	145.15	156.10	164.26	139.40
30-May-00	DRY	174.18	173.93	171.21	170.24	148.40	164.83		160.99	146.53	156.09	164.46	139.75
30-Jun-00	DRY	173.98	NR	171.29	170.17	148.42	164.86		160.92	146.20	156.30	164.49	139.21
17-Jul-00	DRY	173.92	NR	171.04	170.13	148.27	164.66		160.54	146.14	156.07	164.33	139.09
30-Aug-00	DRY	173.56	NR	170.45	169.92	147.93	164.16		159.31	145.61	155.77	163.84	138.38
29-Sep-00	DRY	173.75	NR	169.79	172.54	147.79	163.96		158.84	145.37	155.54	163.64	138.46
31-Oct-00	DRY	174.43	NR	169.71	172.64	147.80	164.61		158.14	145.28	155.86	164.25	138.70
27-Nov-00	DRY	175.52	NR	169.72	171.54	148.07	165.38		158.57	145.46	156.31	165.03	139.90
18-Dec-00	DRY	176.47	NR	170.27	170.89	148.28	166.09		158.53	145.97	156.85	165.79	140.64
29-Jan-01	DRY	175.74	NR	172.20	170.59	149.05	166.82		160.55	146.73	157.35	166.53	141.25
17-Jul-01	DRY	174.60	*	170.96	170.47	148.70	165.63		*	146.51	156.76	165.34	140.18
03-Sep-01	172.36	174.17		170.03	170.00	148.10	164.93			145.73	156.13	164.66	139.17
31-Oct-01	DRY	173.80		169.04	170.64	147.37	163.59			144.57	155.36	163.74	137.72
05-Dec-01	DRY	173.17		168.25	171.43	147.14	161.95			144.14	154.98	164.87	137.38
15-Jan-02	DRY	173.17		167.35	170.10	146.64	162.73			143.57	154.34	162.47	136.69
07-Mar-02	172.40	174.42		167.19	170.86	146.40	162.74			143.09	154.20	162.49	136.34
04-Apr-02	DRY	173.94		166.94	170.24	146.32	162.69			143.10	154.11	162.46	136.08
14-May-02	DRY	173.46		166.81	169.94	146.16	162.89			142.72	154.09	162.72	135.60
17-Jun-02	DRY	173.64		167.00	170.02	146.02	162.86			142.51	153.95	162.69	135.12
22-Jul-02	DRY	173.21		167.10	169.82	145.96	162.71			142.47	153.90	162.51	134.76
15-Aug-02	DRY	173.06		166.78	170.06	145.80	162.39			142.19	153.62	162.16	134.56
10-Sep-02	DRY	172.87		166.60	169.91	145.58	162.01			142.00	153.42	161.78	134.27
11-Oct-02	DRY	172.90		166.48	169.83	145.43	161.72			141.81	153.18	161.50	133.96
12-Nov-02	DRY	173.93		166.58	172.15	145.50	162.06			141.67	153.57	161.79	133.74
23-Dec-02	DRY	174.49		167.08	170.81	145.93	162.35			142.11	153.78	162.06	134.45
14-Jan-03	DRY	174.92		167.43	168.89	146.18	163.15			142.31	154.30	162.85	134.98
13-Feb-03	172.87	175.02		168.52	169.45	146.48	164.18			142.84	154.88	163.92	135.62
13-Mar-03	172.45	174.39		168.65	169.13	146.69	164.73			143.15	155.20	164.54	135.74
08-Apr-03	DRY	173.97		169.15	168.65	146.97	164.97			143.36	155.45	164.78	135.85
15-May-03	DRY	173.68		168.90	168.69	146.83	NR			143.36	155.27	164.43	135.54
25-Jun-03	DRY	173.22		168.60	168.32	146.59	164.53			143.12	155.09	164.38	135.25
23-Jul-03	DRY	173.20		168.55	168.54	146.50	163.92			142.92	154.78	163.66	134.94
15-Aug-03	DRY	173.19		168.39	168.55	146.33	163.55			142.61	155.55	163.29	134.62
08-Sep-03	DRY	173.13		168.12	168.50	146.13	163.16			142.34	154.29	162.88	134.36
20-Oct-03	DRY	172.72		166.98	168.22	NR	162.20			141.87	140.68	161.96	132.83
28-Nov-03	DRY	172.79		166.07	168.13	145.18	161.48			141.34	152.96	161.26	133.32
22-Dec-03	DRY	173.33		165.73	170.67	145.00	161.27			141.00	152.77	160.97	133.12
22-Jan-04	DRY	174.18		165.64	171.34	145.07	161.42			141.05	152.92	161.18	133.16
25-Feb-04	DRY	174.93		165.70	168.44	145.35	161.63			141.41	153.24	161.42	133.63
15-Mar-04	DRY	174.35		165.62	167.80	145.30	161.56			141.51	153.07	161.35	133.91
20-Apr-04	DRY	174.70		165.77	169.55	145.40	162.01			141.48	153.31	161.81	134.04
23-Apr-04													
13-May-04	DRY	174.87		166.03	168.51	145.43	162.17			141.55	153.34	161.96	134.23
14-May-04													
04-Jun-04	DRY	174.49		156.06	167.89	145.50	162.30			141.67	153.45	162.11	134.63
01-Jul-04	NR	174.44		165.82	167.65	145.51	162.31			141.63	153.42	162.11	134.49
20-Aug-04	Dry	175.24		165.69	170.59	145.52	162.31			141.71	153.58	162.07	134.31
22-Sep-04	Dry	176.39		166.52	168.37	146.04	162.78			142.37	154.12	162.55	135.02
20-Oct-04	Dry	176.36		166.73	168.31	146.33	163.13			142.94	154.44	162.97	135.44
11-Nov-04	173.74	176.12		166.49	168.70	146.72	163.48			143.43	154.72	163.11	135.68
22-Dec-04	173.66	176.03		166.61	168.07	146.78	163.60			143.61	154.77	163.44	136.16
07-Mar-05	173.64	175.85		166.33	167.15	147.12	163.86			143.88	154.98	163.72	136.16
10-Jun-05	172.83	174.78		164.83	166.28	146.55	163.13			143.07	154.28	162.99	135.50
09-Aug-05	dry	173.97		164.26	166.26	145.93	162.31			142.10	153.63	162.13	134.62
28-Oct-05	dry	172.83		164.40	167.35	145.38	161.06			141.24	152.92	160.93	133.75
04-Jan-06	dry	173.31		164.74	168.11	145.56	160.79			141.91	152.91	160.62	133.87
20-Apr-06	dry	173.41		164.07	168.28	145.18	161.07			141.08	152.71	160.95	flooded
06-Jul-06	dry	173.43		163.88	166.76	145.11	161.42			140.99	152.67	161.34	flooded
12-Oct-06	dry	172.99		163.38	168.48	144.99	161.14			140.51	152.48	160.99	buried
20-Dec-06	dry	173.44		dry	168.87	145.01	161.06			140.76	152.45	160.79	buried

Moneystone Quarry, Oakamoor

WATER MONITORING BOREHOLES

Table D5

BOREHOLE NUMBER	80003	80004	83001	92010	92017	92029	92032	95009	95011	95012	95013	95014	95015
NORTHING	346058	346082	346146	346297	346022	346092	346364	346540	346114	345921	346170	346427	345776
EASTING	404774	404777	404494	404295	404206	403898	403914	404350	404409	404336	404029	403774	404506
SURFACE LEVEL (m.AOD)	201.56	203.90	181.70	188.01	181.19	166.55	170.38	199.90	185.15	169.12	161.61	171.69	164.70
Tip Set at (m.A O D)	172.33	172.19	165.03	157.51	157.95	134.90	143.88	183.90	155.81	136.32	140.37	137.27	127.70
Date read													
28-Feb-07	172.66	174.59		dry	168.97	145.35	161.40			141.34	152.57	161.45	buried
12-Apr-07	173.14	175.07		163.51	167.79	145.47	161.79			141.50	152.47	161.95	buried
15-Jun-07	DRY	173.52		DRY	166.80	146.60	161.63			141.94	*	161.76	BURIED
13-Sep-07	DRY	174.91		DRY	166.93	146.03	161.12			142.76		161.32	BURIED
03-Dec-07	DRY	173.56		DRY	169.26	145.38	160.41			142.02		160.62	BURIED
26-Feb-08	175.13	177.86		DRY	167.64	145.43	160.30			142.14		160.77	BURIED
27-Jun-08	172.58	173.88		DRY	166.75	144.71	159.12			141.54		159.59	
10-Sep-08	172.73	174.68		DRY	170.18	144.12	158.23			140.30		158.56	
21-Jan-09	172.38	174.10		DRY	168.41	143.73	157.63			139.82		158.05	
14-May-09	DRY	173.26		DRY	168.35	143.59	157.98			138.48		158.48	
29-Sep-09	DRY	173.09		DRY	168.49	143.50	157.34			138.91		157.63	
05-Mar-10	DRY	174.12		DRY	168.06	143.28	157.13			139.80		157.96	
29-Jun-10	DRY	172.52		DRY	166.69	142.93	155.96			140.07		157.11	

Water Levels are m.AOD

NI = Not Installed

NR = Not Read

* = location quarried

1980,1992 and 1996 series holes are 19mm ID pipe with 30cm porous element at base

1995 series holes are 50mm ID pipe with 1 metre slotted at base

2002 (22) series holes are 50mm ID pipe with 3 metre slotted at base

2003 (23) series holes were drilled during December/January 2004.

Notes:

Foot and mouth restrictions Feb - June 2001

Standpipe 22003 is drilled close to the position of the blocked standpipe 95009

Moneystone Quarry, Oakamoor

WATER MONITORING BOREHOLES

Table D5 A5

									South of road	North of road
BOREHOLE NUMBER	96007	22003	22011	22014	23006	23008	23001	23004	24012	24013
NORTHING	346190	346535	346974	346683	346639	346792	346522	346515	346162	346229
EASTING	404503	404366	404350	404102	403737	403867	403897	403620	404412	404430
SURFACE LEVEL (m.AOD)	193.59	198.74	230.15	191.69	184.42	197.00	183.73	166.60	174.93	192.70
Tip Set at (m.A.O.D)	168.79	183.24	224 19	179.19	151 11	173.08	158.63	146 88	156.39	163.70
Date read										
29-Mar-85										
17-May-85										
17-Jun-85										
21-Nov-85										
15-Oct-86										
28-Jan-87										
14-Jun-88										
15-Dec-89										
09-Jul-91										
04-Dec-92										
29-Jan-93										
24-Jan-94										
04-May-94										
21-Jul-94										
22-Sep-94										
17-Nov-94										
01-Mar-95										
26-May-95										
29-Sep-95										
24-Oct-95										
30-Oct-95										
23-Nov-95										
19-Dec-95										
30-Jan-96										
05-Mar-96										
04-Apr-96										
03-May-96										
31-May-96										
12-Jul-96										
05-Aug-96										
02-Sep-96										
01-Oct-96										
04-Nov-96	DRY									
02-Dec-96	DRY									
06-Jan-97	DRY									
31-Jan-97	DRY									
03-Mar-97	DRY									
07-Apr-97	DRY									
06-May-97	DRY									
02-Jun-97	DRY									
07-Jul-97	DRY									
12-Aug-97	DRY									
01-Sep-97	DRY									
09-Oct-97	DRY									
03-Nov-97	DRY									
01-Dec-97	DRY									
05-Jan-98	DRY									
09-Feb-98	DRY									
10-Mar-98	DRY									
30-Mar-98	DRY									
30-Apr-98	DRY									
26-May-98	DRY									
29-Jun-98	DRY									
24-Jul-98	DRY									
24-Aug-98	DRY									
28-Sep-98	DRY									
28-Oct-98	DRY									
23-Nov-98	DRY									
22-Dec-98	DRY									
25-Jan-99	DRY									
22-Feb-99	DRY									
29-Mar-99	DRY									
26-Apr-99	DRY									
24-May-99	DRY									
28-Jun-99	DRY									
19-Jul-99	DRY									
25-Aug-99	DRY									

Moneystone Quarry, Oakamoor

WATER MONITORING BOREHOLES

Table D5

									South of road	North of road
BOREHOLE NUMBER	96007	22003	22011	22014	23006	23008	23001	23004	24012	24013
NORTHING	346190	346535	346974	346683	346639	346792	346522	346515	346162	346229
EASTING	404503	404366	404350	404102	403737	403867	403897	403620	404412	404430
SURFACE LEVEL (m.AOD)	193.59	198.74	230.15	191.69	184.42	197.00	183.73	166.60	174.93	192.70
Tip Set at (m.A.O.D)	168.79	183.24	224.19	179.19	151.11	173.08	158.63	146.88	156.39	163.70
Date read										
27-Sep-99	DRY									
25-Oct-99	DRY									
29-Nov-99	DRY									
20-Dec-99	DRY									
31-Jan-00	DRY									
29-Feb-00	DRY									
20-Mar-00	DRY									
27-Apr-00	DRY									
30-May-00	DRY									
30-Jun-00	DRY									
17-Jul-00	DRY									
30-Aug-00	DRY									
29-Sep-00	DRY									
31-Oct-00	DRY									
27-Nov-00	DRY									
18-Dec-00	DRY									
29-Jan-01	DRY									
17-Jul-01	DRY									
03-Sep-01	DRY									
31-Oct-01	DRY									
05-Dec-01	DRY									
15-Jan-02	DRY									
07-Mar-02	DRY									
04-Apr-02	DRY									
14-May-02	172.76	NI								
17-Jun-02	174.46	188.42								
22-Jul-02	173.14	188.09								
15-Aug-02	173.11	187.73								
10-Sep-02	172.43	187.43								
11-Oct-02	172.07	187.20								
12-Nov-02	172.52	187.18	NI							
23-Dec-02	172.52	188.39	DRY	NI						
14-Jan-03	172.56	189.29	DRY	188.01						
13-Feb-03	173.11	189.62	DRY	188.70						
13-Mar-03	172.52	189.38	DRY	189.04						
08-Apr-03	172.59	189.39	DRY	189.07						
15-May-03	172.33	188.96	DRY	188.58						
25-Jun-03	171.79	188.71	DRY	187.92						
23-Jul-03	171.62	188.30	DRY	187.36						
15-Aug-03	171.85	188.08	DRY	186.95						
08-Sep-03	171.73	187.92	DRY	186.51						
20-Oct-03	172.04	187.36	DRY	185.49						
28-Nov-03	171.68	186.90	DRY	185.04	NI	NI				
22-Dec-03	172.76	186.71	DRY	185.18	162.44	175.98	NI			
22-Jan-04	174.25	186.69	DRY	185.73	162.35	175.96	162.08	NI		
25-Feb-04	173.91	187.86	DRY	186.29	163.26	176.74	162.39	161.57		
15-Mar-04	172.87	188.35	DRY	186.29	163.12	177.21	162.49	161.64		
20-Apr-04	172.51	188.69	DRY	186.86	163.77	177.80	163.00	162.02	NI	NI
23-Apr-04									166.18	168.23
13-May-04	172.44	198.74	DRY	186.98	163.93	178.02	163.23	162.17	166.09	168.15
14-May-04							after filled with water		165.99	174.04
04-Jun-04	172.02	blocked	DRY	186.85	164.06	178.02	163.41	162.32	165.75	172.41
01-Jul-04	171.69	blocked	DRY	186.71	164.01	177.80	163.40	162.29	165.55	171.09
20-Aug-04	174.32	blocked	DRY	186.65	163.97	177.26	163.05	162.21	166.25	169.62
22-Sep-04	177.49	blocked	DRY	186.95	164.48	177.84	163.66	162.71	168.15	169.75
20-Oct-04	176.32	blocked	DRY	187.26	164.85	178.17	164.17	163.09	168.07	170.07
11-Nov-04	175.58	blocked	DRY	NR	165.04	178.23	164.65	163.22	167.40	169.86
22-Dec-04	175.14	blocked	DRY	187.66	165.51	178.45	164.81	163.58	167.34	169.62
07-Mar-05	173.39	blocked	DRY	187.75	165.72	178.33	165.07	163.86	166.59	169.16
10-Jun-05	171.68	blocked	DRY	186.97	164.93	177.83	164.32	163.16	164.90	167.95
09-Aug-05	171.15	blocked	DRY	186.00	163.89	177.03	162.39	162.31	164.58	167.46
28-Oct-05	173.39	blocked	DRY	184.96	162.45	176.11	162.06	161.23	165.20	167.33
04-Jan-06	173.31	blocked	DRY	185.63	162.14	176.34	161.71	160.87	165.69	167.67
20-Apr-06	172.73	blocked	DRY	186.34	162.87	177.07	162.09	161.27	165.38	168.76
06-Jul-06	171.84	blocked	DRY	186.87	163.61	177.92	162.61	161.67	164.91	167.57
12-Oct-06	170.55	blocked	DRY	186.05	162.98	177.19	162.26	161.36	163.88	166.90
20-Dec-06	172.98	blocked	DRY	186.29	162.68	176.71	161.94	161.15	164.44	166.54

Moneystone Quarry, Oakamoor

WATER MONITORING BOREHOLES

Table D5

BOREHOLE NUMBER	96007	22003	22011	22014	23006	23008	23001	23004	24012 (South of road)	24013 (North of road)
NORTHING	346190	346535	346974	346683	346639	346792	346522	346515	346162	346229
EASTING	404503	404366	404350	404102	403737	403867	403897	403620	404412	404430
SURFACE LEVEL (m.AOD)	193.59	198.74	230.15	191.69	184.42	197.00	183.73	166.60	174.93	192.70
Tip Set at . (m A.O.D)	168.79	183.24	224.19	179.19	151.11	173.08	158.63	146.88	156.39	163.70
Date read										
28-Feb-07	171.49	blocked	DRY	187.48	164.14	178.18	162.76	161.89	164.52	166.86
12-Apr-07	171.74	blocked	DRY	188.26	164.20	179.12	162.58	161.67	164.56	166.87
15-Jun-07	170.90	BLOCKED	DRY	188.15	164.62	178.75	163.44	162.20	164.06	168.20
13-Sep-07	171.66		DRY	187.50	164.21	178.50	162.86	161.63	164.33	166.37
03-Dec-07	171.15		DRY	186.90	163.25	177.68	162.12	161.19	164.09	DRY
26-Feb-08	173.35		DRY	NR	164.07	178.64	162.30	161.49	165.01	DRY
27-Jun-08	170.72		DRY	186.75	162.63	177.74	161.28	160.30	164.11	DRY
10-Sep-08	171.19		DRY	186.15	161.15	176.75	159.95	159.13	164.02	DRY
21-Jan-09	171.58		DRY	186.17	160.94	177.24	159.44	158.65	163.04	DRY
14-May-09	NR		DRY	186.44	161.64	177.61	160.11	159.17	163.91	DRY
29-Sep-09	NR		DRY	185.86	160.90	177.13	159.36	158.44	163.94	DRY
05-Mar-10	NR		DRY	187.33	161.69	178.02	159.09	158.79	164.13	dry
29-Jun-10	NR		DRY	186.64	160.89	177.64	159.15	157.90	163.41	dry

Moneystone Quarry, Oakamoor
Monthly Rainfall figures since 1984 (mm/month)

Table B6

	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Jan	148	80	136	56	110	50	106	63	50	79	145	180	49	12	109	129
Feb	83	23	12	52	59	92	115	41	53	8	73	101	82	84	24	60
Mar	55	58	89	97	146	96	31	68	96	13	106	70	45	33	110	94
Apr	11	108	112	106	37	115	43	77	57	116	86	24	60	39	102	107
May	39	72	91	44	76	33	26	9	55	57	30	61	39	77	15	45
Jun	56	80	51	138	48	59	78	73	85	134	45	14	34	150	141	107
Jul	29	93	82	58	140	35	38	64	77	114	80	29	27	61	56	49
Aug	68	100	102	106	114	41	44	26	104	52	45	34	54	81	82	89
Sep	107	42	12	53	65	28	88	38	54	100	147	108	18	41	106	102
Oct	81	50	79	130	78	112	116	46	86	74	112	37	91	70	178	107
Nov	141	94	125	79	57	72	70	99	121	62	100	68	133	110	63	59
Dec	63	121	151	81	38	147	83	95	108	186	138	84	69	105	93	124
Total	**881**	**922**	**1042**	**1000**	**968**	**878**	**839**	**700**	**947**	**994**	**1107**	**811**	**701**	**862**	**1079**	**1073**

Moneystone Quarry, Oakamoor
Monthly Rainfall figures since 1984

(mm/month) **Table B6**

	2000	2001	2002	2003	2004	2005	2006	2007		Min	Average	Max
Jan	39	60	116	115	131	60	36	121	**Jan**	12	91	180
Feb	107	106	134	53	37	68	60	105	**Feb**	8	68	134
Mar	56	78	43	36	49	43	102	60	**Mar**	13	70	146
Apr	70	138	43	71	147	58	65	17	**Apr**	11	75	147
May	69	106	88	115	38	43	112	73	**May**	9	59	115
Jun	73	45	54	72	86	75	20	119	**Jun**	14	77	150
Jul	47	60	145	63	71	64	35	192	**Jul**	27	71	192
Aug	58	99	62	25	299	55	168	35	**Aug**	25	81	299
Sep	155	73	56	52	79	53	89	43	**Sep**	12	71	155
Oct	173	123	134	57	115	125	123	30	**Oct**	30	97	178
Nov	214	104	185	53	57	78	87	110	**Nov**	53	98	214
Dec	142	44	139	103	54	108	110	78	**Dec**	38	103	186
Total	**1202**	**1036**	**1200**	**814**	**1163**	**829**	**1007**	**981**	**Total**	700	960	1202

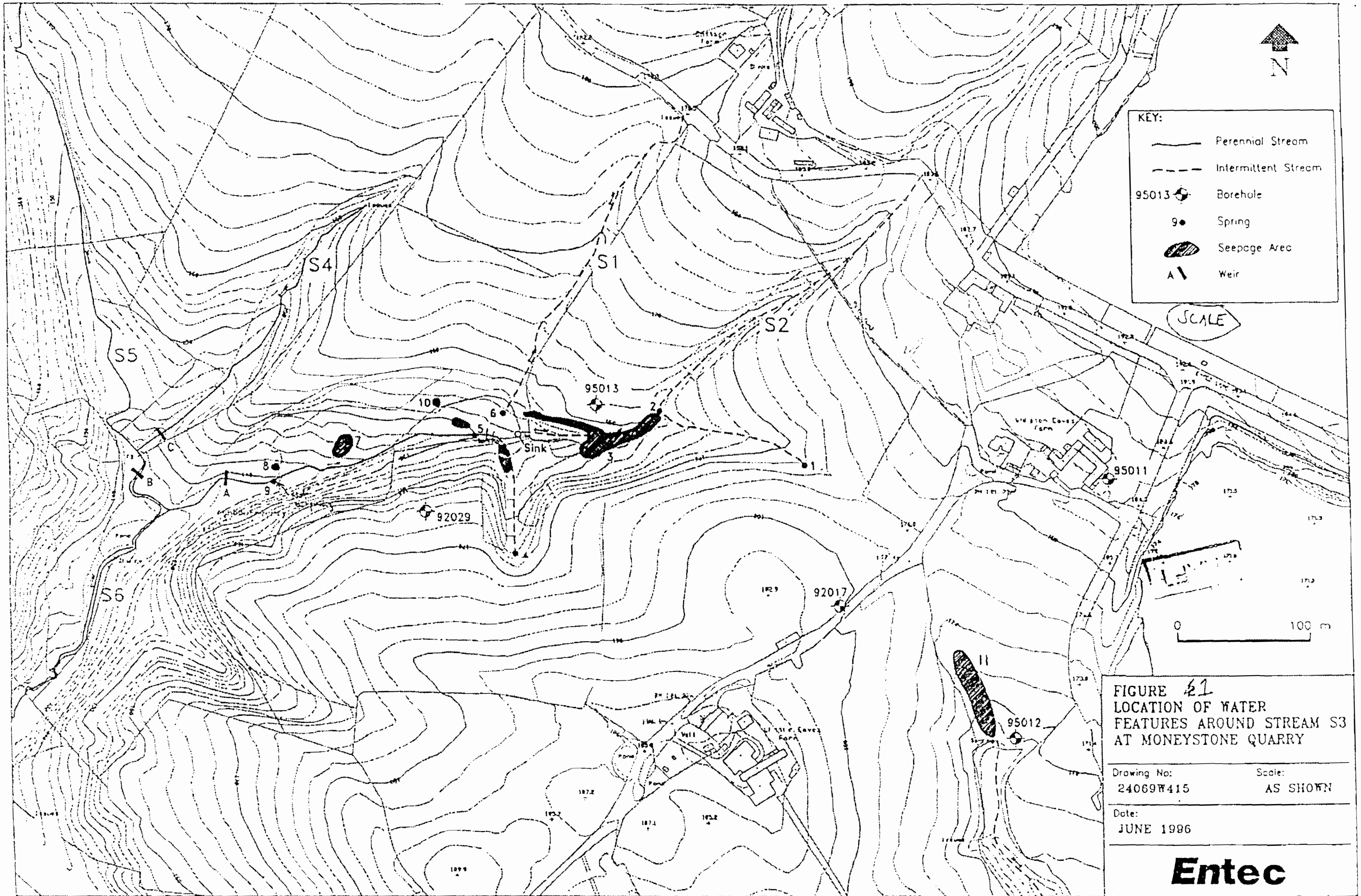


FIGURE B1
LOCATION OF WATER FEATURES AROUND STREAM S3 AT MONEYSTONE QUARRY

Drawing No: 24069W415
Scale: AS SHOWN
Date: JUNE 1996

Entec

Fig B1

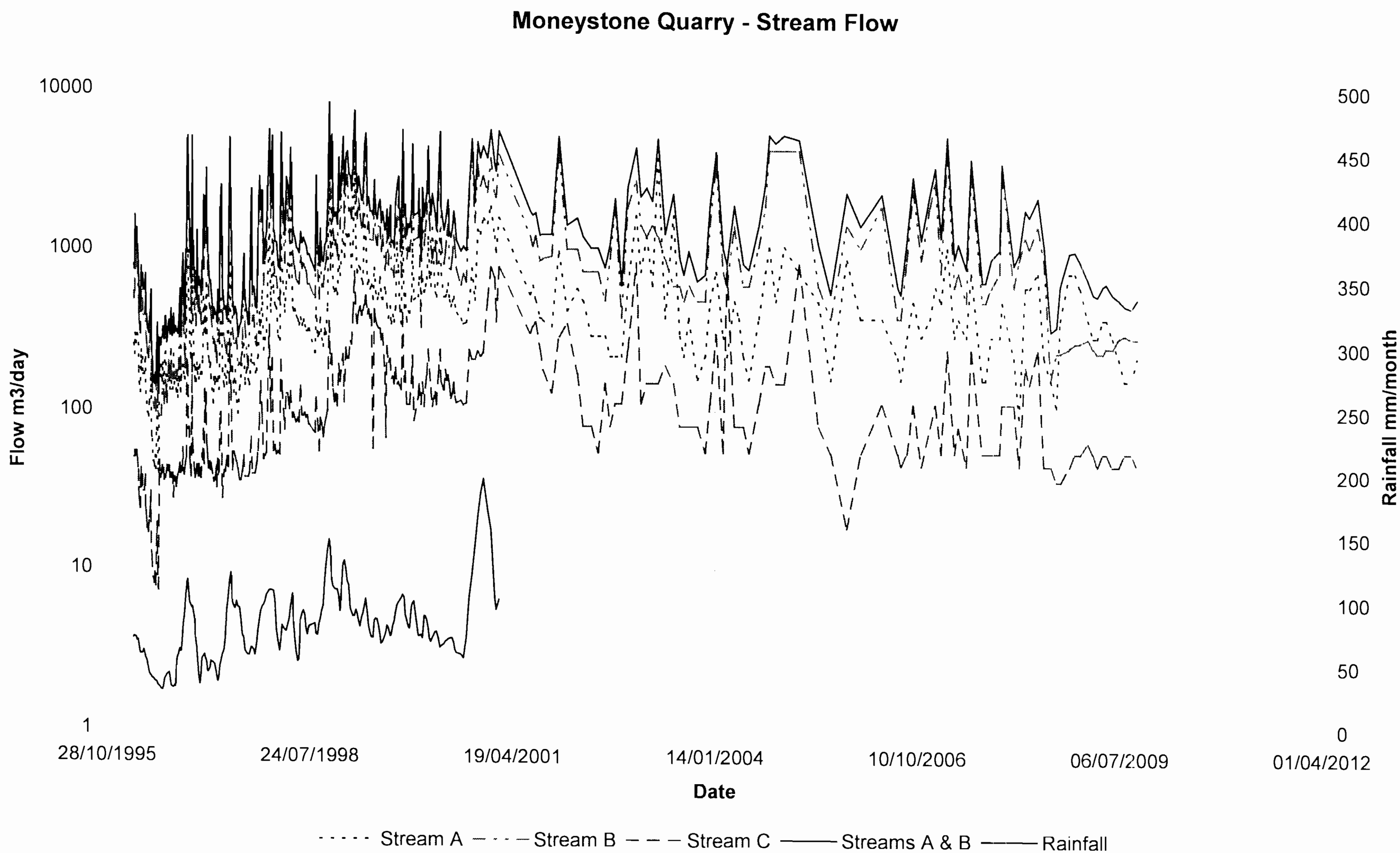
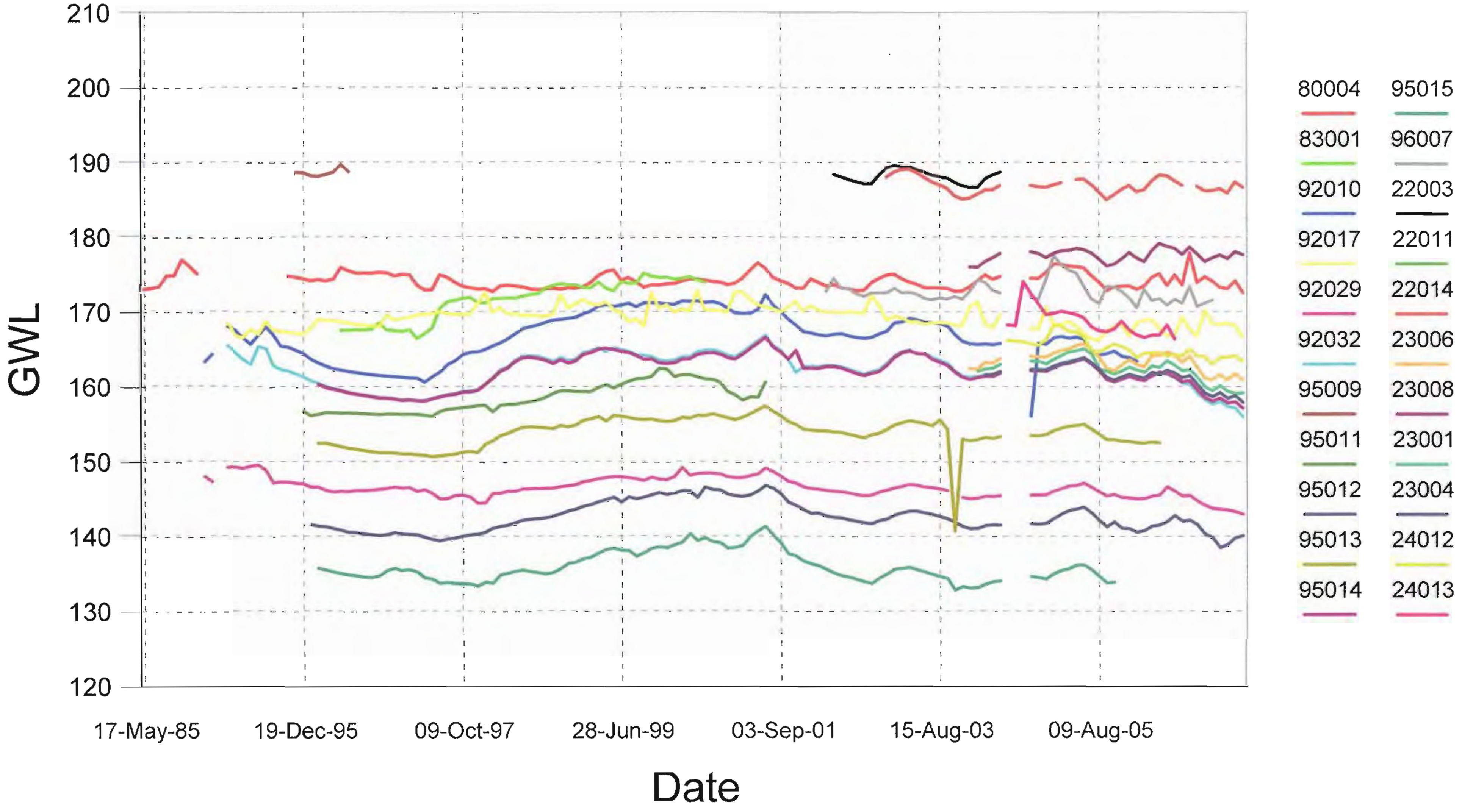

Moneystone Quarry - Stream Flow
10000
1000
100
10
1
Flow m3/day
500
450
400
350
300
250
200
150
100
50
0
Rainfall mm/month
28/10/1995
24/07/1998
19/04/2001
14/01/2004
10/10/2006
06/07/2009
01/04/2012
Date
Stream A
Stream B
Stream C
Streams A & B
Rainfall

Fig B2

Moneystone Quarry
Standpipe Levels
Fig B3



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Quarry References

1. WBB Minerals - Moneystone Quarry Oakamoor, Quarries Regulations 1999, Geotechnical Assessment 2007. October 2008. Report Ref M0201/08/R85F. *Includes topography plans, photos, Piezometer data, oppertating rules and design drawings for L4 & L7.*

2. Binnie & Partners - British Industrial Sand Ltd. Moneystone Quarries Oakamoor. Second report on the use of Disused Quarries for the Disposal of Slurry Waste. October 1984. *Includes logs, photos, plans, sections and testing.*

3. Knight Piesold & Partners. Hepworth Minerals and Chemicals Ltd. Slope Stability Analysis of Oakamoor Quarry, Staffordshire. May 1996. Report Ref 11126\R9350\rjhp. *Includes sections, plans and photographs*

4. Donaldson Associates Limited. Ritchies Ltd. Tunnel Assessment Report. Moneystone Quarry Staffordshire. January 2002. Job No. JS176. *Includes plans, rock mass classification, logs, photos (poor quality),geological mapping, stereographic projections and unwedge analysis.*

5. Plan HP 5.1 Q2E Borehole Location Survey Date 22.22.94. Scale 1:1250. May 1994.

6. Plan HP 5.2 Q2E Borehole Location Survey Date 22.22.94. Scale 1:1250. June 1994.

7. Plan HP 5.3 Q2E Geological Section. Scale 1:1250 / 1:500. May 1994.

8. Plan HP 6.1 Q2 Geological Section. Scale 1:1250 / 1:500. June 1994.

9. Plan HP 7.1 Oakamoor Base of Sandstone contour plan. Scale 1:5000. March 2004.

10. Plan HP 8.2 British Industrial Sand Ltd. Frame Wood Oxide and Clay Pits. Tip 2. Dwg Ref S.OM. 120. Scale 1:500.

11. Plan HP 15.2. British Industrial Sand Ltd. Geological Map of Oakamoor Area. Tip Nos 1&3, 2 and Framewood Clay Tip. Scale 6" to 1 mile.

12. Plan HP 8.3. British Industrial Sand Ltd - Oakamoor. Sections Tip No. 2 Frame Wood. A B Daily Son & Clarke. Job No. 479. Dwg No. 21 Rev B. Scale 1:500. April 1974.

13. Plan HP 8.4. British Industrial Sand Ltd - Oakamoor. Sections Tip No. 2 Frame Wood. A B Daily Son & Clarke. Job No. 479. Dwg No. 22 Rev A. Scale 1:500. July 1974.

14. Report HR 8.1 Sibelco Minerals and Chemicals Ltd. Moneystone Quarry Staffordshire. Report Under Regulations 18 of the Mines and Quarries (Tips) Regulations 1971. Tip No. 2 Frame Wood Clay. CLOSED. May 2001.

Rainfall @ Moneystone Quarry

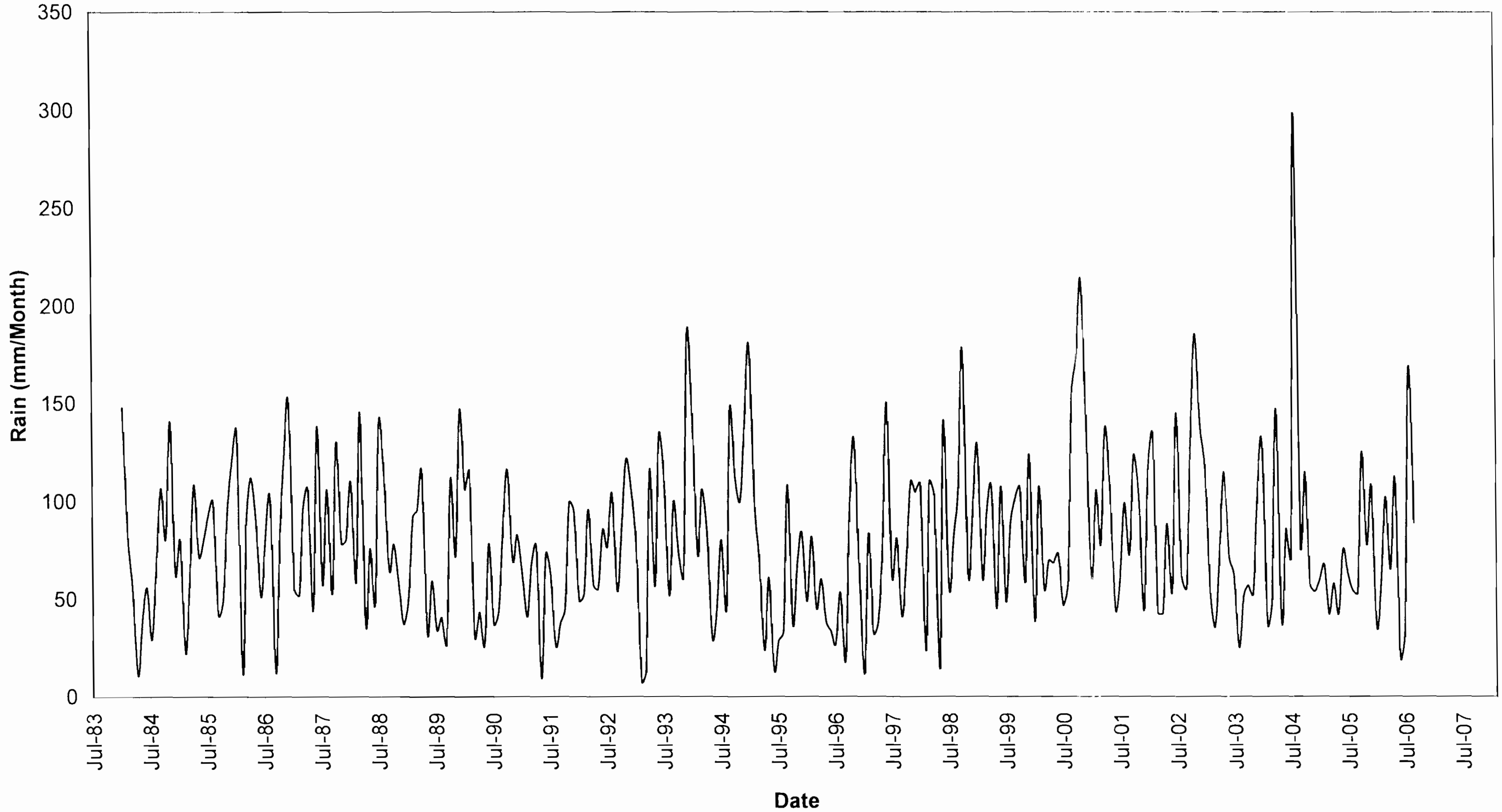
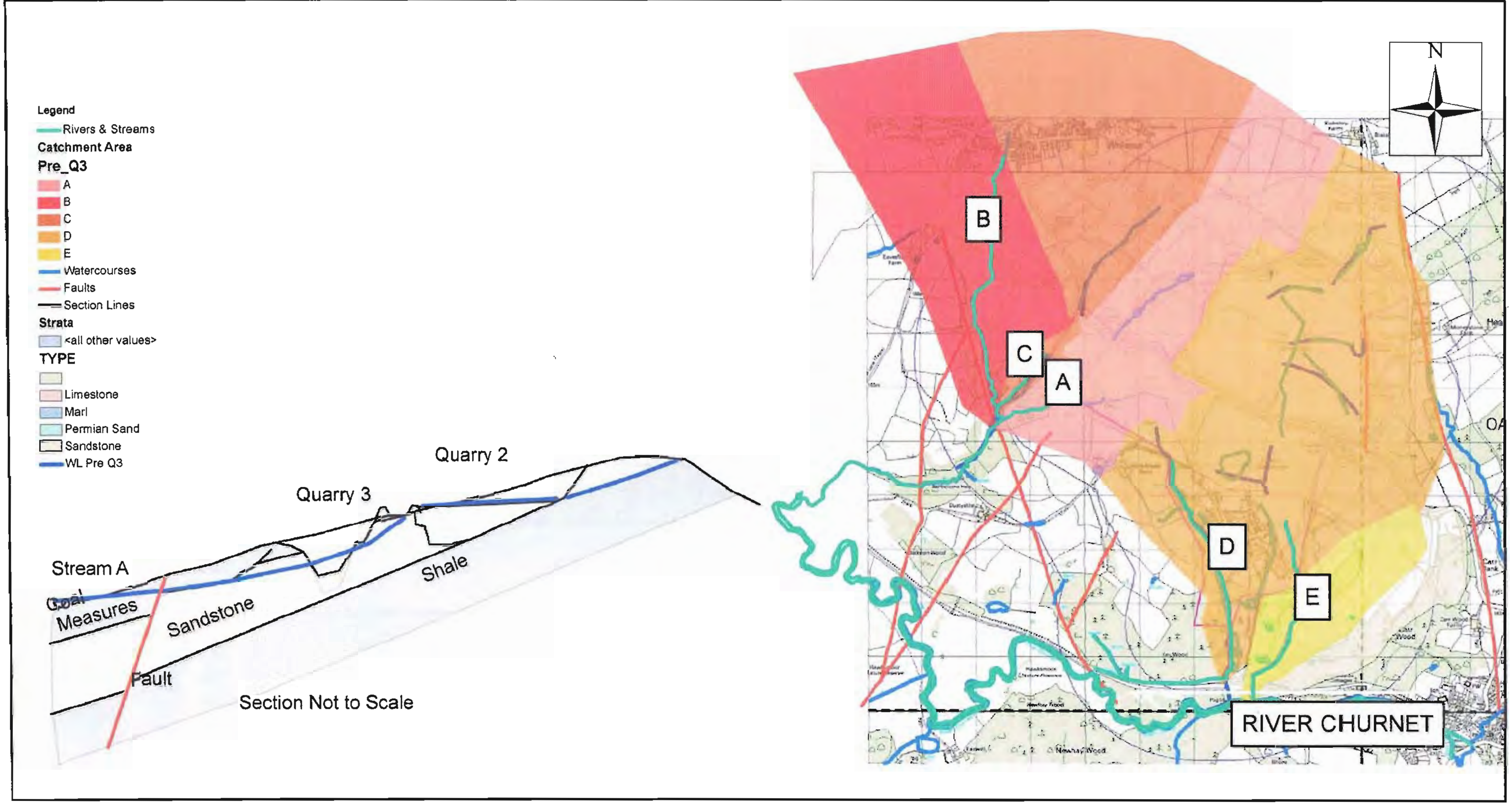


Fig B4.



Abbeydale Building Environment Consultants

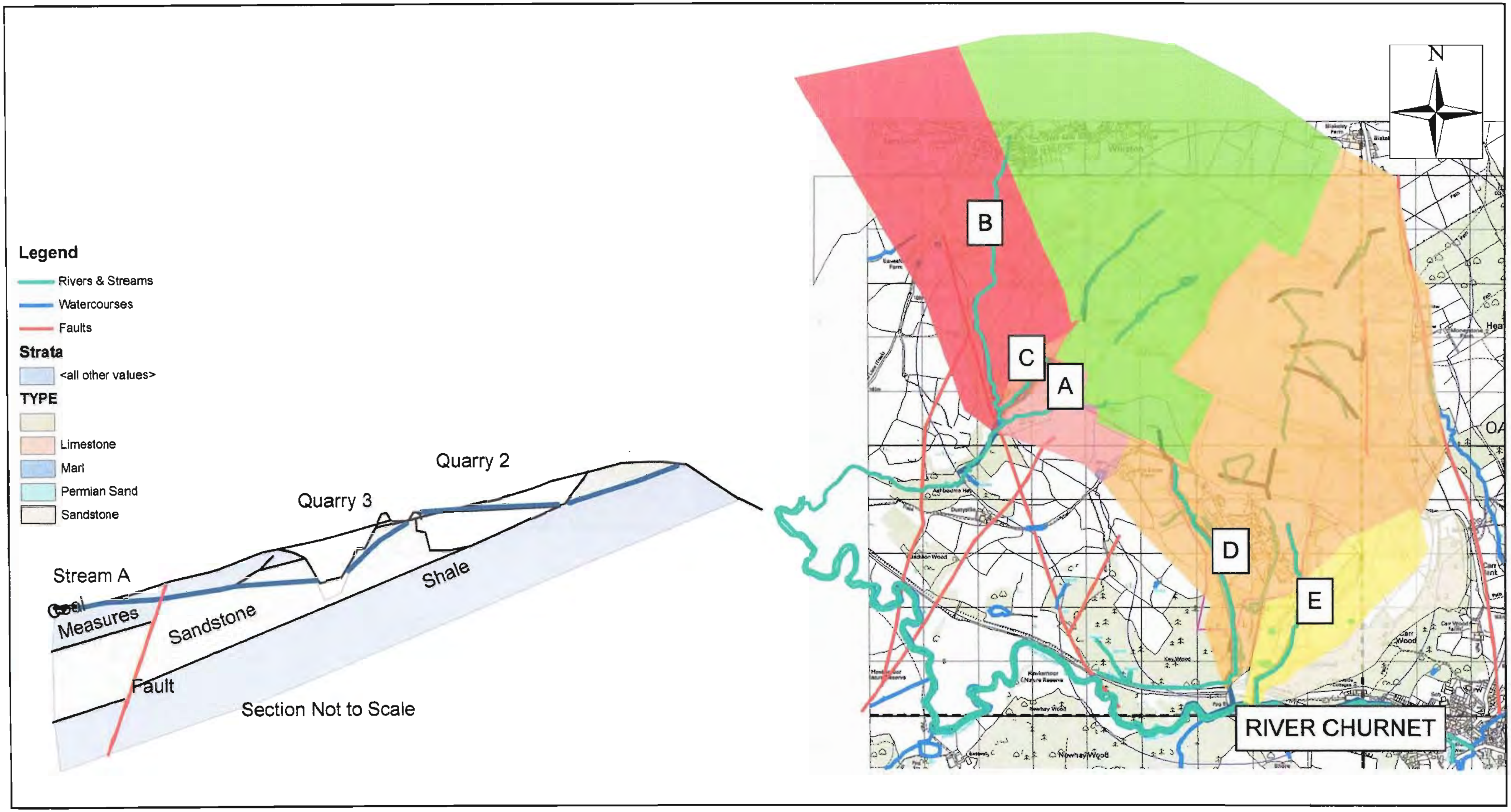
4 Neville Street WF1 5EF Tel: 01924 376622 www.abbeydalebec.com

1:20,000

Pre Q3 Catchment Areas

Project: Moneystone Quarry Oakamoor
Job No: 418040
Client: Laver Leisure
February 2011

Fig B 5a



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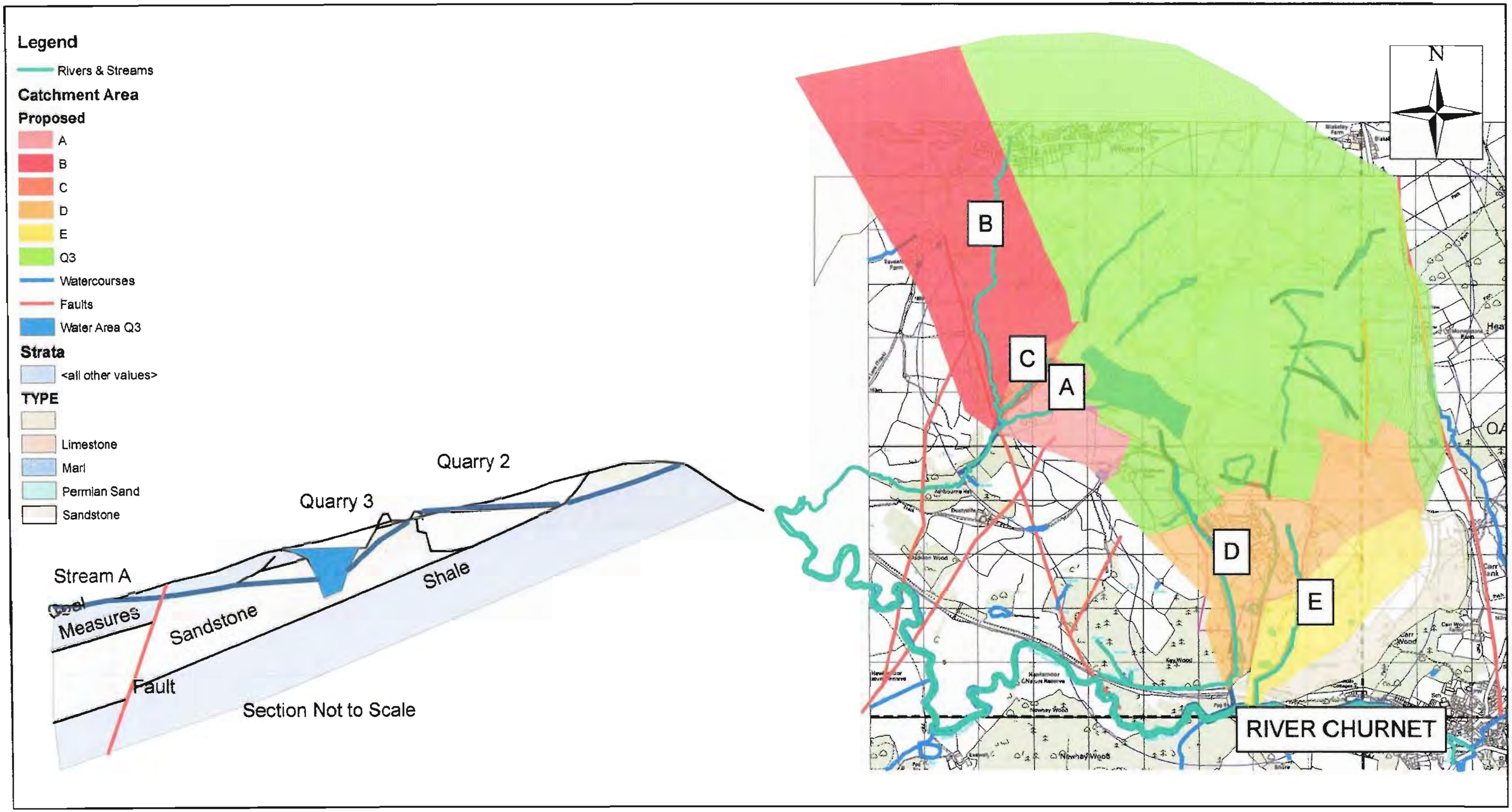
1:20,000

Current Catchment Areas

Project: Moneystone Quarry Oakamoor
Job No: 418040
Client: Laver Leisure
February 2011

Fig B5b



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Building Environment Consultants
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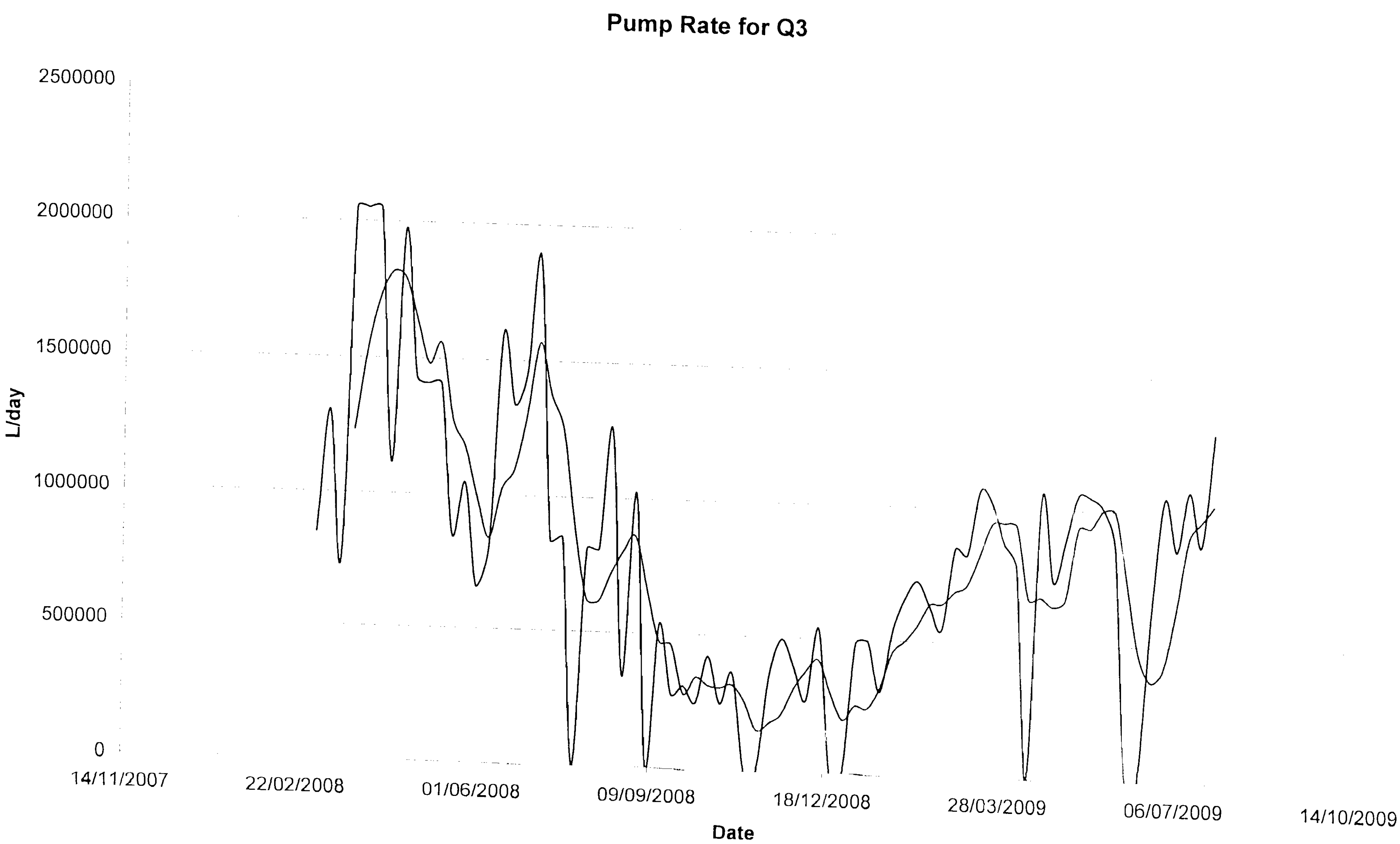
Proposed Catchment Areas

Project: Moneystone Quarry Oakamoor
Job No: 418040
Client: Laver Leisure
February 2011

Fig B 5c



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500000
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01/06/2008
09/09/2008
18/12/2008
28/03/2009
06/07/2009
14/10/2009
Date

Fig B6

APPENDIX C

Slope Stability Assessment

APPENDIX C

Slope Stability Assessment

For an initial assessment we have use the parameters used by the quarry engineers. (*Reference 2,3 and 50*). Our own assessment of the sensitivity of parameters and cross checks with existing slopes indicate that slope stability on a number of the slopes are at or close to unity. The parameters used are given below in Table C1. As indicated in the table comments column the parameters have in part obtained by site and laboratory testing, and in part by empirical figures available for the materials present. As with all analysis of this type the values are un-factored as in certain situations both raising and lowing the parameter can reduce the safety of the slope being considered.

Table C1	**Geotechnical Parameters used in the Analysis**			
Strata	**Density kN/m3**	**Effective Friction Angle Degrees**	**Cohesion kN/m2**	**Data Source/ Reference**
Shale	22	12.5	1	References 2 & 50
Sandstone	22.7	41	25 to 100	References 2 & 50
Weathered Sand	21	30	1	References 2 & 50
Tailings	17	28	1	References 2, 3, 4 & 50
Bunds & Caps	18	35	0	References 2 & 50

The initial analysis was undertaken on existing slopes which had been previously analysised by the quarry engineer to determine whether we concurred with the previous analysis undertaken. For our analysis program Rocscience Inc. 2D limit equilibrium slope stability for soil and rock slopes program 'Slide' was used. Both circular and non-circular analysis has been undertaken using Bishop, Janbu, and Morgenstern-Price analysis methods. Critical surfaces were obtained by both grid and Auto Refine Search methods. For the desk study assessment six critical sections have been examined. The resultant analysis summary sections have been presented at the end of the text and summarised table is given in Table C2.

Section 1 - Landbridge between Q2W and Q3E.

Previous analysis had been undertaken for both the landbridge between Q2E and Q1 and between Q2W and Q3E. As the landbridge between Q2E and Q1 has since been buttressed by material infilling Q1 the risk of failure will have been reduced and was therefore considered less of a risk than the Q2W and Q3E landbridge.

Before developing Q3 it had been identified that the slide failure of the landbridge into Q3 might occur through the shales at the base of the sandstone being quarried. Following analysis the quarry limited their excavation to within 2m of the base of the sandstone to provide passive resistance to movement. Using MCG parameters and profile similar FoS to MCG were achieved (Ref; Analysis 1, 1A & 1B). Analysis 1C shows that with a 2m cover of sandstone in the base of Q3 a FoS in excess of 1.3 is achieved across the landbridge. This is very sensitive to groundwater levels, but with the proposal to drain Q2W (with only isolated surface ponds present) stability will improve.

Further analysis showed that for the steep lower Q3 slopes to remain stable, the rock needs to have some cohesion. However, by adding 100kPa cohesion to the sandstone in Analysis 1D, a FoS in excess of 1.3 is achieved. As the rock mass will have a compressive strength well in excess of 100kPa the stability of the Q3 slope is satisfactory in the north east corner provided the proposed hotel does not require excavation into the rock slope or removal of the sandstone currently retained in the quarry base. As the existing quarry floor is above the proposed water level of the lake in the northeast of Q3, flooding of the quarry for the proposed lake has no adverse affect.

Sections 2 and 3 - North and South Sides of West End of Q3.

Using MCG parameters the middle and lower part of the existing (stable) slope are shown by Analysis 2A to be unstable. However, Analysis 2B shows that the sandstone only needs a small amount of cohesion (25kPa) to be stable.

Examination of the existing quarry face at the quarries west end shows that some of the slope is highly weathered to sand. This is typical of what might be expected if there was a zone of faulting. However, no defined lines of movement were evident in the exposed faces. It should be noted that the western end face of the quarry was cut at a much slacker slope angle (18 degrees) and is therefore less of a concern.

Regardless of its origin the high degree of weathering will have a significant bearing on the slopes stability when saturated by the quarries flooding. Wetting of a weakly cemented sandstone will result in a reduction of its cohesive strength, particularly where unconfined. Consequently with the flooding of the quarry our observations would suggest the over steep quarry sides face will decay and cause localised instability into the lake. Analysis would suggest that instability would not initially affect the ground beyond the quarry crests, but if unchecked this might be a concern, although, provided it is left, slipped debris in the lake floor would have the effect of improving the stability of the side slopes.

Although this scenario may be acceptable in a quarry setting where public access is limited, in an area developed for lake activities and lodges on the quarry sides, localised slipping could not only affect the areas of movement, but by displaced water in the lake might be expected to surge in a wave across the lake and endanger lakeside activities. To develop the lake there is a desire to have shallow water, to limit the amount of cold deep water. If therefore the west end was part infilled say to 1.5m to 2m below proposed lake level the steep quarry faces at the west end would be confined. As shown by Analysis 2F and 3E this would increase the side slope stability above the minimum 1.3 FoS required.

The remaining concern is the affect of rapid draw down of the lake water. Following the cessation of quarrying the quarry pumps have been removed and the water levels left to naturally rise. As development works are not scheduled to begin for at least 12 months after pumping ended, water levels would be expected to have reached a level close to there equilibrium estimated to be 155m to 157m AOD. See Section 11. The earthworks contractor may prefer to raise the lake floor levels by re-draining the quarry and placing and compacting the spoil in a dry state onto the quarry sides and floor. The analysis (Analysis 2E and 3D) undertaken would suggest that existing slopes might fail if the support of the lake water was suddenly removed. Therefore if the drawdown of lake water is proposed we would recommend the conditions are further investigated and analysised prior to work proceeding. A further option might be to place the infill into water. This would result in a reduced density of infilling and again will need to be further investigated and analysised before any earthwork is undertaken.

Section 4 - Dam holding L3 tailings.

During a period of flooding in the mid 1960's the quarry records (*References 43 to 47*) would suggest the dam came close to failing which as speculated at the time could have resulted in the water and tailings contained behind the dam flooding down Stream D through the railway sidings and into the River Churnet valley. As shown by quarry records and a 1964 aerial photo (Fig C1) water streamed through the dam and got close to overtopping its crest.

Records would suggest quarry stone was sacrificed to stabilise the dam base, and further material was used to raise the dam crest. At the time the dams face was recorded to have a gradient of 1:3 (v:h) with a back face (as seen on crest) at 1:4 (v:h) It might be noted tailing dams are not necessarily design to stop water from the tailings draining through the dam, but excessive flow could destabilise the lower slope, causing progressive failure at the crest. At the time the dams condition was investigated and measures put in place to limit the depth of water collecting above tailing levels. Between 1976 and 1979 L3 is recorded to have been capped and the stream entering the top of the lagoon directed down the south west side of the former lagoon before draining over the dam. However, further concerns were raised in 1985 when sink holes appeared in the lagoon area behind the dam and flowing water could be heard below the surface. It appears the solution used was to reduce the weir height to 164.86m AOD and cut a trench back diagonally across the lagoon area to presumably drain the surface water collecting. It would not be unreasonable to expect the lagoon tailing were settling, which could have resulted in ground levels being lower than the weir.

We would anticipate with time the tailings in L3 will have consolidated further and dried. This was confirmed during our site visit when further ponding of water in an area of trees behind the dam was observed. Although the consolidation and strengthening of the tailings behind the dam will reduce the pressures on the dam, whilst ponding of water at the surface still occurs there remains the risk of running sand conditions and slump failure of the dam occurring. Initial analysis has shown the dams stability remains a concern, but with further investigation and drainage measures employed a satisfactory stability of the dam should be achievable.

We would therefore conclude at the desk study stage that before development of this site, particularly in areas on or next to the lagoon or on or below the dam, further investigation and analysis of the dam and its environs will be required.

Section 5 - North West slope of Q2E.

It is understood from quarry records in *Reference 1 & 50* that in 1980's the north eastern face of Q2E slipped on mass over the quarry shale base into the quarry area. Inspection of this north eastern face revealed the Crowtree Fault several metres behind the face. Site inspection found the slipped block have remains on the north side of the now infilled quarry and earthworks have been used to bund the lower north west slope of the original quarry. The limited stability assessment undertaken would suggest this area is stable in its current state, but could easily be destabilised if excavation in this area was to occur. Current proposals are to leave this area to ecologically naturalise in its current profiles. However, if any development were to be proposed then further assessment and probably stability analysis will be required.

Section 6 - North Slope of Q2W

Quarrying has left a wedge of sandstone on top of the underlying shale along the north edge of the quarry. With a basal dip of around 12 degrees wedge failure of the retained 1:2 (v:h) sandstone face has been assessed. At the time of our assessment it was not known whether two tips (T3 and T4) beyond the crest of the slope were to be removed or retained. We conclude from our initial assessment that in both conditions the slope should have a FoS greater than the 1.2 required.

As the lower slacker shale slope may be terraced as part of the development we would recommend that analysis is undertaken when slope profiles are better known. At this stage we would recommend that the shale slope is not cut into more than 1m below the top of the shale, and earthworks within 5m of the sandstone slope is avoided. Removal of the stockpile of overburden fill from Q3 is not considered to be a concern.

Slope Stability Assessment of Q3

Table C2

Section 1
Landbridge between Q2W & Q3E

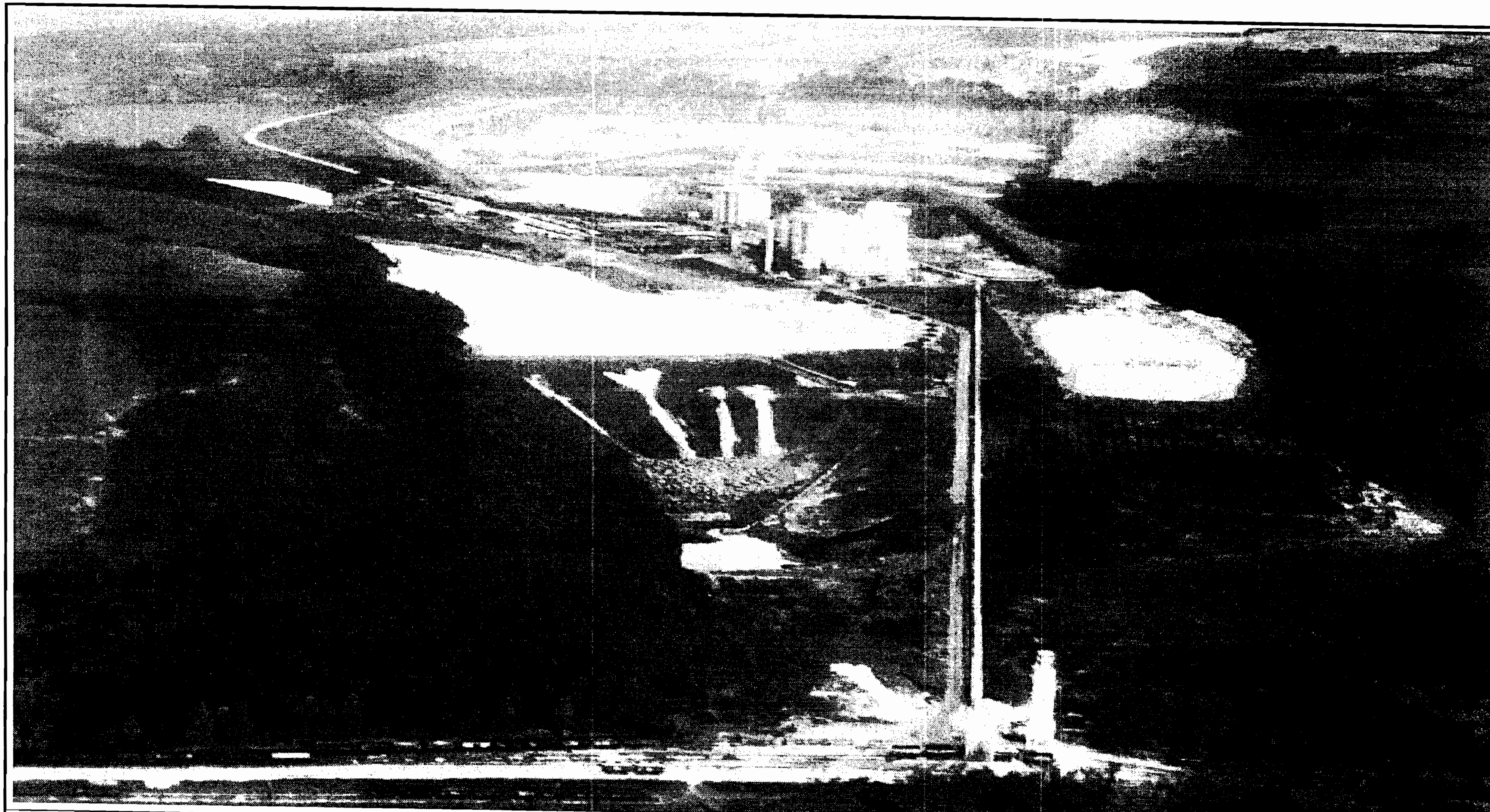
Ref	FoS	Comment
1	1 066	MCG Analysis showing low fos if all sandstone from Q3 removed
1A	1.117	1st attempt to mimick MCG analysis
1B	1 032	2nd attempt showing without sandstone base fos low.
1C	1 385	Showing with MCG justified parameters fos of existing landbridge acceptable
	0.756	Quarry slope shown to be less stable
1D	1 397	Quarry slope stability if sandstones cohesion is increased a small amount (100kPa)
1E	1.586	Showing flooding of quarry has no adverse affect
1F	1.327	Similarly with sandstone cohesion flooding lake Okay
1G		Rapid dewatering however could reduce stability.

Section 2
North side of West End of Q3

2		MCG analaysis paramenters used
2A	0.766	Middle and lower part of slope shown as unstable
2B	1.012	Existing slopes stability reliant on small but significant (25kPa) cohesion
2C	1.16	circular analysis of same
2D	1.126	Flooded lake shows small but not sufficient increase on 2B
2E	0.839	Rapid drawdown of lake shows a drop in stability from existing 2B
2F	1.572	Infilling quarry to 2m below flooded level
2G	1.521	Rapid drawdown of filled quarry also stable
2H	1.076	Cement softening could cause local instability
	1.391	however main slope will stay stable
2J	0.898	Flooding and uncemented sandstone would cause instability

Section 3
South side of west end of Q3

3		MCG Analysis parameters used
3A	1.178	Existing slope maitained with low fos in lower half of slope
	1.5	Whole slope showing greater stability
3B	1.372	circular analysis of same
3C	1.518	Flooding lake with same strata parameters increases fos
3D	0.672	Rapid drawdown would cause lower
	0.943	and who slope to fail
3E	1.889	Infilling quarry to 2m below flooded level increases fos
3F		Stability with rapid drawdown of filled quarry also stable



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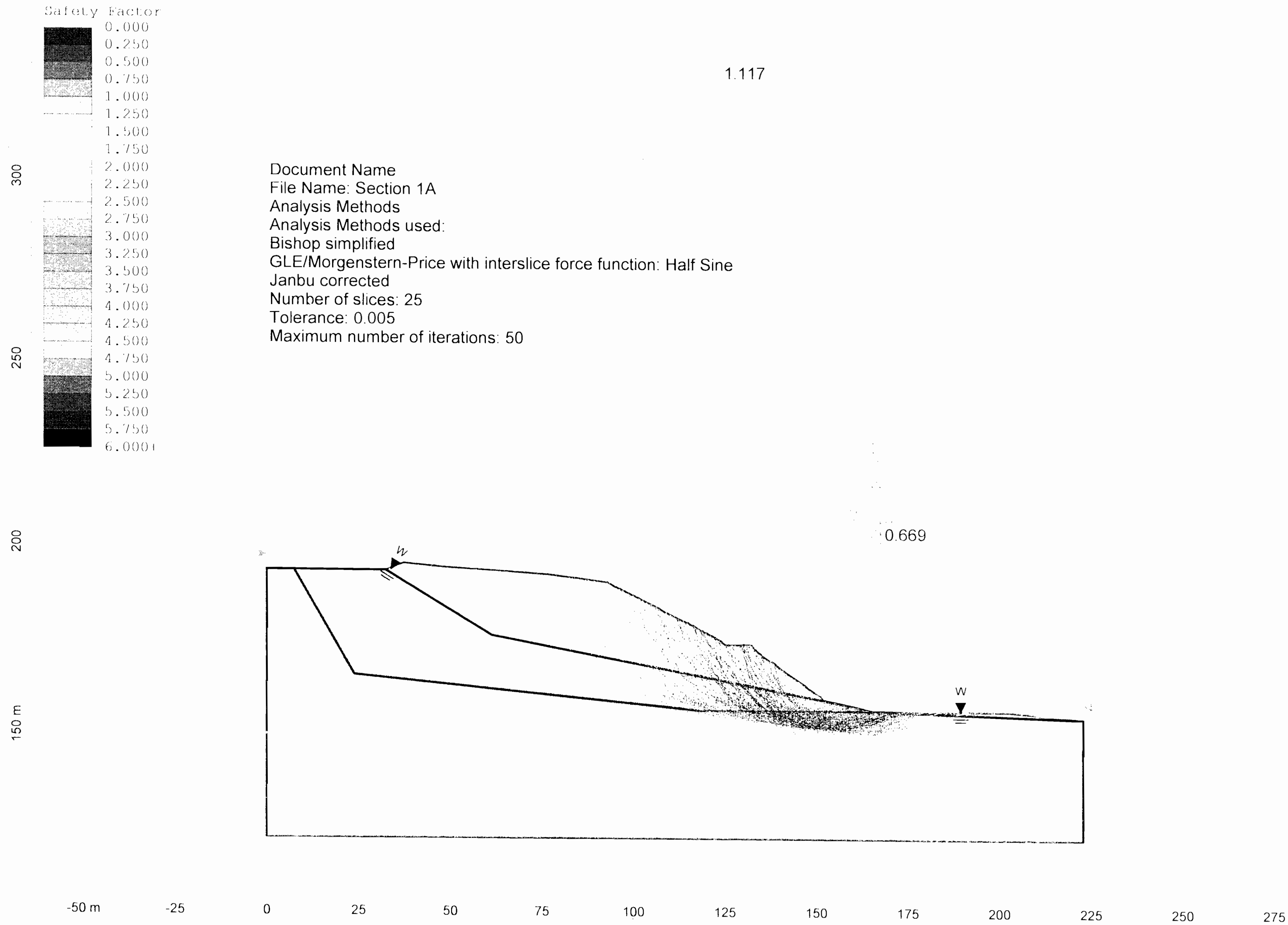
1964 PHOTOGRAPH (looking North)

Job No: 418040
Project: Moneystone Quarry, Oakamoor
Client: Laver Leisure

Fig. C1



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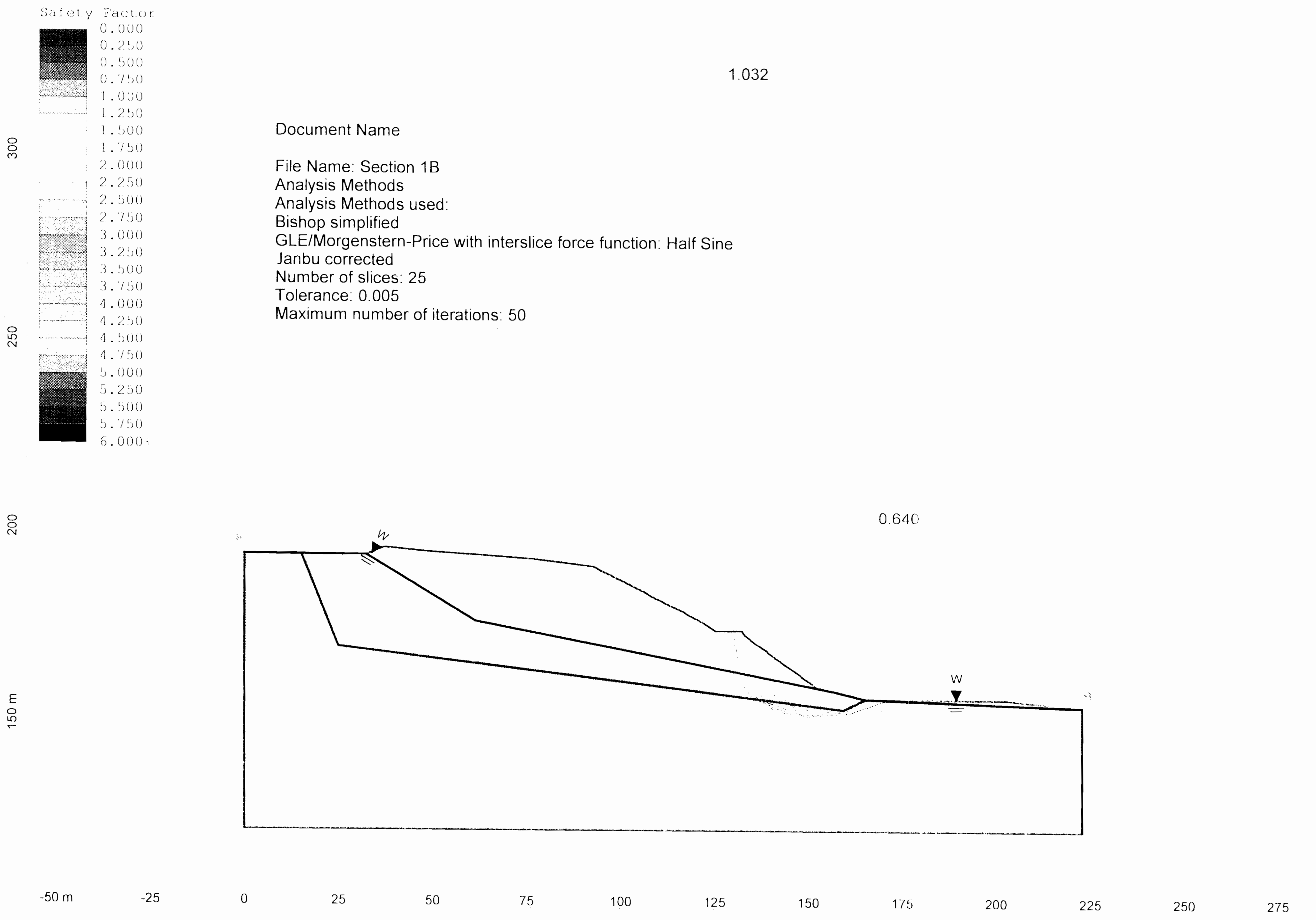

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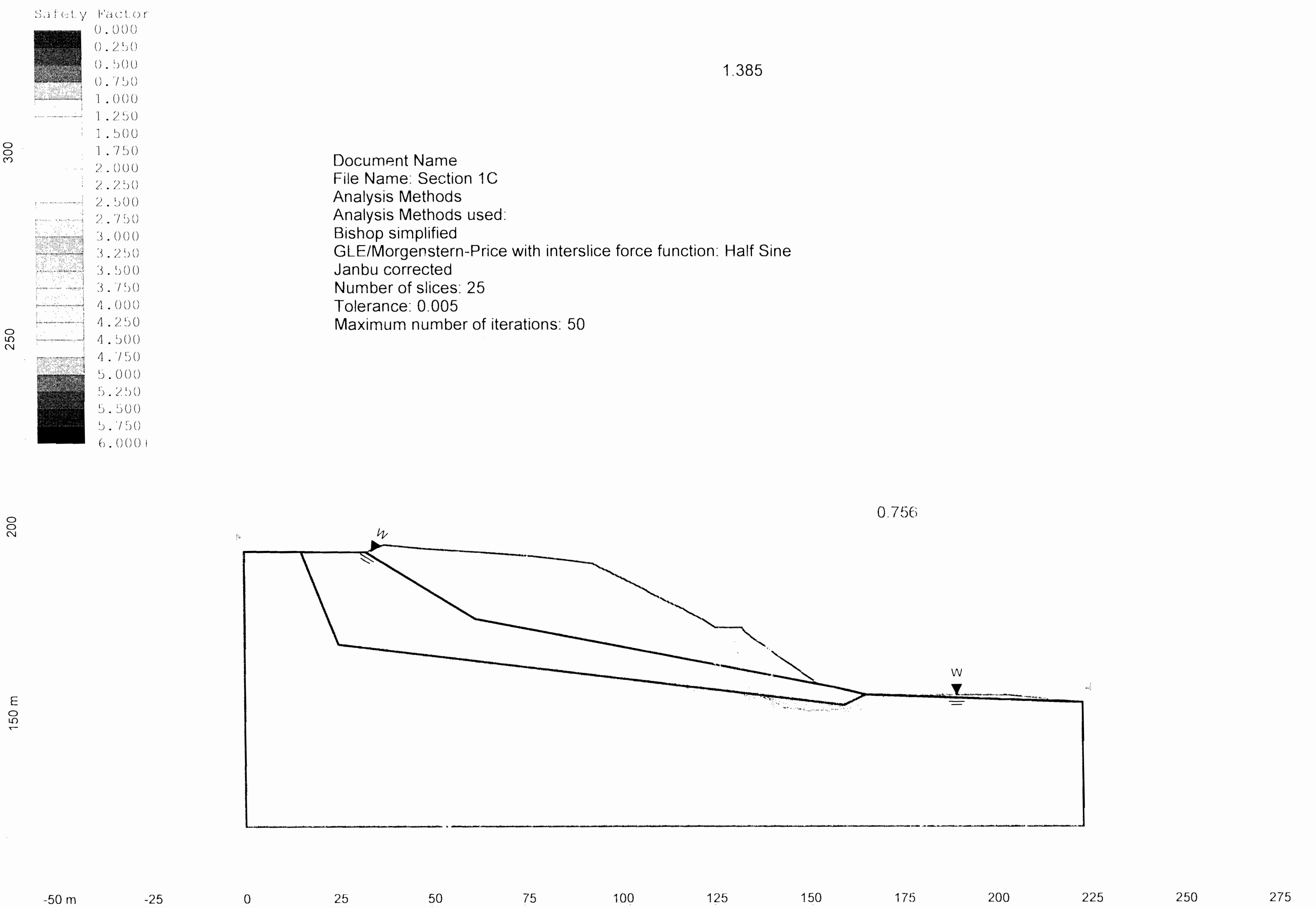

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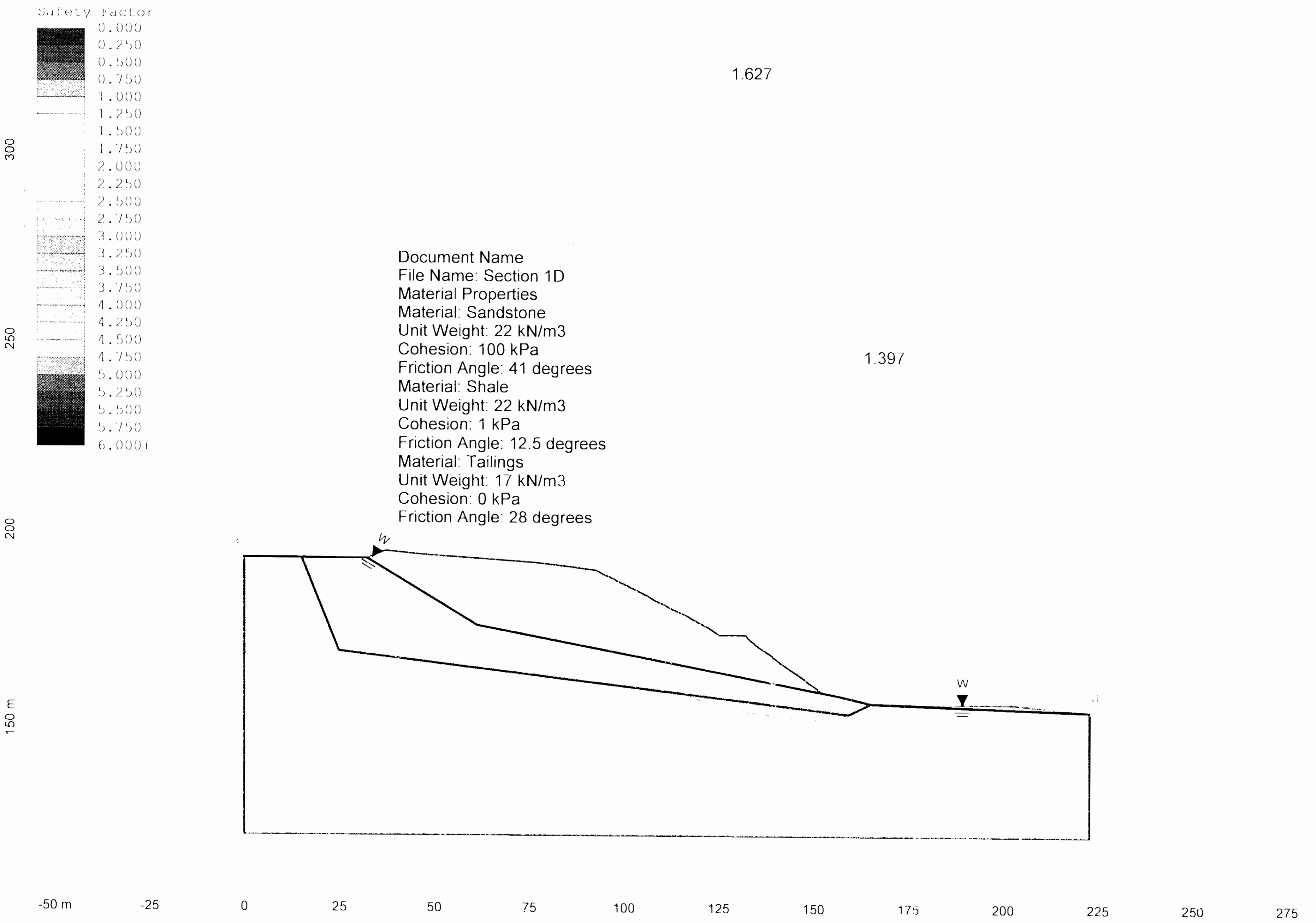
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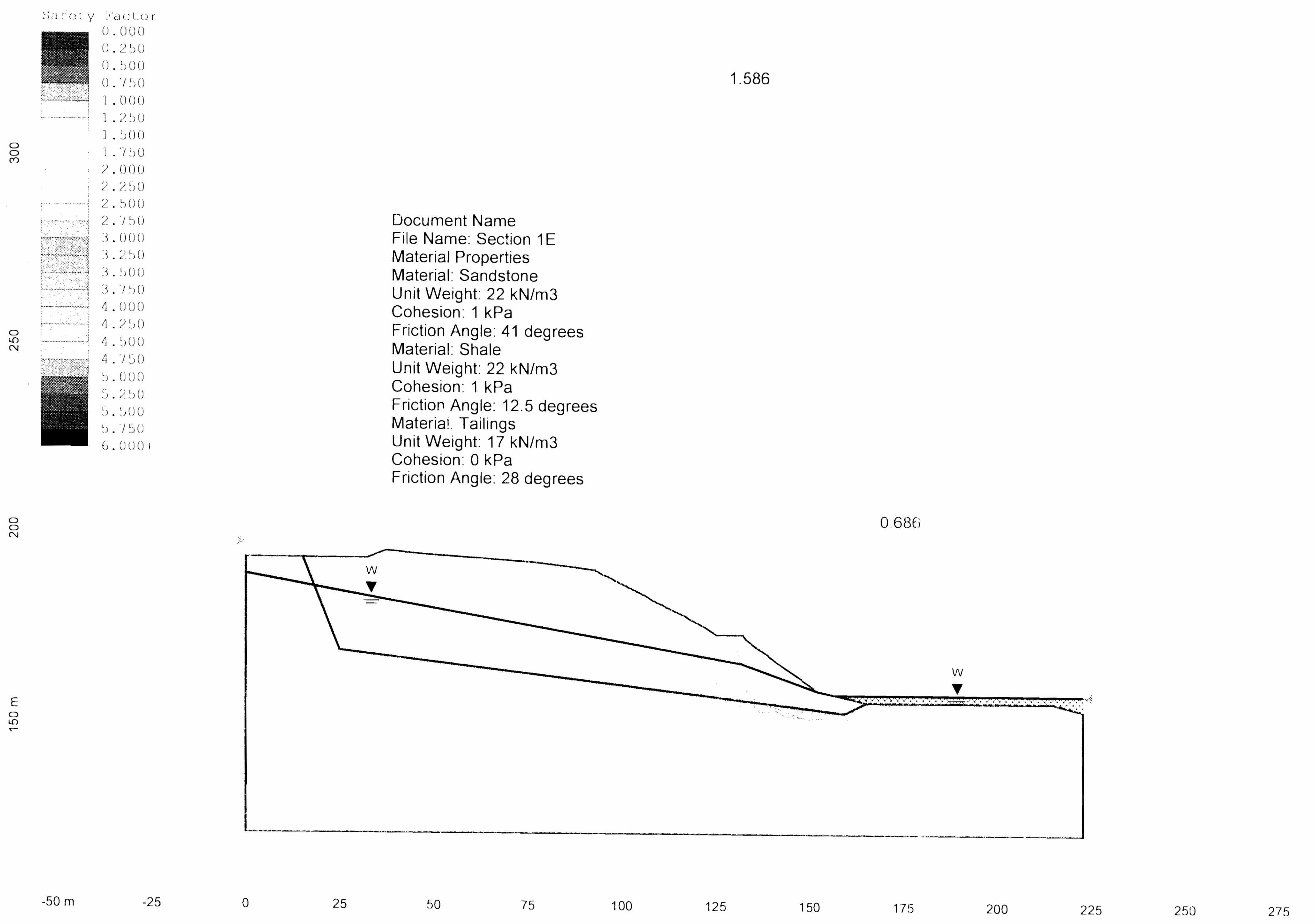

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Cohesion: 0 kPa
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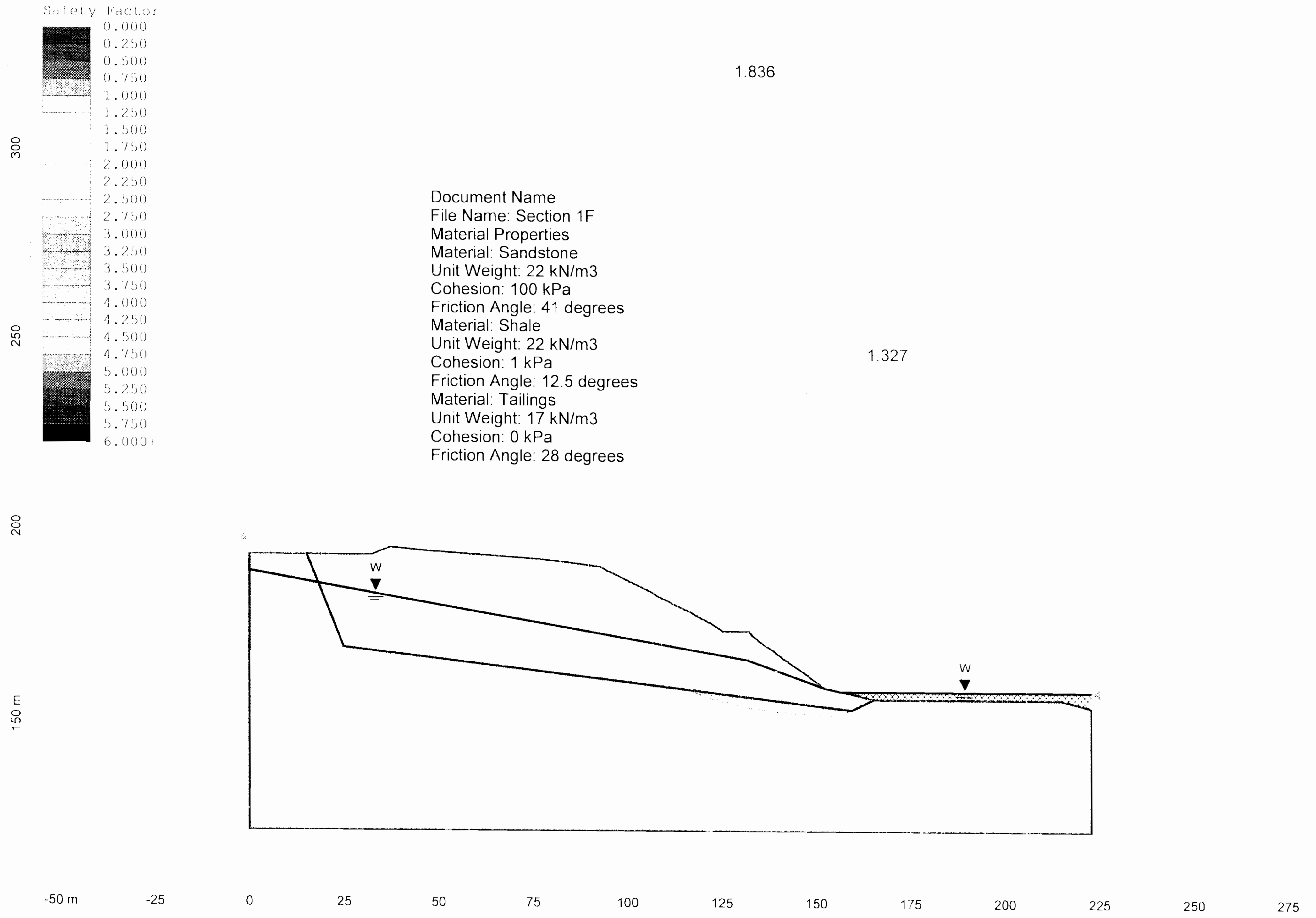
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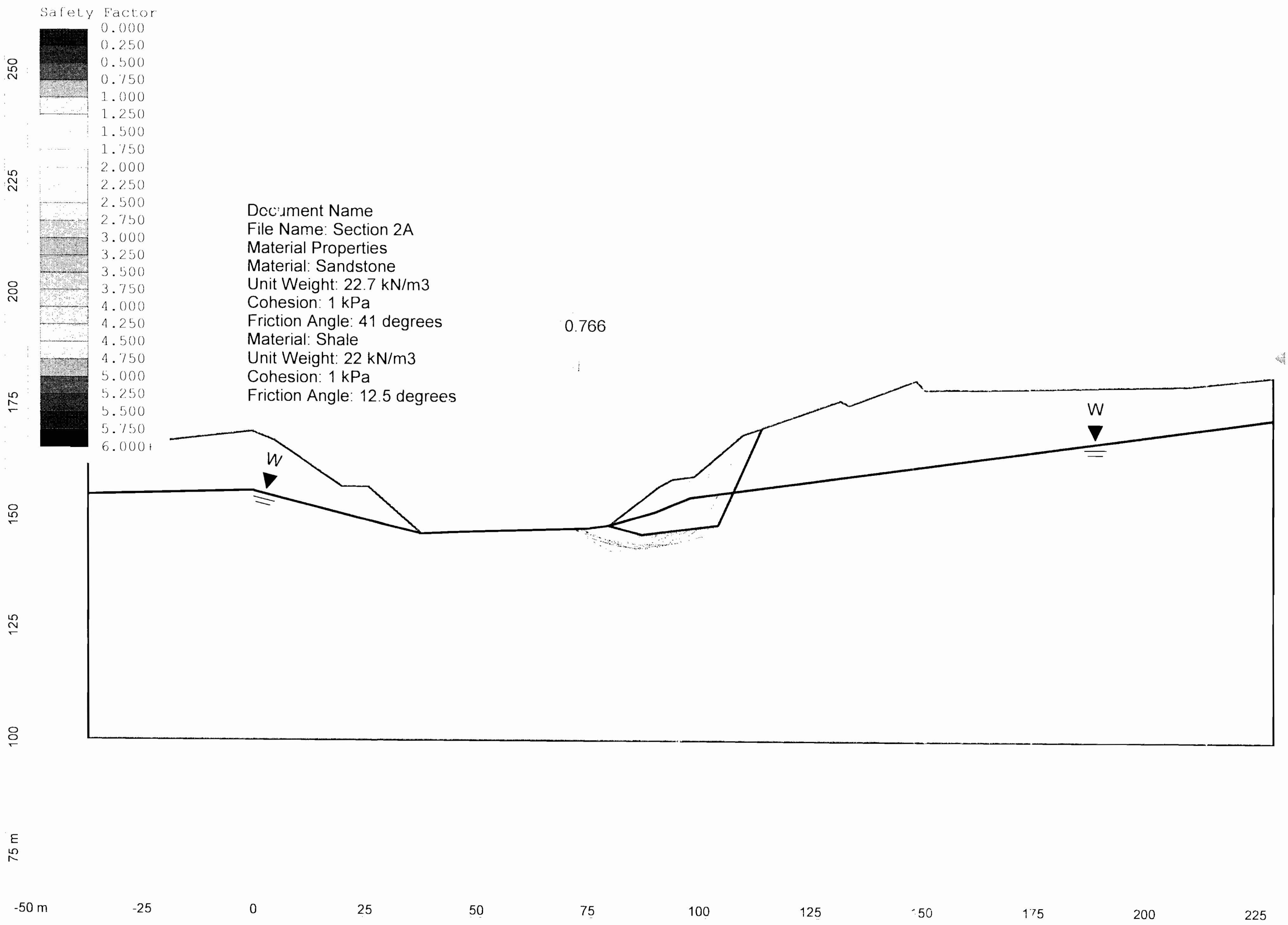
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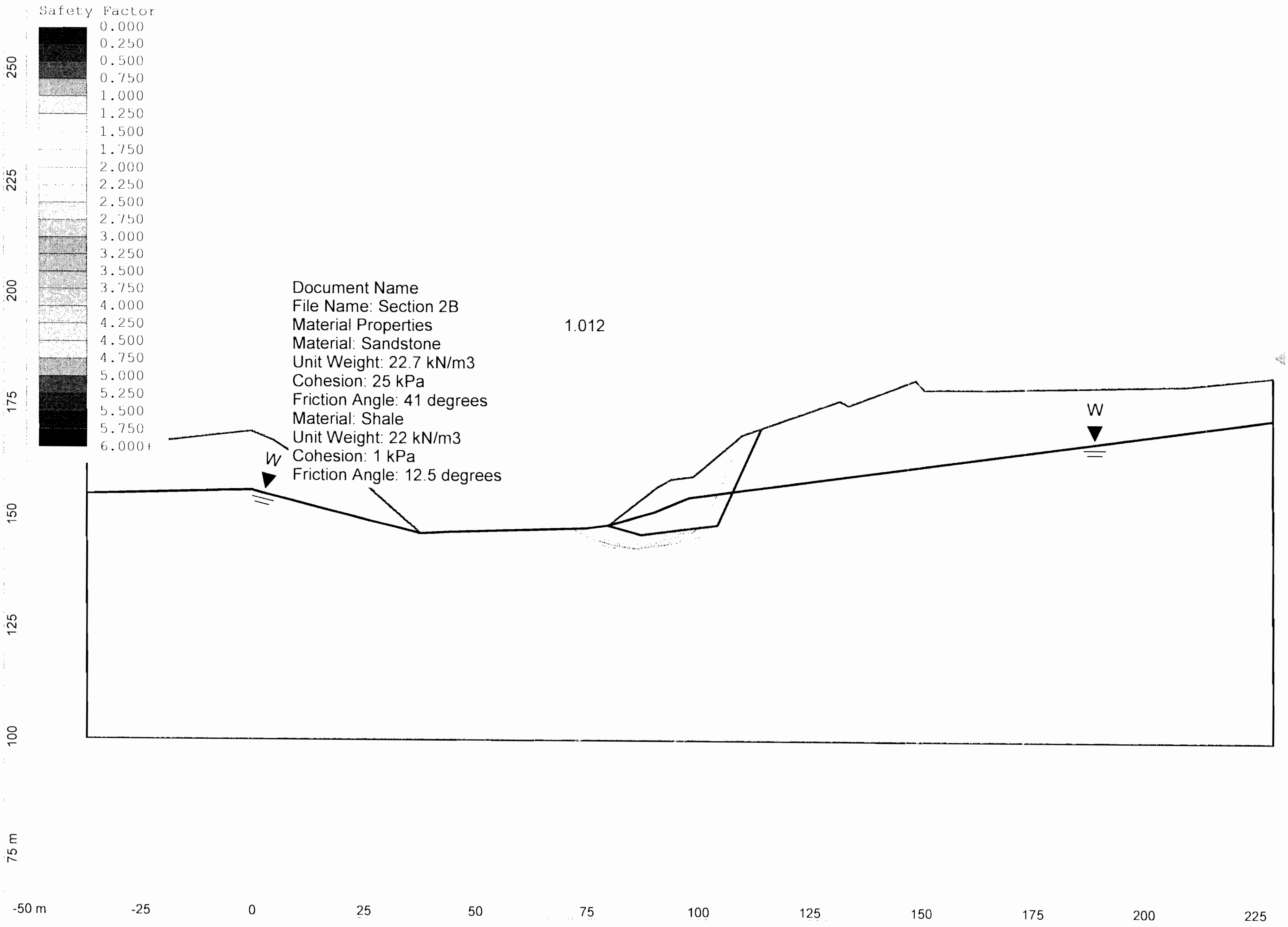
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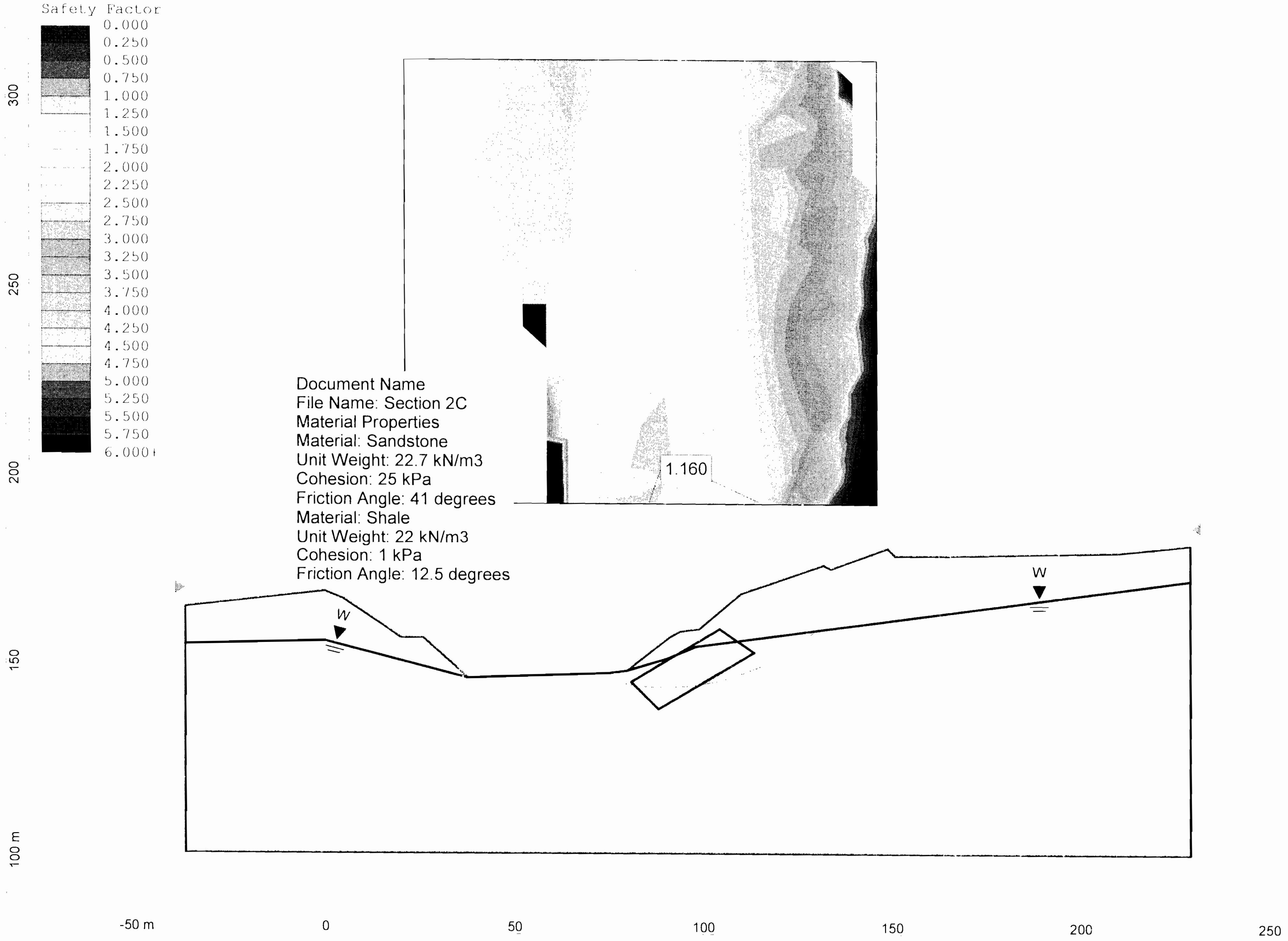
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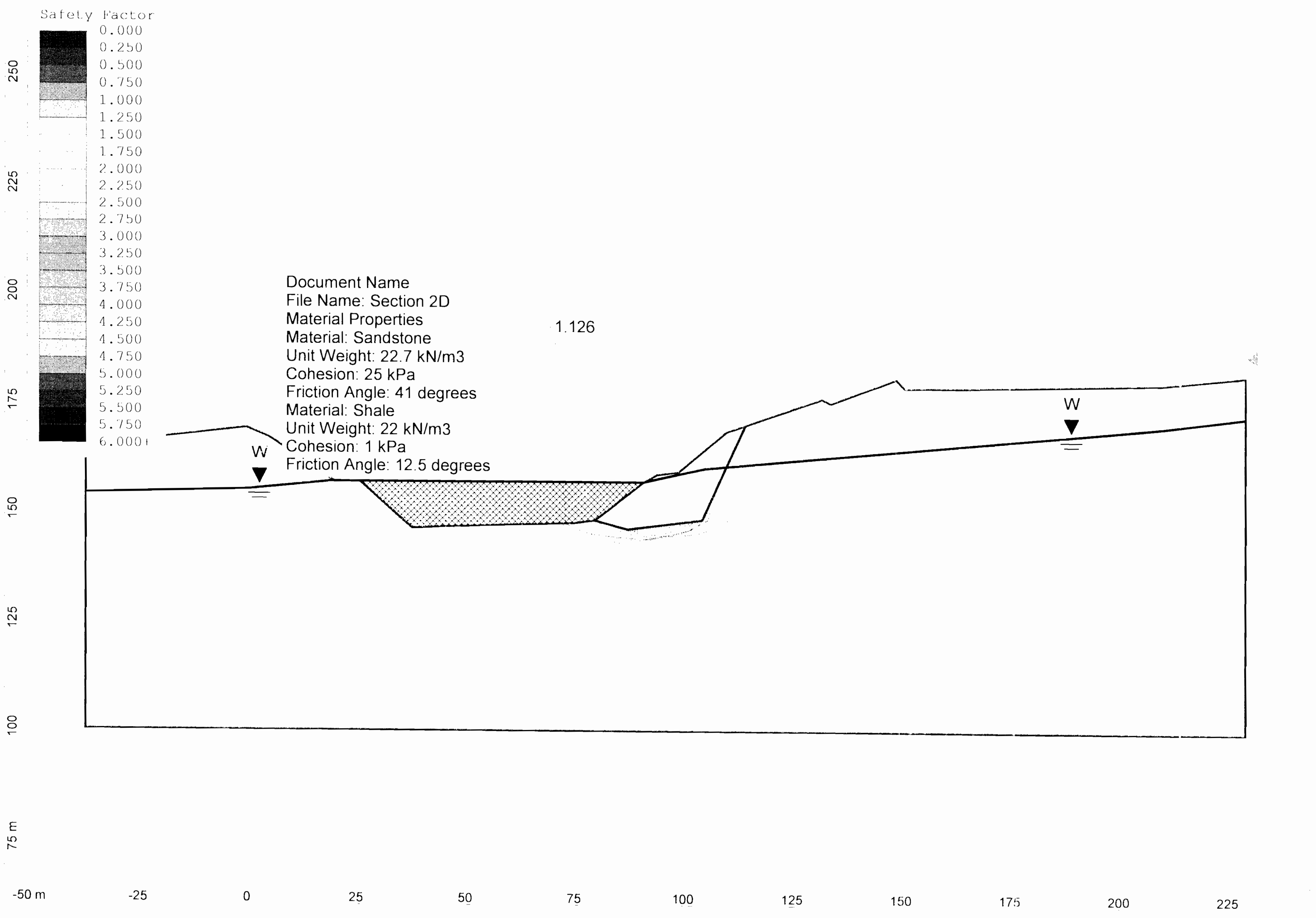
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Friction Angle: 12.5 degrees
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W
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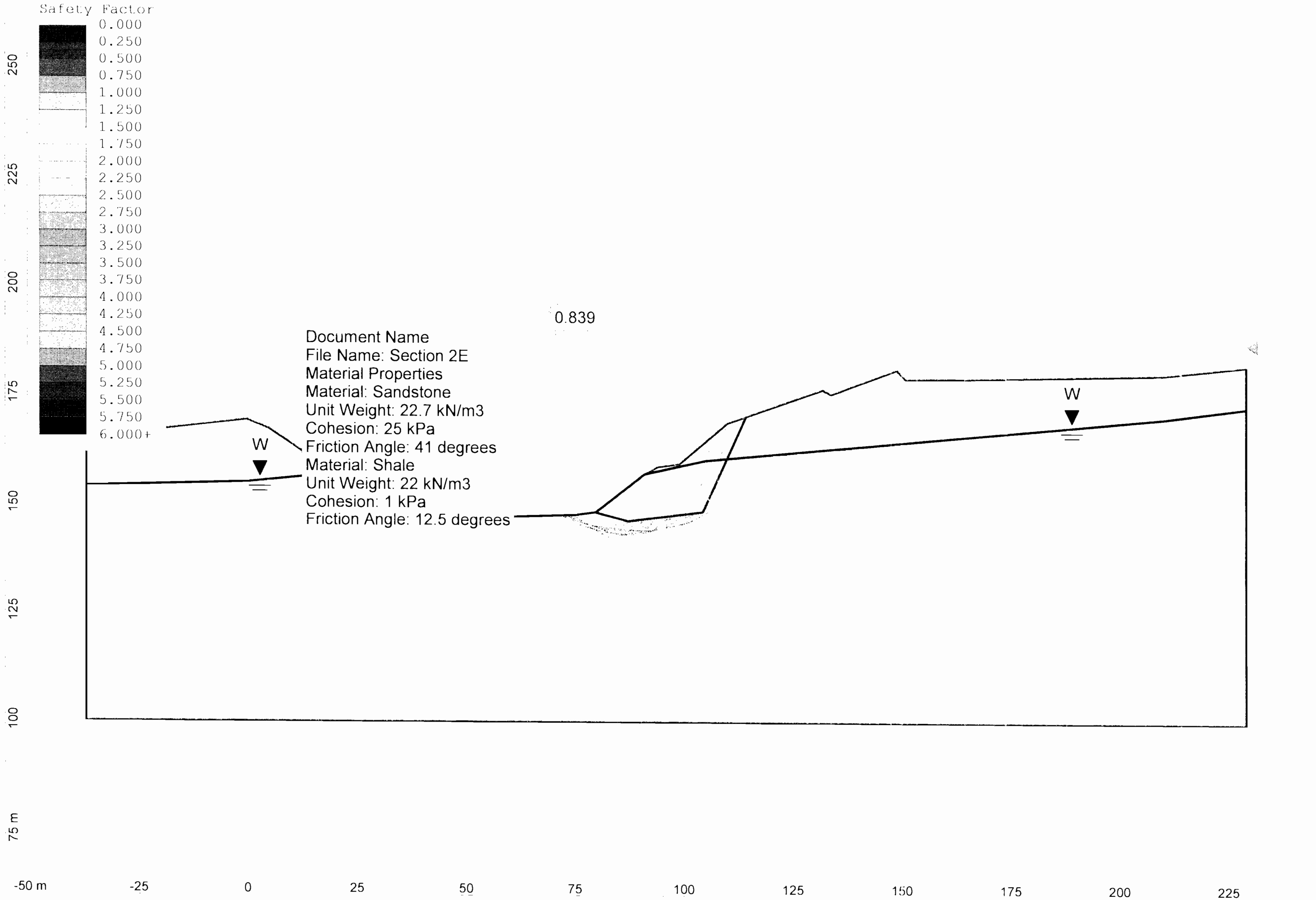
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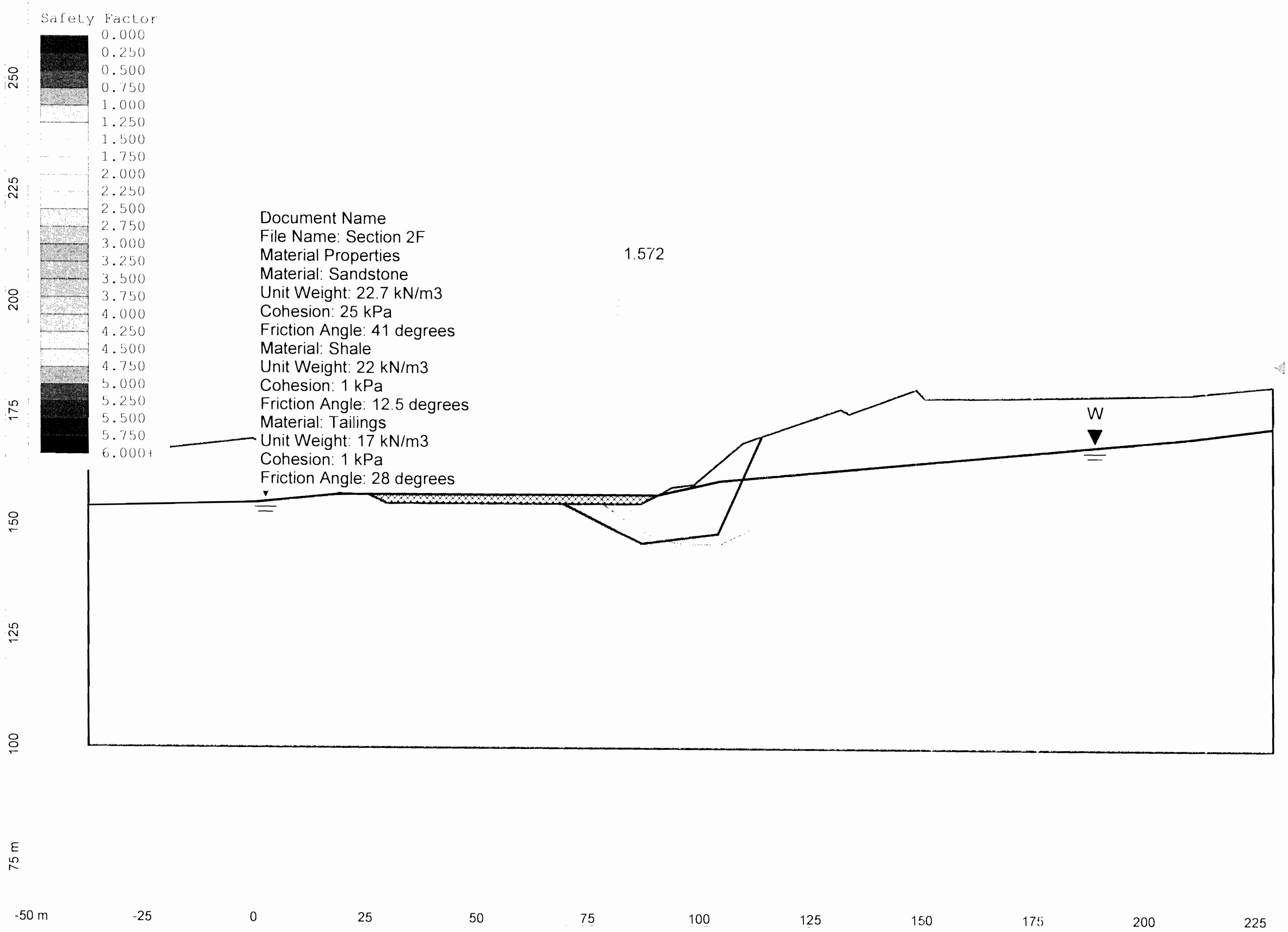
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Friction Angle: 12.5 degrees
Material: Tailings
Unit Weight: 17 kN/m3
Cohesion: 1 kPa
Friction Angle: 28 degrees
1.572
W
250
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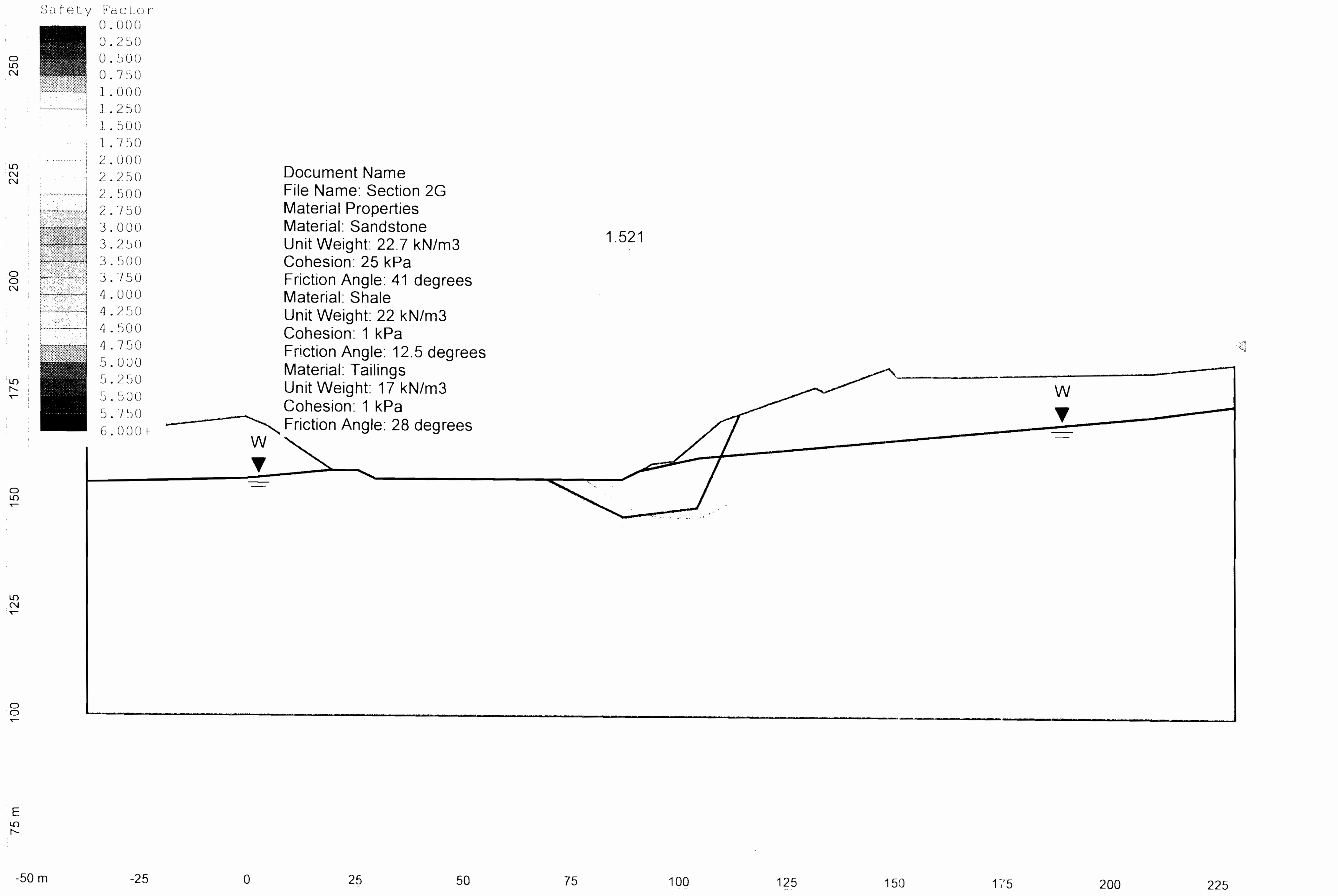

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Material: Tailings
Unit Weight: 17 kN/m3
Cohesion: 1 kPa
Friction Angle: 28 degrees
1.521
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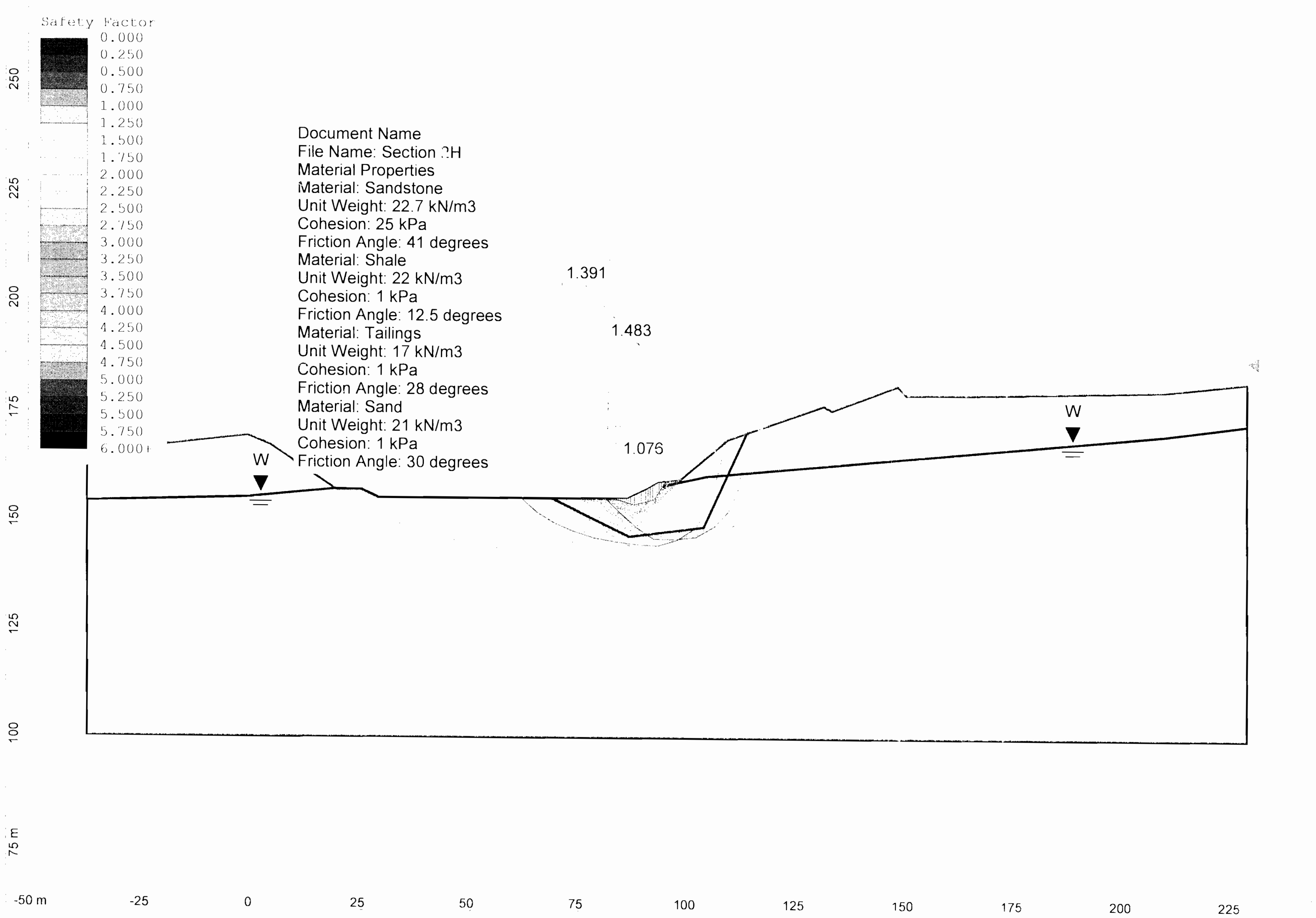
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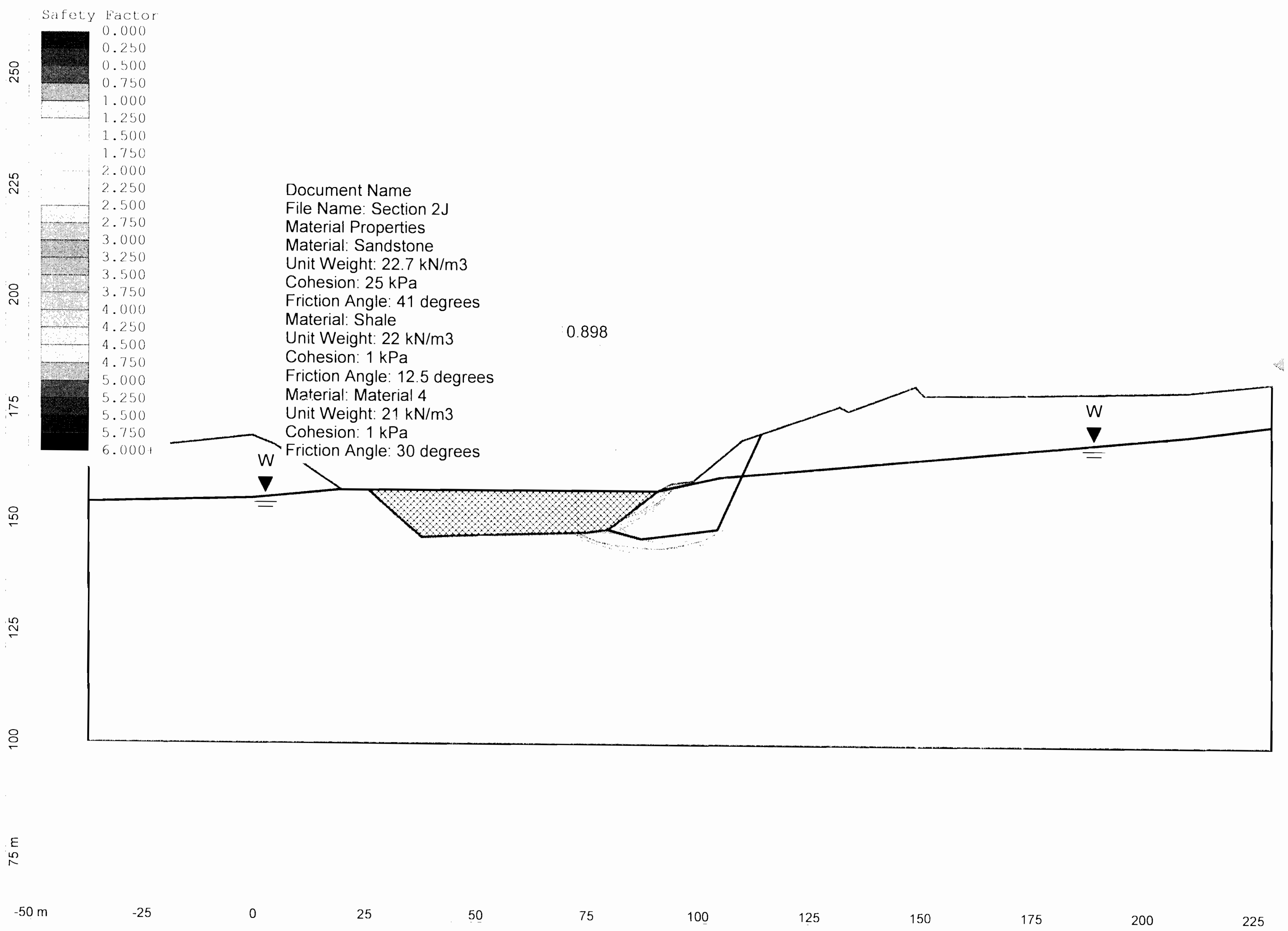

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Friction Angle: 12.5 degrees
Material: Material 4
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W
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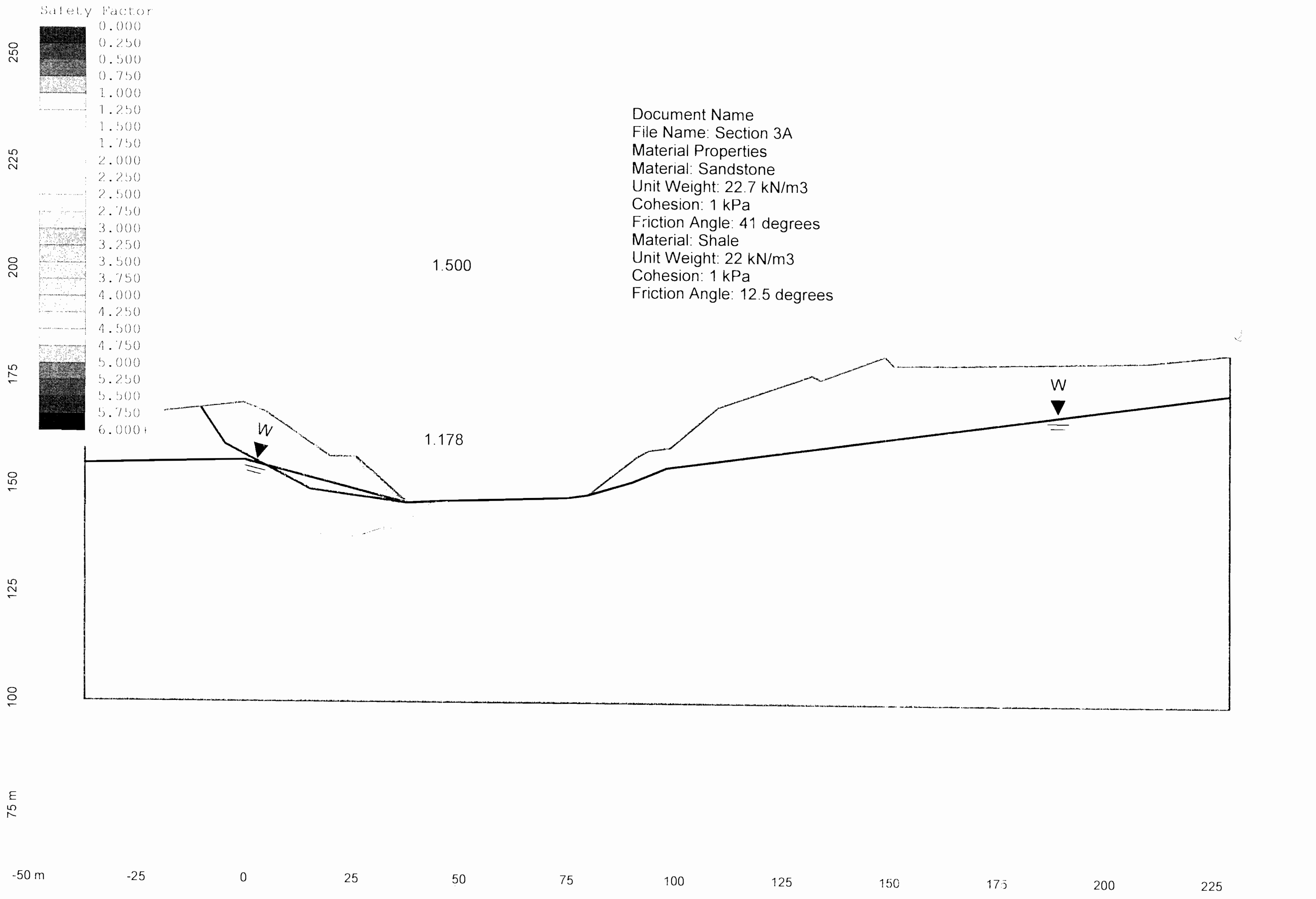
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1.178
W
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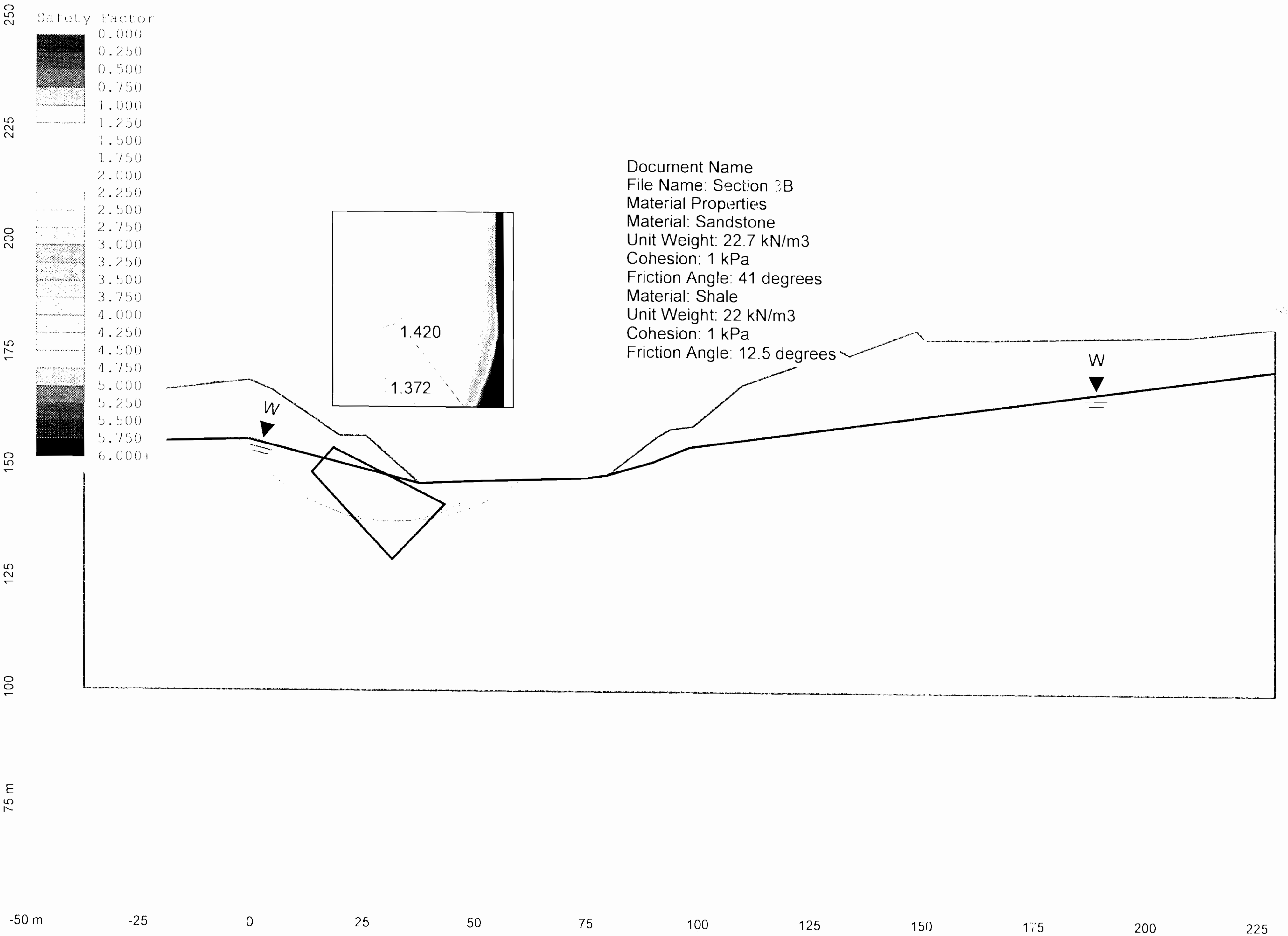
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Cohesion: 1 kPa
Friction Angle: 12.5 degrees
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1.372
W
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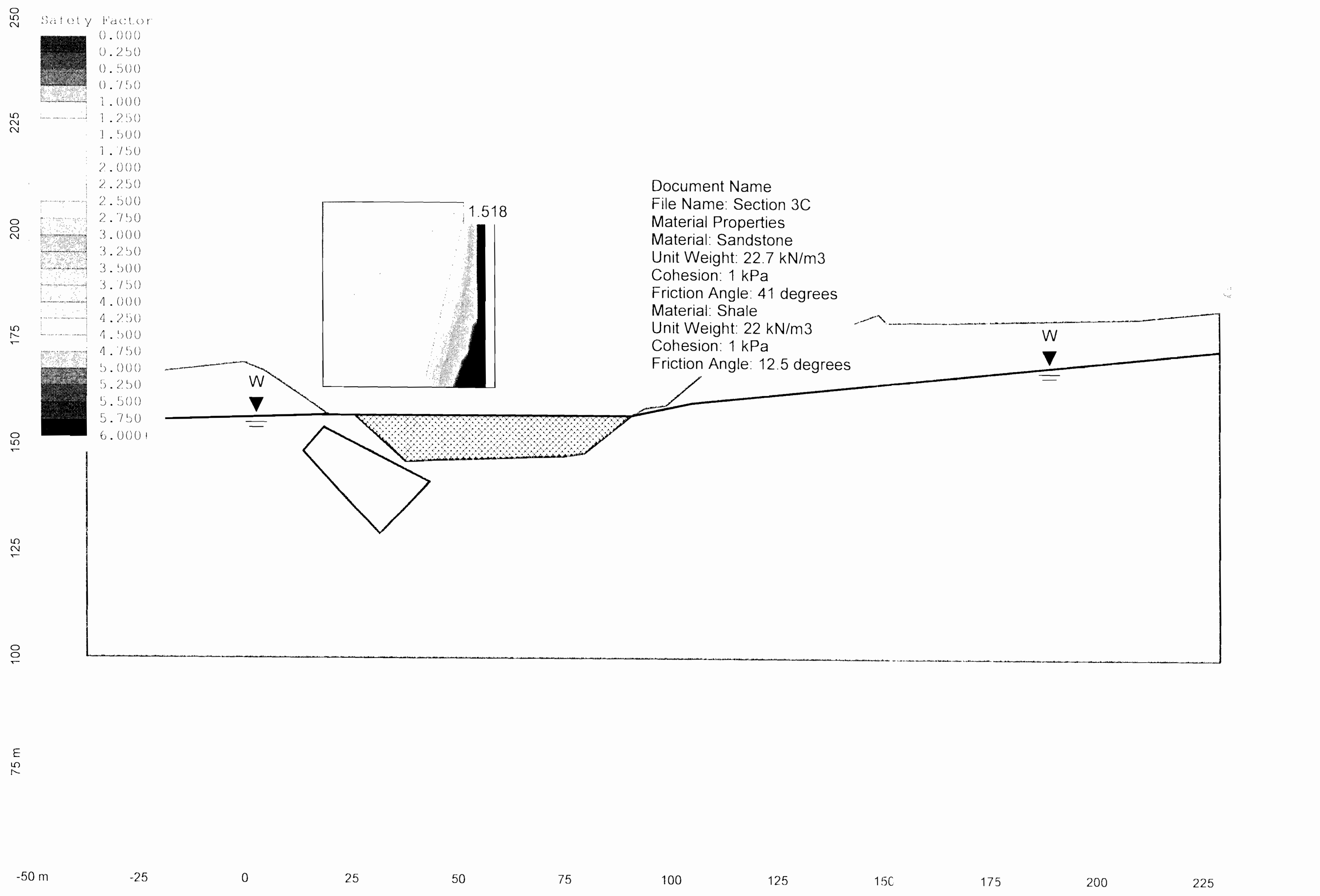
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Cohesion: 1 kPa
Friction Angle: 41 degrees
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Cohesion: 1 kPa
Friction Angle: 12.5 degrees
W
W
250
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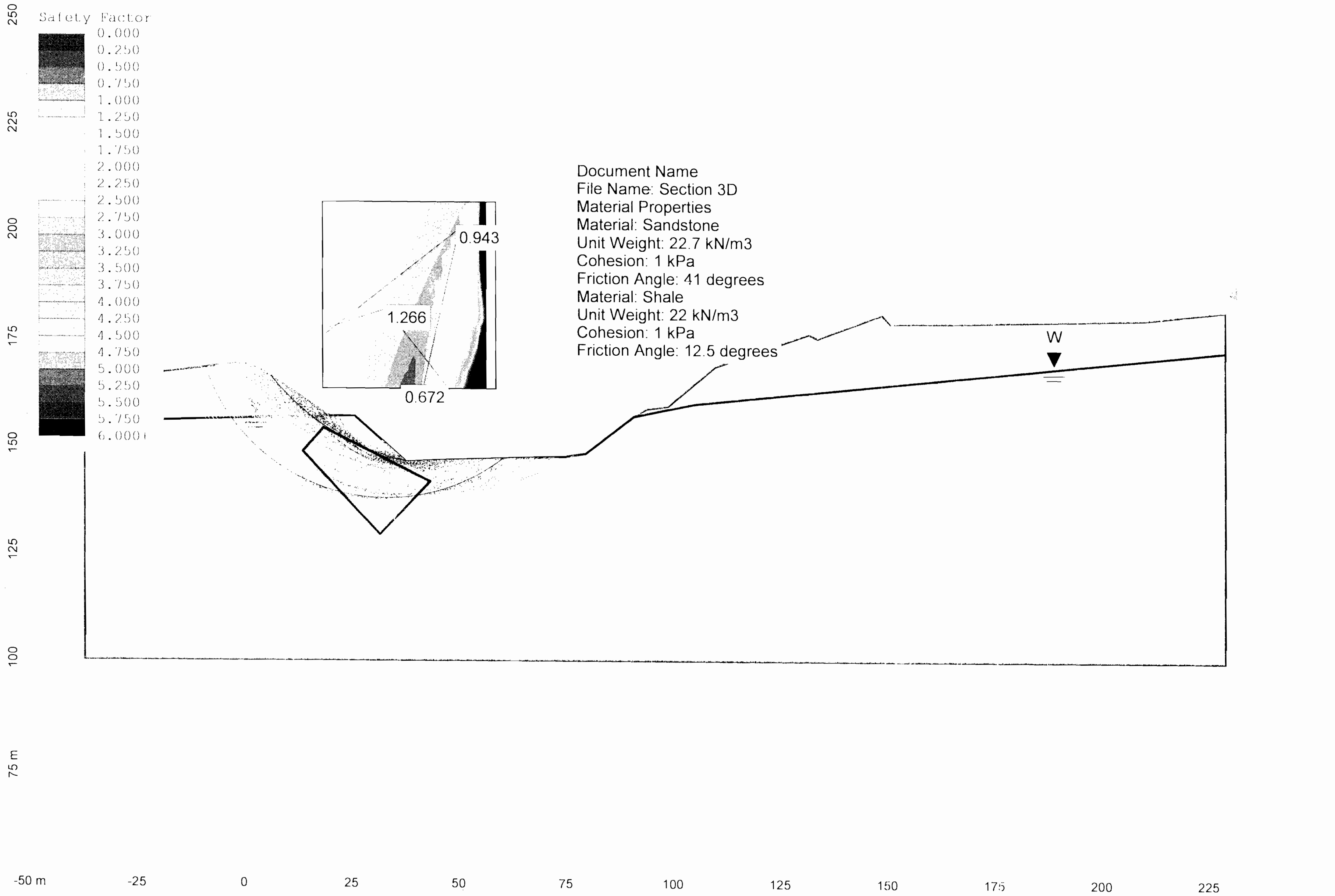
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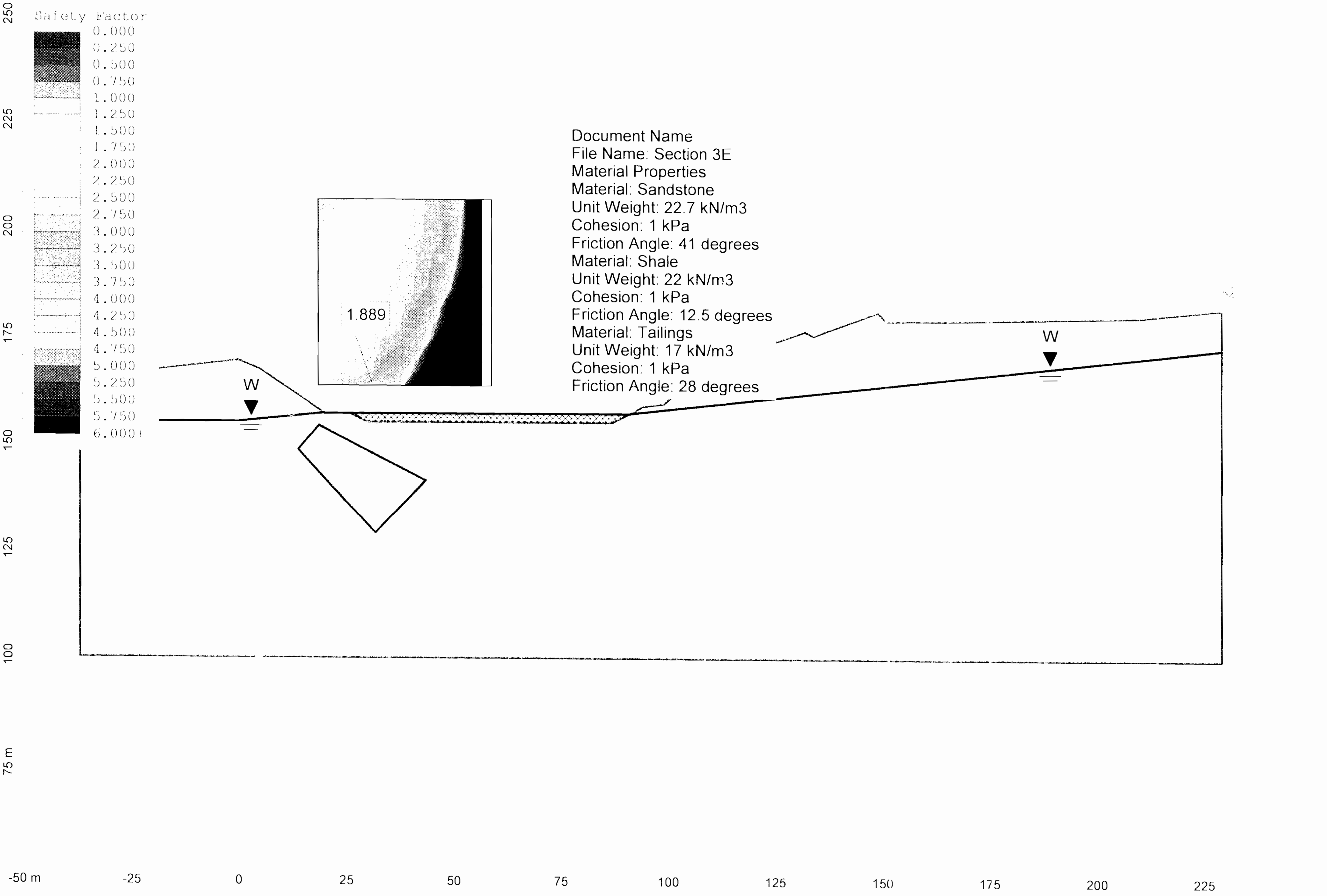

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Friction Angle: 41 degrees
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Friction Angle: 12.5 degrees
Material: Tailings
Unit Weight: 17 kN/m3
Cohesion: 1 kPa
Friction Angle: 28 degrees
250
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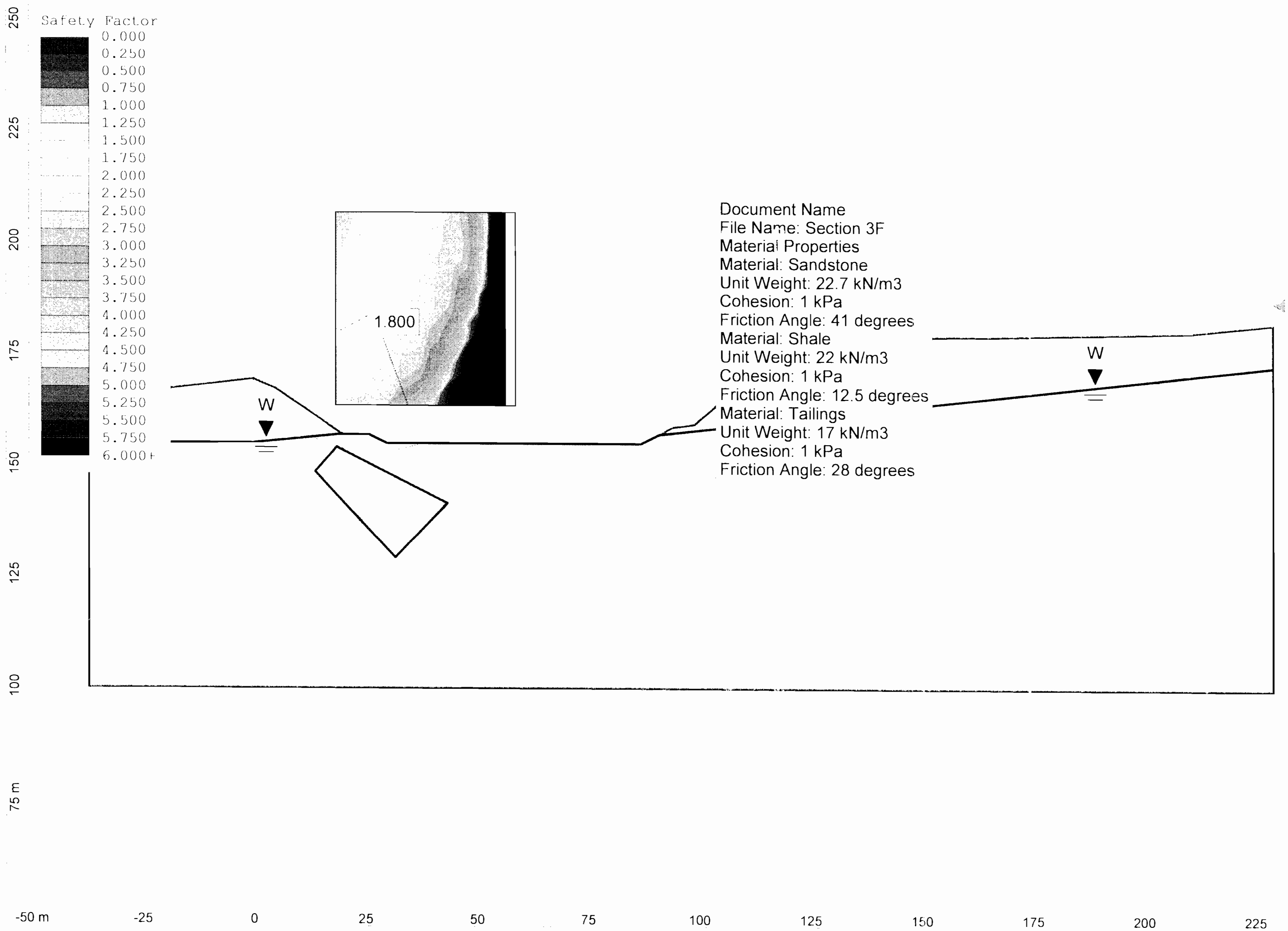
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6.000+
1.800
W
W
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Material: Tailings
Unit Weight: 17 kN/m3
Cohesion: 1 kPa
Friction Angle: 28 degrees
250
225
200
175
150
125
100
75 m
-50 m
-25
0
25
50
75
100
125
150
175
200
225

APPENDIX D

ASSESSMENT OF EARTHWORKS

APPENDIX D

ASSESSMENT OF EARTHWORKS

At the time of reporting the development was in outline stage. To assess the viability of the development the earthworks requirements for each area were assessed and are presented below. A viable method of delivering the earthworks was then developed and have been presented in this document as a working document which may be altered and changed as requirements are better understood.

Q1W

Existing

This area has been capped apart from a pond area in the central southern part of the area which is reported to be directly underlain by lagoon tailings. The water in the pond is about 1m deep and is acting as a sump for the area. The original Q1W quarry was in the order of 30m deep and was infilled with tailings. This was covered by approximately 2m of capping material gained from overburden and dry production waste tipped from March 2001.

Proposed

Timber lodges are being considered on the high ground in the north east of the area adjacent to the tunnel, otherwise the majority of this area is to be left as green space with limited modification to existing ground levels.

Earthworks to develop

A small amount of surplus soil would be expected from the construction of the lodges, access and service. Area would be available during early phases of development, but the transportation of earthworks material around the development may temporarily isolate this area.

Estimated time to complete 1 to 3 months.

Q1E

Existing

Currently L4 covers most of the area. From WBB records quarry infill (from the top) consists;

4m	tailings
2m to 3m	capping fill
4 to 15m	tailings

Proposed

Timber Lodges are proposed around a stream and a number of ponds.

Earthworks to develop

Option 1.

Remove the 4m thickness of more recently placed tailings and expose the pre 2004 capping layer. This should produce a working platform at 168m to 171m AOD which would be ready to build on with minor earthworks, which has also been pre-loaded. From this exercise we would estimate about 123500m^3 of tailing would be available for infilling Q3. However, because of the materials pH some washing (naturalising) of the material may be required before it is considered in Q3.

Estimate 123500m^3 of tailings would be released. Also existing bunds will release additional capping material.

Estimated time to complete 6 months to 1 year, depending on the time taken to nuturalise tailings.

Option 2
Cap the existing lagoon with +2m of dry capping material suitable for subsequent founding of lodges. Prior to capping the existing tailings will need to be left for a period to dry out. The quarryman have in the past waited for about 2 years before attempting to cap. An option using GeoGrid and draining using sand wicks could be considered but this would significantly add to development costs.

Estimate 61700m^3 of capping would be required.

Estimated time to complete 2 to 3 years.

Q2E
Existing
The old quarry has been infilled with tailings and capped. Landscaping is in an advanced stage with grass and shrub vegetation taking hold. From WBB records quarry infill (measured from the top) consists;

2m to 3m	capping fill
0m (north) to 25m(south)	tailings

Landslips have occurred in north east of quarry area which would restrict development and earthworks on the ground that forms the raised north eastern backdrop to this area.

Proposed
Timber Lodges are proposed on the old lagoon area around a surface water stream which include a number of ponds which run into Q2W area.

Earthworks to develop
The depth of capping and state of tailings need to be checked, but this area would appear to be ready for lodge development with minor re-modification to surface profiles.

Estimated time to complete 1 to 3 months.

Q2N

Existing

This area is separately defined as it is the remains of Q2 quarry floor formed of shale bedrock. The ground rises gently at about 1:9 (v:h) from 203m to about 211m AOD to the north east and overlooks Q2W. It is then backed by a steeper 1:2 (v:h) sandstone slope which runs around the north of the whole quarry. The Currently a stockpile of Q3 overburden spoil is stockpiled over its central area. Also groundwater seeps from the sandstone forming the steeper slopes to the north.

Proposed

As foundations will be into mudstone shale rock the lodges can be of a more conventional strip foundation design. This area would therefore also lend itself to other larger structures. e.g. Restaurants, hub buildings etc. The current November 2010 layout shows lodge layout suitable for relatively level ground. We would suggest that the lodge layout is changed to follow the slope contours and water features are limited to streams. However, lodge types can be up graded to stilt or earth lodges.

Earthworks to develop

Seepage's from the higher ground will need to be directed into drainage channels before any earthworks is undertaken. Before development an estimated 127000m^3 of Q3 overburden spoil will need to be removed. Additionally there will be spoil created by the construction of lodges, particularly if earth lodges are used.

Option 1

The spoil would form the equivalent to about a metre layer across the whole of L7. Being the closest area requiring spoil this would be the best location in terms of transportation distances for this material to be placed. However, this would severely delay any development on the Q2N area until after Q2W was capped.

Estimate 127000m^3 of capping material would be released. Also a small amount of capping would be released as lodges are built.

Estimated time to complete 4 to 5 years.

Option 2

The spoil could be used to form a bund closing the western end of Q3 and allowing the Q1E tailing for Option 1 to be moved. Spoil is also required to protect the remaining underwater north slope of Q3. Any surplus spoil could be placed at the north end of L7 in readiness for its capping at a later date. However, this would result in double handling of the material which would add to earthworks costs.

Estimate 127000m^3 of bund material would be released. Also a small amount of capping would be released as lodges are built.

Estimated time to complete 6 months to 1 year.

Q2W

Existing

Lagoon L7 area is currently being used to deposit acidic tailings and we presume it will be in continued use until production of the sand products ends in September 2011. The tailings have fanned out into the quarry from locations both on the south and the north sides of the quarry with tailing thickness ranging from next to nothing in the north to 35m thick in the south. Tailing levels over a large part of the quarry have reached capacity at 193m AOD, however deeper areas of water remain in the north west and south east of the quarry. A neutralising flume channel runs from close to the tunnel entrance to the lagoons northern shore. At the start of the flume acidic water from the production works is mixed with lime to reduce its acidity. No records of its actual acidity have been provided by the quarry. We understand from discussions with the quarry staff the lagoon water has a acidity of around pH 4 when it returns to the production area.

Proposed

Timber lodges are being proposed in the L7 area with a stream and a series of ponds running from the higher ground to the north to a low point close to the tunnel. It is presumed the stream is to have a natural fall and that the water will then be channeled through the tunnel to continue as the proposed stream in Q1E.

Earthworks to develop

At the end of production it may be beneficial to run pumps for a period until the water running out of the lagoon increases to a minimum of pH 6.5 (EU minimum bathing water standard). However, at some stage it will be necessary to start draining the lagoon to allow the tailings to form a dry surface crust. In the past this has taken at least two years to complete. When water flow/pumping is stopped it would be useful to divert spring water away from the lagoon. This could be undertaken by blocking the outfall of the flume and running the spring water in reverse down the flume to the tunnel. The spring water could then be gravity piped to Q1E or Q3 to further neutilise the water.

Currently no capping material for Q2W has been identified other than any surplus from the stockpile on Q2N. As the capping is going to take sometime to complete the use of inert imported fill could be considered. For technical reasons the capping is going to need to be spread out mainly from the south side of the quarry. Therefore the ideal point of starting would be the southern tailings inlet point located off Eves Lane, nearly opposite the quarry entrance. A temporary access point at this location would allow inert fill to be imported and stockpiled, and periodically spread out, before further stockpiling of material is undertaken. The procedures would need to follow similar procedures laid out in the WBB documentation.

Because the tailings at the inlet point area are coarser and have been placed for some time, the capping in this area may be able to start sooner than the two year delay the quarry has used. Having a small starting operation which could build up over 3 possibly 4 years would allow the tailings to be pushed forward in front of the capping, into the low areas currently containing deeper water. Also stockpiling 2m to 3m of material on already capped areas will have the advantage of pre-loading the cap before development takes place.

A further consideration is that during development material will be generated from the site. Although some of the material will be suitable for reuse elsewhere, this material could be added to the stockpile for spreading out as capping and would keep material disposal costs down.

Estimate 214000m^3 of bund material would be required for capping.

Estimated time to complete 3 to 4 year.

Q3
Existing
Q3 was excavated down to 2m above the base of the sandstone at between 140 and 135m AOD in the eastern half of the quarry. This was completed in December 2010 and the quarry pumps were removed.

Currently L8 is filling the east side of the quarry with tailings to about 152m AOD. The bund crossing the quarry has a crest of about 154m AOD. The lagoon continues to be drained at its south west corner. However, when production works closes it is anticipated this pump will also be removed and the ingress of groundwater will bring the lake level somewhere between 156m and 159m AOD. The level depending largely on the seasonal rainfall.

Previous WBB stability checks on the quarry have assumed that provided stability remains above unity then stability is acceptable. However, for the proposed development stability's 20% to 30% above unity will be required. Stability checks in the eastern land bridge area would suggest with a 2m thickness of sandstone floor (which was proposed) and the tailings in place the stability of the land bridge will be adequate. At the western end of the quarry much of the sandstone being excavated has been weakly cemented and consequently if wetted in an unconfined state is likely to degrade. It was noted that the quarry side angles has been significantly reduced on the western end face, but the north and south side faces have been cut as steep as in other sections of the quarry. Angles of 26 degrees at the top increase to 45 and 52 degrees in the lower sections where observed when we inspected the quarry in November 2010.

Initial stability analysis using parameters previously used by WBB show that cohesion is required for the existing quarry slopes to have stability's above unity. Although the analysis shows that filling the quarry with water may initially improve stability, the potential degradation of the sandstone, particularly on the up-dip northern side will make the slopes unstable. Also with rapid draw down of the water in the quarry instability involving the whole slope could occur.

Proposed
It is our current understanding that the development requirement is to provide a lake with shallow (1m to 2m deep water), with a deeper area for deep water diving. Also to have one or more sandy beach. Lodges on stilts of the slopes above the lake are proposed along the northern face of the quarry and a hotel with restaurant /cafe /spa facilities are proposed with a beach area in the south eastern and western ends of the quarry.

Earthworks to develop

Using the overburden spoil from Q2N and the noise bunds from the north and east sides of Q3 a bund could be constructed across the west end of the quarry at or close to where the quarry reduces in width. Compacting this material would help to provide lateral support to both north and south cut slopes. An additional spoil bund could then be placed against the northern quarry wall to protect the remaining bedrock along the central zone between the two bunds where strata dips into the quarry. Some protection of the southern face may also need to be considered. This would leave the central area deep.

Using Option 1 for Q1E tailings could be pumped into the western end of Q3. Water draining from this area would need to be siphoned over the bund and pumped from the existing Q3 base. back to Q1E for further hydration of the tailings together with any groundwater collected. At the same time water from the river would be pumped and drained into Q1E to increase the pH of the water being circulated. This would allow surplus water to continue to drain down Stream D, so allowing the pH of the water in Q1E and Q3 to be kept above 6.5, but at minimum above 5. The result of this action would be to raise the floor of the quarry to around 155m AOD except for the central area which would remain between 135 and 140m AOD.

A further alternative would be to transport the tailings from Q1E by truck, down the existing ramp and along the newly formed bund on the north side of the quarry to its west end. However, the logistic of tipping across the whole of the bunded western area would need to be considered further.

A further action that will need to take place before Q3 is allowed to fill is to create a new outfall. Current predictions is that Q3 will fill with groundwater to 156 to 159m AOD. This fluctuation would form very good beaches, but is unlikely to be a good amenity feature. We would therefore suggest that the outfall to Stream A is reduced to 157m AOD with a low flow outlet set at 156m AOD. This would provide a lake with beaches which increase in size during the dryer/sunnier months which would then be partly covered in wetter periods. Modeling to achieve this feature will need to be undertaken.

As part of the outfall an area of reed pond would need to be constructed in the lake area to provide a water feed to the lower level outfalls. This will particularly be required for the initial period so that the quality of the water outfalling from Q3 to Stream A can be regulated. Prior to the lake reaching the outfall level, the lake waters pH will need to be monitored. If the pH remains low then the lake water will need to be kept below the outfall level by pumping. We would also anticipate the EA will want some controlled water to be drained through Stream A over the outfall before the lake levels over top the outfall Therefore creating a small reed pond in the lake area around the outfall area will need to be considered.

Estimate 157000m^3 of material would be required to infill the west end of Q3 including 7000m^3 of tailings to 155m AOD.

Estimated time to complete 1 to 2 years, dependent of the time to neutralise the lake water.

North of Quarries

Existing
Tip 3 and 4 are made up of material removed from the preparation of Q2. They form 19m and 5m high tips which have become vegetated with trees.

Proposed
Option 1
Remove tips. This would leave two relatively flat areas on which lodges can be built and could have views over the surrounding area. This would have the added advantage of relinquishing up to 125000m^3 of bund or capping materials.

Option 2
Build the proposed lodges in and around the existing tip. This would have the advantage of retaining some of the tree cover.

Earthworks to develop
The amount of earthworks required will be dependent on the option taken. If option 2 was taken then we would suggest the material is removed during the first phase of work as the material would need to be transported through the site.

Estimate up to 125000m^3 of bund material would be available for capping.

Estimated time to complete 6 months to 1 year.

Fields East and West of Quarry
Existing
The two areas to be developed consist of fields and are mainly located on the sandstone outcropping to the east and west of the quarry.

Proposed
Lodges are proposed on the land to the west of Q3, whilst Crowtree Farm lodges are to be of a static trailer type.

Earthworks to develop
Both areas will generate a small amount of soil associated with development.

Production Area
Existing
The production area has remained in the same area since quarrying began.

Proposed
To be confirmed

Earthworks to develop
The substructures are substantial and where not required will need to be broken out. The concrete product could be crushed into Class 6F2 or Type 1 and stockpiled for later development.

In removing substructures in the production area consideration will need to be given to how surface water flows through the area is to occur, and whether some of the existing channels will need to remain. Consideration might also need to be given to the final levels the area is left, following demolition. Consideration should be given to the production areas levels being reduced so that the amount of material required to infill holes left by substructures can be reduced. The level to be adopted might be best determined by having all crushed product stockpiled separately, then regrading the remaining material to a lower level, but maintaining a gradient to the south, to allow natural surface run-off to occur.

Southern Adventure Park

Existing
Woodland on old tipped areas sloping down to the river.

Proposed
This woodland area, together with the production area is going to need further consideration once development proposals are better known. At this stage it is envisaged only limit spoil will be generated from these areas.

Of greatest concern in this area is the dam retaining the tailings forming L3. The quarry's record show that the dam has been close to failure in the past. Further assessment and consideration will be required before the lagoon area and the valley below the dam is developed.

APPENDIX E

Foundations on Tailing Lagoon Areas

APPENDIX E

Foundations on Tailing Lagoon Areas

Preparing the lagoons for capping

In depositing the tailings in lagoons a considerable amount of water is entrapped between the sand, silt and clay sized particles. With time and drainage of the surface water, the groundwater will drain from the tailings initially forming a dry crust at the surface, but with time drying out the underlying infill down to the level of the standing water. Below standing water level, natural dewatering will continue, albeit slower, as the weight of the ground above squeezes the water out.

The quarrymen have found the initial drying out process takes about 2 years before the surface is strong enough to allow a capping layer to be spread out. It may be possible to speed the draining and stiffening process if the surface run-off from other areas is diverted and where practical is efficiently removed from the lagoon surface. Installing artificial drainage is not likely to be practical until after the cap has been installed. There is also the significant installation costs if large areas are to be artificially drained.

Capping in the past has been undertaken by pushing out about a 2m thickness of dry waste product over the tailing lagoon. Initially the material is stockpiled at the edge of the quarry and then the material is bulldozed out onto the desiccated surface of the tailings. As discussed in previous reports care needs to be taken for heavy plant not to go too close to the edge of the capping front, in case they sink into the tailings. As the capping is placed the tailings will tend to rise like a wave infront of the capping front. Where there are hollows in the tailing surface the wave effect can be used to help infill. However, if capping is undertaken too quickly or too early the capping fill will sink and displace the underlying tailings, so preventing further progress in that area of the capping front until water pressures have dissipated.

Consideration also needs to be given as to where capping is started, and progressed. If in Lagoon 7 the capping was to be started at the shallower north end, tailings could be forced over the bunds at the southern end. Therefore capping from the south is recommended, with the cap not being pushed out in other areas until at least a 1/3 across the lagoon, from areas where tailings could potentially rise and overtop the quarry face. Similarly, the cap should be pushed out from the eastern side before the capping front reaches the eastern side of the lagoon retained by bunding. As with the existing capped areas capping generally is extended from the edges into the centre of the lagoon in stages.

Until the tailings have been confined they can still continue to move. Therefore, until capping has been completed over the whole lagoon area no development of any part of the lagoon area can take place. The cap is placed both to confine the tailings and allow loads to be spread. However, because of the high moisture contents in the tailings (particularly close to the surface) settlement both from increased bearing loads and creep movement can be significantly large for some years following capping. The amount of settlement is dictated by the proportional increase in load being applied, depth of tailings and the tailings moisture content over and above its plastic limit.

With time the moisture will be squeezed out of the tailings and the levels of movement will reduce.

In 1981 several boreholes and associated laboratory testing were carried out on the lagoon tailings in Q1E an reported in *Reference 51*. At that time the tailings were being capped, having previously been allowed to dry out for about two years. Vane shear strength recorded strengths of less than 5kN/m^2 were recorded just below the cap, increasing to 20 to 40kN/m^2 at the quarry base at 13.5m bgl. See Fig 6. These low strengths are consistent with the high moisture contents and will have resulted in significant self weight creep settlement over intervening period. See Fig 5.

Q1W and Q2E have subsequently been capped, whilst Q2W remains an active lagoon and Q1E since 1981 has been further over tipped and an estimated 4m of tailings pumped over the original cap.

Proposed Development

The current proposals for development on former lagoon areas of Q1E, Q2E and Q2W are lodge developments. There is also some lodge development on raised ground in Q2E which quarry records suggest is on a terrace of either rock or quarry bund material. Each area will have their own pattern of settlement related to the tailing depth, historic loading and retained moisture. To date, no additional investigation and testing has been identified on the remaining lagoons.

At this stage only an overall assessment of the method of founding for the lodges can be provided. It has been assumed that no lodges are going to be placed within 15m of any quarry high wall. Before development proceeds further investigation and associated testing will need to be undertaken to determine the future levels of movement that might be expected, and to determine whether the existing capping thickness is sufficient for the development proposed.

Using the 1981 investigation results from Q1E the condition of the tailings can be better understood shortly after the capping has been placed. Where the capping has been in place for some time (Q2W and L3) or where the capping and tailings have been over-tipped (Q1E) it is not unreasonable to anticipate that the tailing moisture contents have reduced and consequently their strength have increased. On these caps the early stages of settlement will have occurred and differential settlement might be expected to be less server. However, continued settlement from both creep and bearing pressure increase remain significant and will require the ability for supports to the lodges to be adjusted from time to time. Also there will be the need for services entering lodges and crossing the quarry highwalls to accommodate differential movement.

We understand that single and twin static lodges are to be used in these areas. As examples the Willerby, Vogue Connoisseur and New England Lodge range have been considered. The 13m x 4m and 13m x 6m footprints require a hardstanding or concrete base on which supports are placed at strategic locations under the lodge frame. Lodge delivery weights are in the order of 18kN/m^2, which with live loads might be expected to increase to between 25 to 30kN/m^2. There are various methods of estimating settlement resulting from bearing loads. Assuming loads are spread by a foundation slab under the lodge footprint and 0.5m of compacted fill the following range of settlements have been calculated.

Table D1	Settlement (mm)	
Bearing Pressure	Vogue	New England
kN/m2	4m x 13m	6m x 13m
15	9 to 11	14 to 21
30	15 to 19	19 to 29
50	31 to 38	36 to 59
75	47 to 57	54 to 98
Note:-	Settlement (mm)	

Additional to the above settlements which would be anticipated to have occurred in the first few months, creep settlement will continue over the life time of the lodge.

To limit the amount of bearing settlement and differential movement a number of actions can be taken.

Below the required founding slab one or possibly two Geo-Grid layers can be placed to stiffen the regulatory layer. This should be extended at least 1m beyond the lodge footprint and the footprint should include any areas proposed for raised decking etc.

Where the tailings have recently been capped or greater loadings are being proposed then installing sandwicks into the tailing material can be considered. The wicks would increase the flow of groundwater out of the tailings and consequently cause settlement to occur sooner. This works well with pre-loading, and particularly well in the shallower depth of tailings where existing moisture contents are highest, yet exist above the local groundwater table.

Pre-loading can take many forms. At its simplest a stockpile of spoil can be placed over the area required for pre-loading. Loaded containers such as skips can be used to assist the movement of the load from one area to another. Placing a greater load causes settlement to occur before the final structure is placed. The time the pre-load is required to be in place is proportional to the additional load that is applied and the reduction in settlement required.

Next to streams and water courses additional provisions will need to be made which will depend on future test results and site profiles.

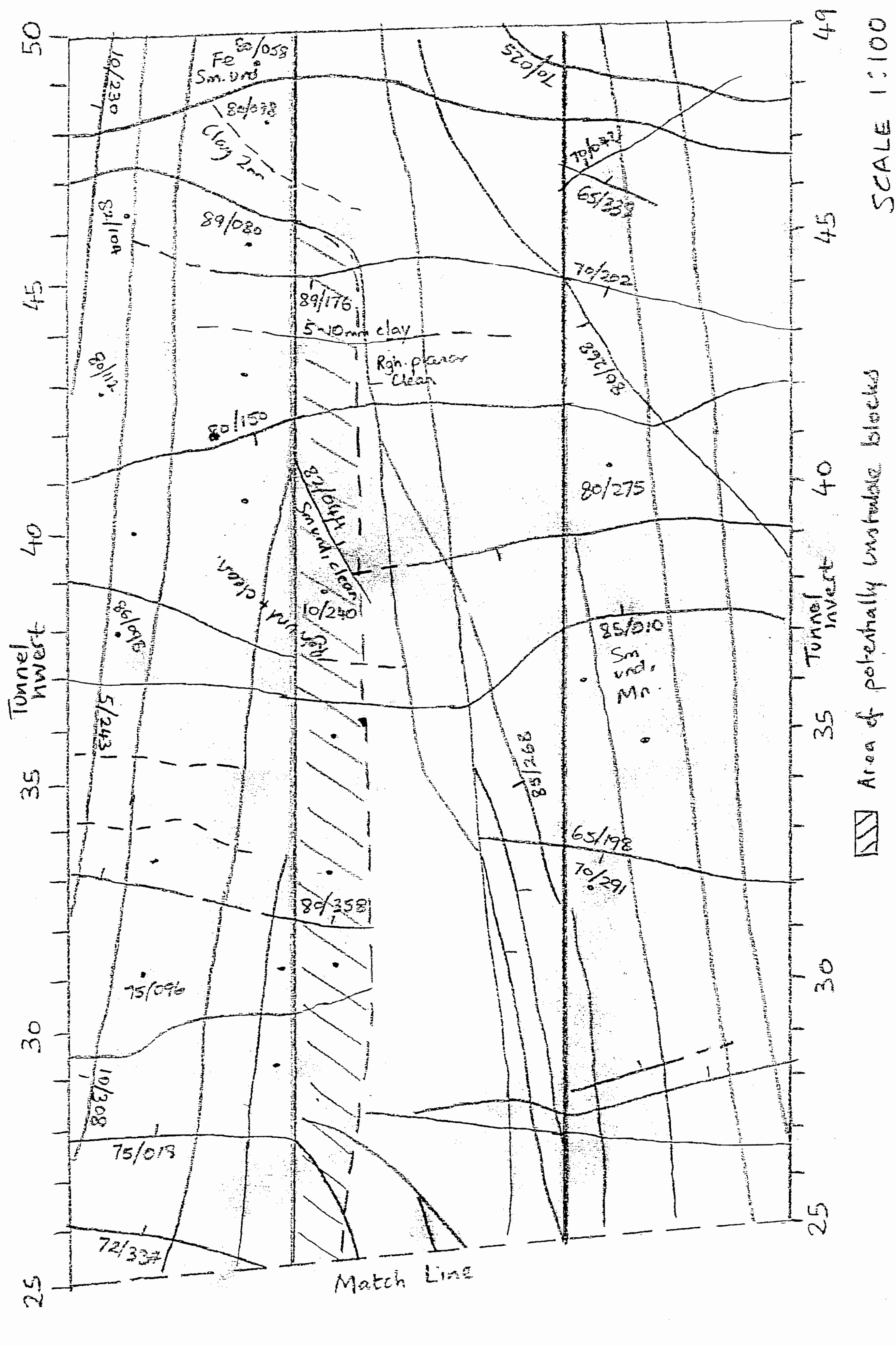
Separate assessments will need to be made for lodges close to the quarry high walls.

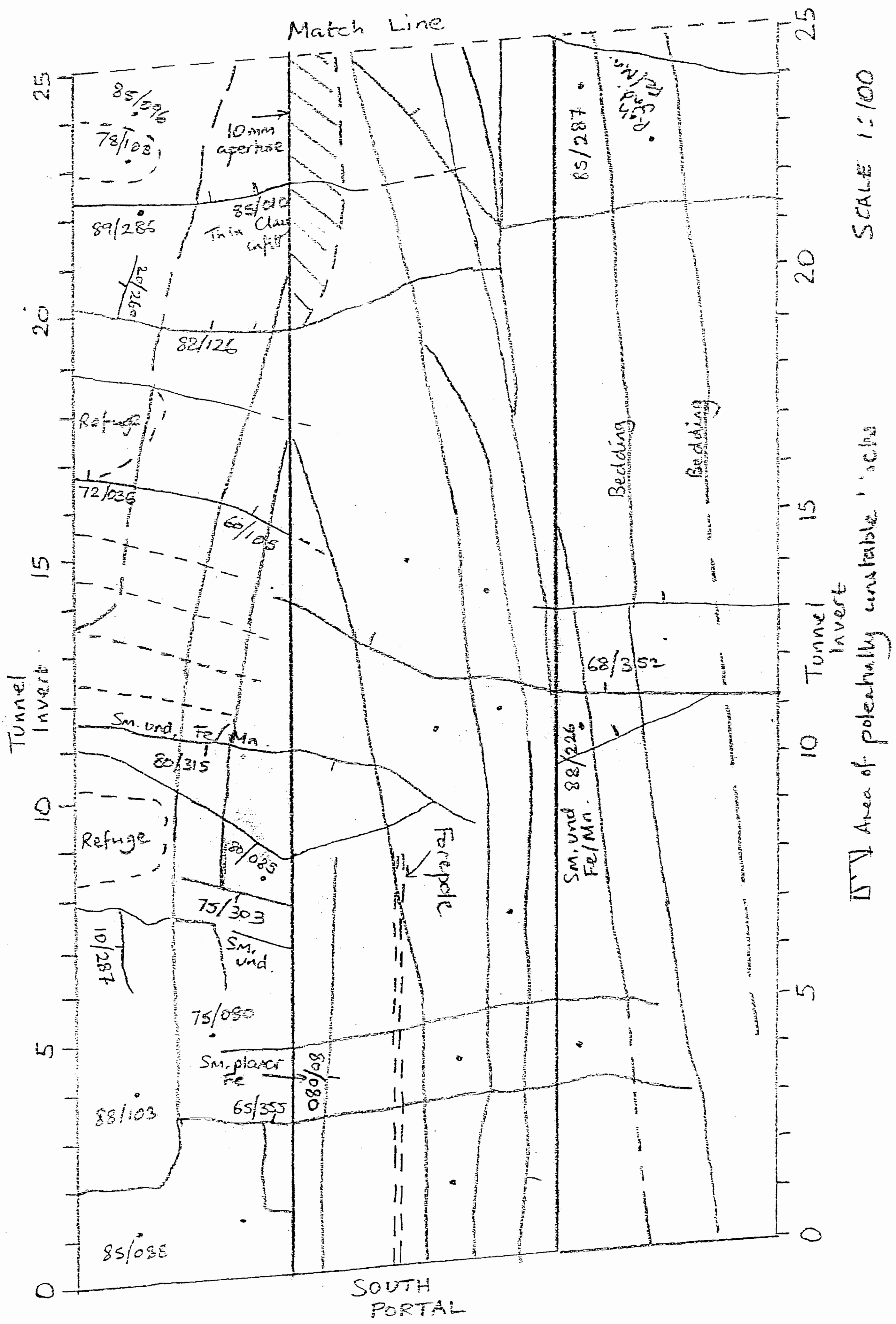
APPENDIX F

PREVIOUS REPORT ASSESSMENTS

Reference 4.
Tunnel Assessment.

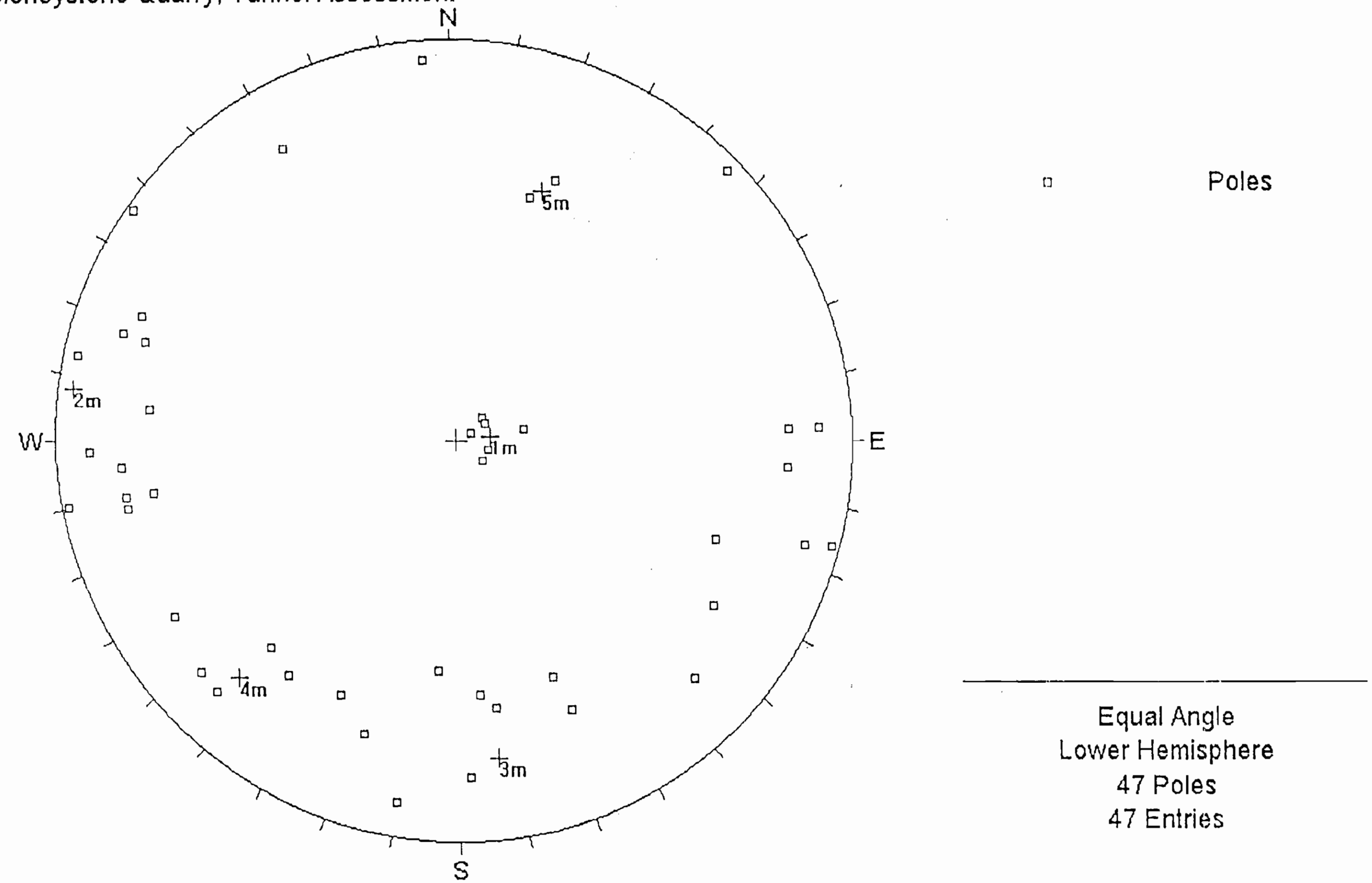
NORTH PORTAL





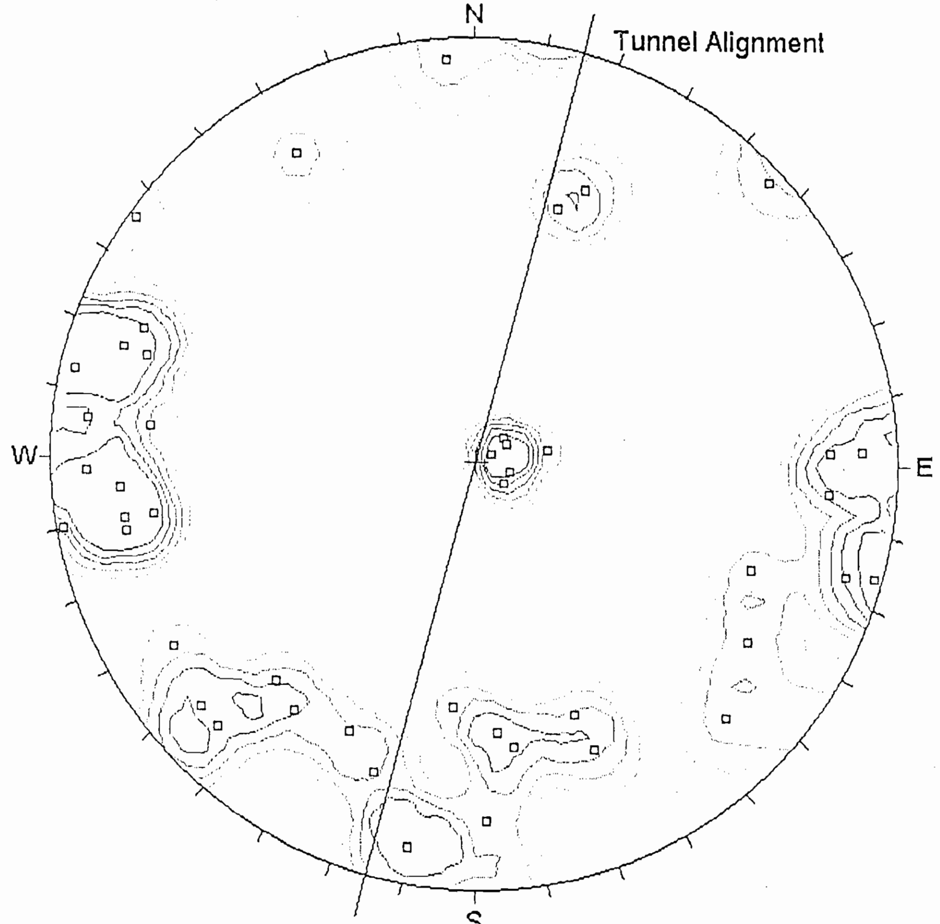
Match Line
SOUTH PORTAL
SCALE 1:100
Area of potentially unstable rocks
Tunnel Invert
Tunnel Invert
Refuge
Refuge
Bedding
Bedding
Fire pole
10mm aperture
Thin Clay infill
Sm. und. Fe/Mn.
Sm. und 88/226 Fe/Mn.
Sm. und.
Sm. planar Fe
85/296
78/102
89/285
85/010
20/260
88/126
72/036
60/105
80/315
88/085
75/303
10/287
75/080
080/08
65/355
88/103
85/038
85/287
68/352
0
5
10
15
20
25

Moneystone Quarry, Tunnel Assessment



Sibelco Minerals and Chemicals

Moneystone Quarry, Tunnel Assessment□



Sibelco Minerals and Chemicals

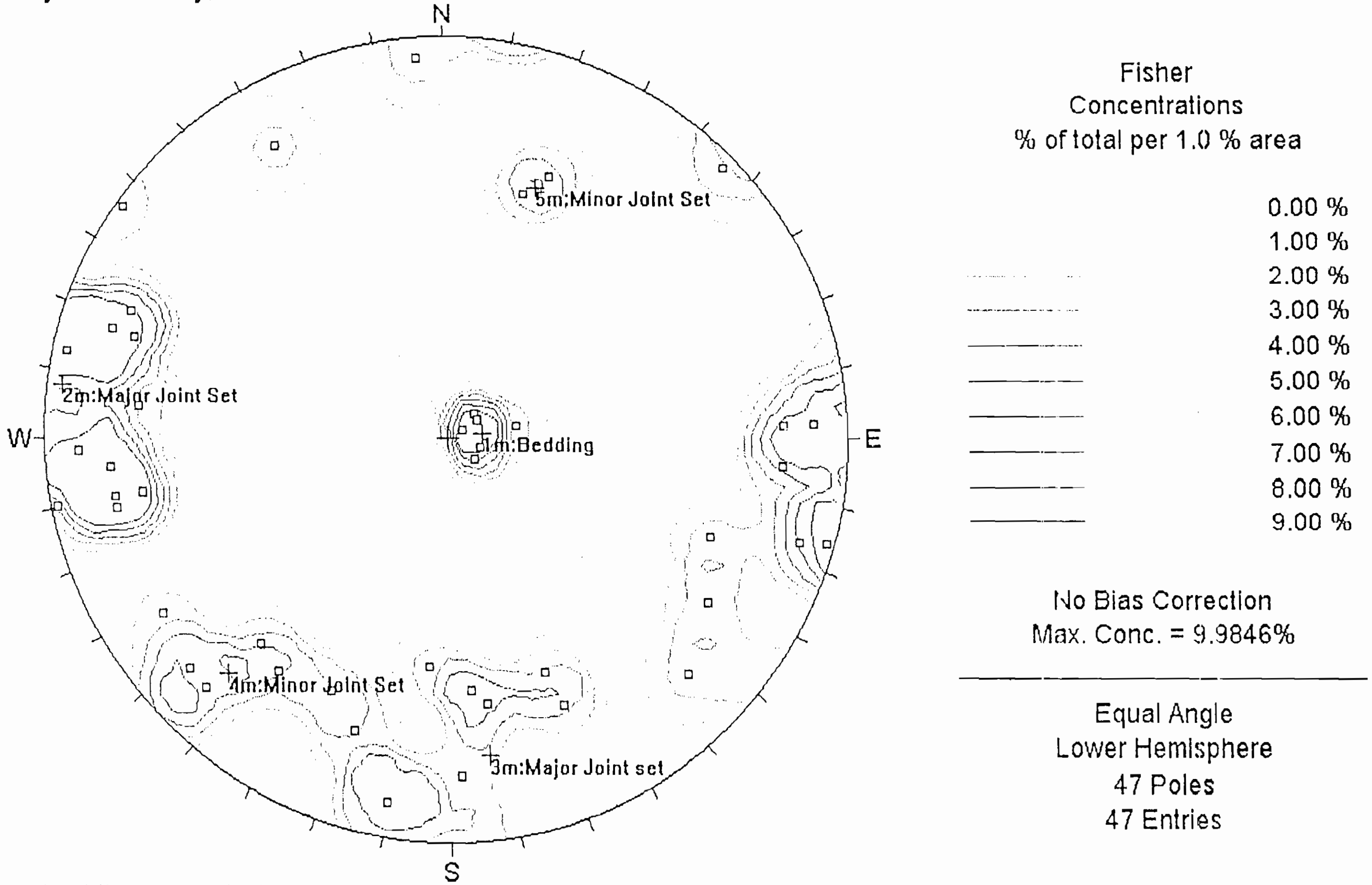
Fisher
Concentrations
% of total per 1.0 % area

0.00 %
1.00 %
2.00 %
3.00 %
4.00 %
5.00 %
6.00 %
7.00 %
8.00 %
9.00 %

No Bias Correction
Max. Conc. = 9.9846%

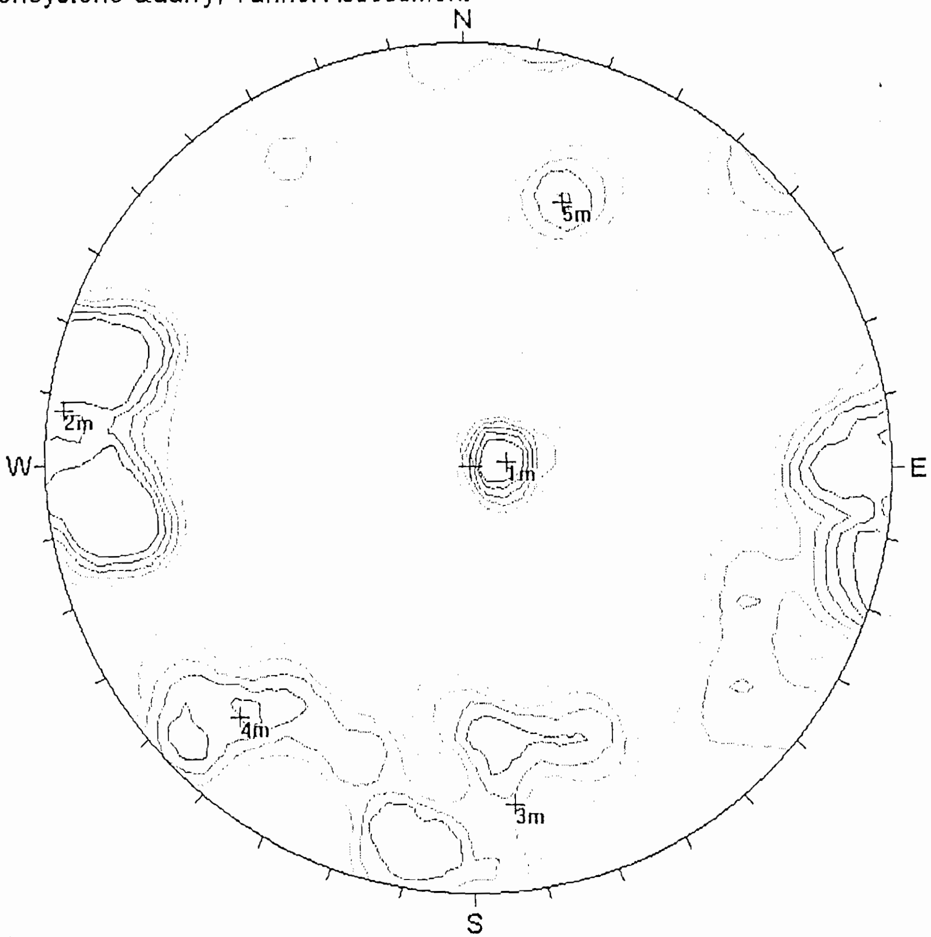
Equal Angle
Lower Hemisphere
47 Poles
47 Entries

Moneystone Quarry, Tunnel Assessment



Sibelco Minerals and Chemicals

Moneystone Quarry, Tunnel Assessment



Sibelco Minerals and Chemicals

Orientations

ID		Dip / Direction
1	m	010 / 262
1	w	010 / 262
2	m	088 / 98
2	w	088 / 98
3	m	077 / 353
3	w	077 / 353
4	m	078 / 43
4	w	078 / 43
5	m	067 / 200
5	w	067 / 200

Equal Angle
Lower Hemisphere
47 Poles
47 Entries