



***ENVIRONMENTAL
MANAGEMENT PLAN –
CONDITION 4-1, MS.521
REVISED NOVEMBER 2016***

SHIRE OF DENMARK

OCEAN BEACH LIMESAND QUARRY, DENMARK

11 May 2017

Ministerial Statement 521

EXECUTIVE SUMMARY

In June 1998, the Shire of Denmark (SoD) submitted a Consultative Environmental Review (CER) to the Environmental Protection Authority (EPA) for assessment to continue and expand an existing limesand quarrying project located within A Class Reserve 24913 vested in the Shire of Denmark.

On 30 August 1999, the Minister for the Environment issued a “Statement that a Proposal may be Implemented” - No. 521.

Condition 4-1 of MS521 required the proponent (SoD) to “*demonstrate to the requirements of the Environmental Protection Authority on advice of the Department of Environmental Protection, the Department of Conservation and Land management and the Department of Minerals and Energy that there is in place an Environmental Management Plan which includes....*”.

In November 1999, the SoD submitted an Environmental Management Plan (EMP) to the EPA which was prepared by the Denmark Conservation Society Inc for the SoD. The EMP was approved by the EPA on 17 March 2001 for Stage 1 (historic quarry) only, with additional information relating to Stage 2 required prior to the commencement of Stage 2.

Condition 4-2 of MS521 states: “*The proponent shall implement the Environmental Management Plan referred to in Condition 4-1*”.

This revised and updated EMP is submitted as requested by the Office of the EPA (OEPA) in a letter dated 31st August 2016.

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APPENDICES

Appendix 1: Letter dated 1st December 2016 from DPaW concurring with request from SoD to remove 202 individuals of P4 species, *Thomasia quercifolia*, with removal of the buffer zone and incorporation of the zone into the future mining envelope

Appendix 2: Wall Stability Geotechnical Study (Infra Tech Consulting Pty Ltd (2016))

ACRONYMS USED IN THIS DOCUMENT

| | |
|----------------|--|
| ASMP | Aboriginal Sites Management Plan |
| CAR | Compliance Audit Report |
| CER | Consultative Environmental Review |
| DAA | Department of Aboriginal Affairs |
| DCS | Denmark Conservation Society |
| DEC | Denmark Environment Centre |
| DER | Department of Environment Regulation |
| DIM | District Inspector of Mines (DMP) |
| DMP | Department of Mines & Petroleum |
| DoL | Department of Lands |
| DPaW | Department of Parks & Wildlife |
| EMP | Environmental Management Plan |
| EPA | Environmental Protection Authority |
| ha | hectare |
| ha/yr | hectare per year |
| km/hr | kilometres per hour |
| m | metre |
| mASL | metres above sea level |
| mm | millimetre |
| m ³ | cubic metre |
| MCP | Mine Closure Plan |
| MS521 | (Environment) Ministerial Statement 521 |
| OBQL | Ocean Beach Limesand Quarry |
| OEPA | Office of the Environmental Protection Authority |
| P1, P2, P4 | Priority 1, 2, 4 flora species |
| PCR | Performance and Compliance Report |
| RPR | Rehabilitation Performance Review |
| SoD | Shire of Denmark |
| t | tonnes |
| tpa, t/a, tpy | tonnes per annum |

1 SUMMARY

This Environmental Management Plan (EMP) is submitted in accordance with **Ministerial Statement No.521 Condition 4-1** for the Ocean Beach Limesand Quarry by the Shire of Denmark.

The table below presents the environmental management target/s to measure achievement of the conditioned environmental objective that must be met through implementation of this EMP.

| | |
|--|---|
| Title of proposal | Continuation of Limesand Mining, Ocean Beach Quarry, Portion of Reserve A24913, Ocean Beach Road, Denmark |
| Proponent | Shire of Denmark |
| Ministerial Statement number | 521 |
| Purpose of this Condition EMP | This Environmental Management Plan is submitted to fulfill the requirements of condition 4-1 of the above Statement |
| EPA's environmental objective for the key environmental factor/s | To maintain the representation, diversity, viability and ecological function at the species, population and community levels. |
| Condition environmental objective | Submission, Approval for and Implementation of the EMP |
| Management target/s (<i>measurable, proposal-specific</i>) | Nil |

Corporate endorsement

I hereby certify that to the best of my knowledge, the Condition EMP provisions within this Environmental Management Plan are true and correct and address the legal requirements of condition 4-1 of Ministerial Statement No. 521

[Signature of duly authorised proponent representative]

Name: Gilbert Arlandoo

Signed: 

Designation: Director of Infrastructure Services

Date: 11 May 2017

2 CONTEXT, SCOPE AND RATIONALE

2.1 Background

In June 1998, the Shire of Denmark (SoD) submitted a Consultative Environmental Review (CER) to the Environmental Protection Authority (EPA) for assessment to continue and expand an existing limesand quarrying project located within A Class Reserve 24913 vested in the Shire of Denmark.

On 30 August 1999, the Minister for the Environment issued a “Statement that a Proposal may be Implemented” - No. 521.

Condition 4-1 of MS521 required the proponent (SoD) to *“demonstrate to the requirements of the Environmental Protection Authority on advice of the Department of Environmental Protection, the Department of Conservation and Land management and the Department of Minerals and Energy that there is in place an Environmental Management Plan which includes....”*.

In November 1999, the SoD submitted an Environmental Management Plan (EMP) to the EPA which was prepared by the Denmark Conservation Society Inc (DCS) for the SoD. The EMP was approved by the EPA on 17 March 2001 for Stage 1 only with additional information relating to stage 2 required prior to the commencement of Stage 2.

Condition 4-2 of MS521 states: *“The proponent shall implement the Environmental Management Plan referred to in Condition 4-1”*.

In a letter dated 31 August 2016, the Office of the Environmental Protection Authority (OEPA) advised that a Compliance Audit Report (CAR) had been completed for the limesand quarry project and that two implementation elements were identified as non-compliant and nine implementation elements were identified as requiring clarification. The information requested in the CAR is required to be submitted to the OEPA by 30th November 2016.

In the CAR under the section “Verification Required”, the OEPA states in relation to MS521:M4-2:

“The Environmental Management Plan (EMP) was approved 17 March 2001 for Stage 1 only with additional information relating to Stage 2 required prior to commencement of Stage 2. The Office of the Environmental Protection Authority (OEPA) notes that the SoD submitted a request proposing to amend the EMP in October 2014 to remove a buffer zone around a priority 4 species. The OEPA advised the SoD to submit an updated EMP with the requested changes for review. No updated EMP was provided to the OEPA for approval prior to the commencement of Stage 2 operations which commenced in 2015 as indicated in the 2016 PCR.

Please provide an updated EMP meeting the requirements of Condition 4-1 and covering the remaining Stage 1 requirements and the Stage 2 operations. The SoD should also include the proposed changes to the management of the priority 4 species with justification for the changes along with advice from the Department of Parks and Wildlife. Any proposed changes to the EMP must be approved prior to any changes being implemented.”

On 1st September 2016, the OEPA issued a notification of non-compliance to the SoD relating to Conditions 1-1 and 4-2 of MS521 and required a response by 30 November 2016 from the SoD to assist resolution of the non-compliances. The matters raised in the notification of non-compliance were the subject of a separate submission by SoD to the OEPA. The SoD received notification from the OEPA on 11 January 2017 that the OEPA considers the non-compliances to be resolved.

This revised EMP is submitted to satisfy the verification required by the OEPA in their letter dated 31 August 2016 and outline the mining program for the Stage 2 operations.

2.2 The Proposal

The commencement date of mining operations at the Ocean Beach Limesand Quarry is unknown but occurred prior to 1998. The quarry is now mined on behalf of the SoD to remove a limesand resource based on a regolith of limesand and limestone mineralisation derived from dunes of aeolianite, of a wind generated and lithified origin. The limesand from the quarry is used in the agricultural industries to ameliorate soil acidification.

Mining of the whole proposal area was approved by the Minister with a condition requiring submission of an EMP for Stage 2 prior to commencement of Stage 2 operations.

Stage 1 operations covered mining of an area of existing cleared land and rehabilitation of the existing (original) quarry with Stage 2 covering the expansion into the uncleared areas of the Mining Lease (M70/1038).

The Stage 2 operations included an area excluded from mining and a buffer zone around a Priority 4 flora *Thomasia quercifolia*. At the time of submission of the original CER (1998) and EMP (1999), the species was a Priority 2 species.

In general, the mining operations occur between the months of November to March by contractors selected by the SoD under a tendering process. Approximately, 15,000 tpa is mined and removed from the quarry.

The quarry is accessed from Ocean Beach Road which is a two lane bitumen road south of Denmark Township and then via a 400 m unsealed road (southwards) to the quarry (Figure 1).

The Stage 1 (1.357 ha) and the historical quarry (1.977 ha) plus the internal road and the pit surrounds encompass a total disturbance area of 3.595 ha. Mining in these areas has been completed and they are undergoing rehabilitation work programs.

The proposed Stage 2 mining area (including the existing disturbance) involves disturbing a total area of approximately 5.28 ha (Figure 2). However, as disclosed in the Performance and Compliance Report (PCR) dated December 2010-May 2016 prepared by the SoD, it discloses that Stage 2 encompasses two Sub-Stages, Stage 2a which encroaches within the Priority 4 species buffer zone and Sub-Stage 2, the remainder of the proposed Stage 2 area.

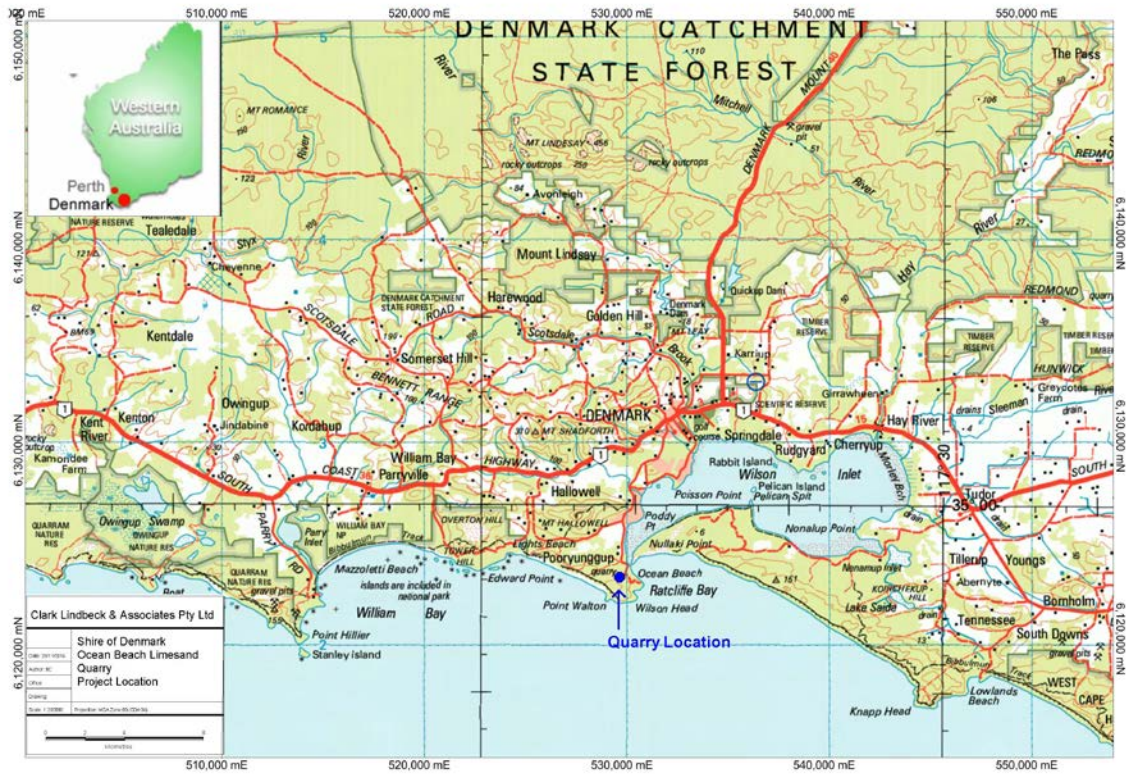


Figure 1: Location of Ocean Beach Limesand Quarry

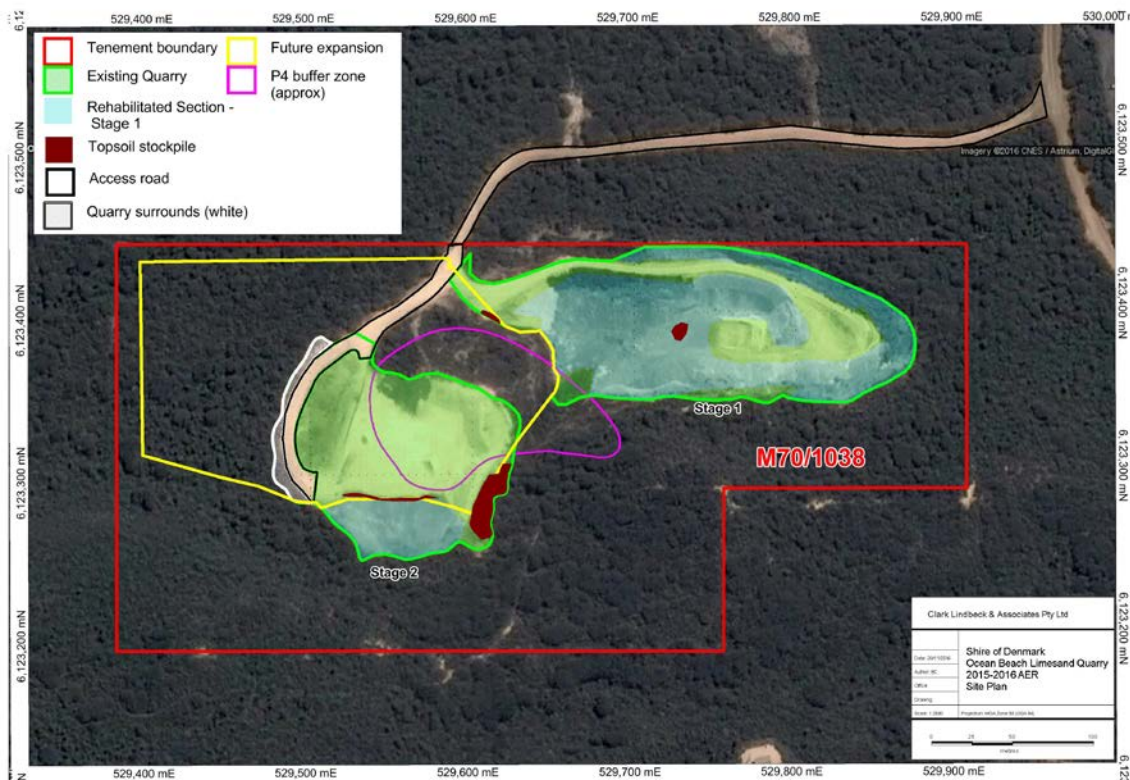


Figure 2: Existing Disturbance at Ocean Beach Limesand Quarry

Letter submissions for approval to vary the original EMP (Denmark Environment Centre – (DEC) 1999) to remove the buffer zone and destroy the now P4 species *Thomasia quercifolia* were forwarded in October 2014 to the Department of Lands (DoL), the EPA and the DMP.

The response dated 16 October 2014 received from the DoL advised that concurrence could not be given by the DoL until the EPA and the DMP had provided their concurrence in the first instance.

On 29th November 2014, the OEPA gave approval to SoD for the limesand mining to continue in the buffer zone, which is included in the approved area of disturbance of 12 ha. In addition, the OEPA noted that Schedule 1 and Figure 2 in MS521 were, basically, out of date and advised the SoD to submit a “Request to change proposal – Ministerial Statement 521” with a submission date of 27 February 2015. It is understood that no submission as requested by the OEPA was forwarded by SoD.

On 11th May 2015, the DMP rejected the application and refused to grant approval because additional information requested by 18th December 2014 (to be provided by SoD) was not received by DMP.

However, it should be noted that continuation of mining in the buffer zone could not go ahead, even though OEPA approval had been received, as a Mining Proposal had not been submitted to the DMP for assessment and subsequently, approval given by DMP.

On 1st December 2016, DPaW granted their approval for 202 individuals of the P4 species located in the buffer zone to be destroyed/removed and their concurrence that the buffer zone could be removed and incorporated into the future mining envelope (Appendix 1).

2.3 Key Characteristics Table

SoD is committed to adhering to the approved Key Proposal Characteristics Table contained in Schedule 1 of MS521.

2.4 Key Environmental Factors Addressed in this EMP

This EMP specifically addresses the Landform, Flora and Vegetation environmental factors, which are part of the overall Land theme, Hydrological Processes environmental factor which is part of the Water theme, and Amenity, Heritage and Human Health environmental factors, which are part of the overall People theme (derived from EPA 2015).

2.4.1 Vegetation

The vegetation communities (Coastal heath and Coastal limestone heath) are common in the area surrounding the quarry and along the southern coast.

The adjacent Reserve A24913 from which the Mining Reserve was excised encompasses an area of 554 ha. The proposed quarrying of M70/1038 (11.625 ha) is expected not to exceed an area of 6 ha on this lease.

Consequently, the vegetation communities represented in the Reserve will not be significantly reduced in area.

2.4.2 Flora

In the original OEPA Bulletin (No. 942), particular attention was paid to protection of the Priority 4 species, *Thomasia quercifolia* (in 1999 a P2 species). SoD committed to retention and protection of a buffer zone around the species.

There are no other Priority or DRF species identified to date on this site.

Disturbance in 2015 encroached into the buffer zone. SoD is of the belief that none or only a few P4 species may have been removed during this disturbance activity.

A targeted survey for this species was undertaken in September 2016 on the lease and the 35 ha of the surrounding Reserve on Wilson Head (Rathbone 2016). Over 4,000 individuals were identified on Wilson Head.

An application was forwarded to DPaW for approval to remove 202 individuals of this species from the buffer zone and removal of the buffer zone. This approval was granted by DPaW on 1st December 2016 (Appendix 1).

2.4.3 Landforms and Reducing Visual Impact

The revegetation of the top of the pit walls has been completed during the winter season in 1999. Seeds were collected from the reserve and sown. In doing so, good germination has been obtained as a result of the process. Furthermore, infill plantings have also continued as new species have been propagating to aid biodiversity.

The screening of the vegetation on the northern lip of the former quarry has been implemented through the establishment of a soil bund which is planted with a dense planting of *Agonis flexuosa* tube stock in the winter season in year 2000. The growth of the *Agonis flexuosa* tube stock has been successful in screening the southern rim from Ocean Beach Road that has been well established.

In terms of the construction of benches on areas of steeper batters, the area of the slope in the south west was planted and directly seeded in 2000. This area refers to the area directly below the buffer zone of *Thomasia quercifolia* which was fenced off. Benches were not required at this area as the slope was approximately 45° and some topsoil was present on the surface. In 2002, brush was installed in the planted area at the request of the Denmark Conservation Council. Planting of additional species and direct seeding has also been undertaken at this area.

In relation to the seedlings planted into the eroded pockets of the wall, the Shire has attempted this program of seedlings, brush laying and direct seeding between 1999 to 2004. The process has had a mix of success and failure. It was successfully implemented on slopes angled at 45°. Some plants have established through direct seeding but the lack of top soil and the rocky nature of the slope has not impeded the required growth of the vegetation. Brushing has not stayed in place and is noted to be of little value as the faces of the slopes are not prone to wind erosion.

Areas at the base of the extreme slopes of approximately 60° have been planted with the cuttings from *Pelargonium capitatum*. Due to the lack of topsoil, the planting process has been a mixed success. To remediate the growth, direct seeding of *Ficinia nodosa* has been introduced along the slopes as additional cover to the affected areas of the slope.

2.4.4 Groundwater Quality

In drilling programs undertaken to depths of 30 m, no groundwater was encountered. It is believed that the groundwater is approximately 3-5 mASL and the lowest point of the quarry is around 30 mASL.

There has been no rainfall runoff retained in the quarry floor as the material is highly porous.

In addition, there have not been any known spills of hydrocarbons at this site.

2.4.5 Road Transport

All road transport of product by contractors or farmers is restricted to the hours of operation as set down in the CER and the EMP.

2.4.6 Public Health and Safety

To ensure the safety of the public with the operations of the OBLQ, fencing has been installed to prohibit access. A locked gate is maintained at the entrance to the site and signs are installed at the main entrance gate and at intervals along the fence.

In addition, some of the quarry walls have been made safe by weighting the toe with spoil and installing bunds which inhibit access.

2.4.7 Aboriginal Culture and Heritage

A recent survey in November 2016 by members (elders) of the local Aboriginal community did not identify any Aboriginal archaeological materials or any heritage sites. An Aboriginal Sites Management Plan (ASMP) for protection and management of any sites that may be identified in the future was prepared by the SoD and provided to the OEPA on 30 November 2016 and to the DAA on 7 December 2016. No response has been received to date from the DAA. On 10 March 2017, the OEPA advised SoD that the ASMP satisfied the requirements of Condition 6-1.

2.5 Requirements of the condition

Specifically, this EMP is submitted in accordance with Ministerial Statement 521, Condition 4-1 for the Ocean Beach Limesand Quarry Project. The requirements of this condition are addressed in the following sections of the EMP:

Condition 4-1 of MS521 states:

4-1 In order to manage the environmental impacts of the project, and to fulfil the requirements of the conditions and procedures in this statement, prior to ground-disturbing activity, the proponent shall demonstrate to the requirements of the Environmental Protection Authority on advice of the Department of Environmental Protection, the Department of Conservation and Land management and the Department of Minerals and Energy that there is in place an Environmental Management Plan which includes the following elements:

(1) Rehabilitation management to address the rehabilitation of various areas of the quarry as they are scheduled for mining, and which contains:

- 1. a schedule of the work to be carried out progressively, including location maps for the various elements of the Plan;*

2. *re-contouring schedules and diagrams;*
3. *topsoil management – its location, schedules for stockpiling and timely redistribution to ensure seed viability;*
4. *strategies to improve visual amenity;*
5. *species of native vegetation to be used in replanting and supplementary seeding;*
6. *weed and rabbit controls to be imposed;*
7. *type and frequency of monitoring for the rehabilitation;*
8. *completion criteria for the rehabilitation; and*
9. *a process for review of the Environmental Management Plan;*

and

(2) Parks and Recreation Reserve management to protect environmental values of the surrounding Parks and Recreation Reserve from quarry impacts, including:

1. *methods to control human and vehicular access from the quarry areas to environmentally sensitive portions of the Parks and recreation Reserve; and*
2. *minimisation of the impacts of quarrying activities on native fauna in the adjacent reserve.*

To comply with Condition 4-2, the SoD commissioned the Denmark Conservation Society Inc to prepare an EMP (DCS 1999). This EMP was approved by the EPA on 17th March 2001.

On 31 August 2016, the OEPA, following a compliance audit of the project, requested the SoD to submit a revised EMP by 30 November 2016. This revised EMP is submitted to fulfil that requirement of the OEPA.

2.6 Rationale and approach in meeting the Environmental Objective

The OEPA's objective is to maintain the representation, diversity, viability and ecological function at the species, population and community levels

2.6.1 Results of (baseline surveys/modelling/scientific studies/tests) conducted

The various surveys have indicated that the vegetation communities are not under threat and occur throughout the coastal region. In addition, the P4 species, *Thomasia quercifolia*, has shown to be more widespread in large numbers.

DPaW has now approved removal of 202 individuals of the P4 species from the buffer zone.

2.6.2 Key assumptions and uncertainties

The main assumptions are that the quarrying operation will be managed in an environmentally acceptable manner as set down in the assessment documents and this EMP.

2.6.3 Management approach

The body of scientific information has indicated that the intensity of the environmental factors identified in 1999 have reduced somewhat since that time.

However, the SoD is committed to operate the OBLQ as set out in these revised documents presented to the OEPA and the DMP.

2.6.4 Rationale for choice of management target/s

The assessment of the relevant environmental factors has resulted in the following targets:

1. No establishment of new weeds and no increase in extent of existing weeds
2. No clearing beyond that approved under the CER
3. Protection of the P4 species outside the quarry disturbance area within the mining lease
4. Nil to no decrease in visual amenity caused by the quarrying operation
5. Continuation of no adverse impacts on surface or groundwater.
6. Rehabilitation of the disturbed areas to a level that equals adjacent analogue sites.
7. Closure of the site that is stable, safe, non-polluting and not a long term liability to the State of Western Australia.

3 REHABILITATION MANAGEMENT

3.1 Historical and Recent Schedules of Work

The original EMP (DCS 1999) comprised two stages:

- (1) Stage 1 – mining of the limesand resource on an area of land already cleared at the time (1998-1999) adjacent to the historical mining area (to the east) which had probably had material extracted over the preceding 40 years. This mining area covered approximately 1.97 ha. No new clearing was undertaken in Stage 1.
- (2) Stage 2 – mining of the remaining areas of the lease up to a maximum of 12 ha, but excluding a buffer zone around a population of the then P2 species *Thomasia quercifolia* (now reduced in Priority rating to a P4 species).

Stage 1 mining has been completed and rehabilitation commenced (SoD 2016a; 2016b). Rehabilitation work has also commenced on some walls of the Stage 2 quarry (SoD 2016a; 2016b; 2016c).

Figure 3 shows the current areas of disturbance at Ocean Beach Limesand Quarry and the approximate dates for mining of the areas along with them showing areas having rehabilitation earthworks completed or in progress.

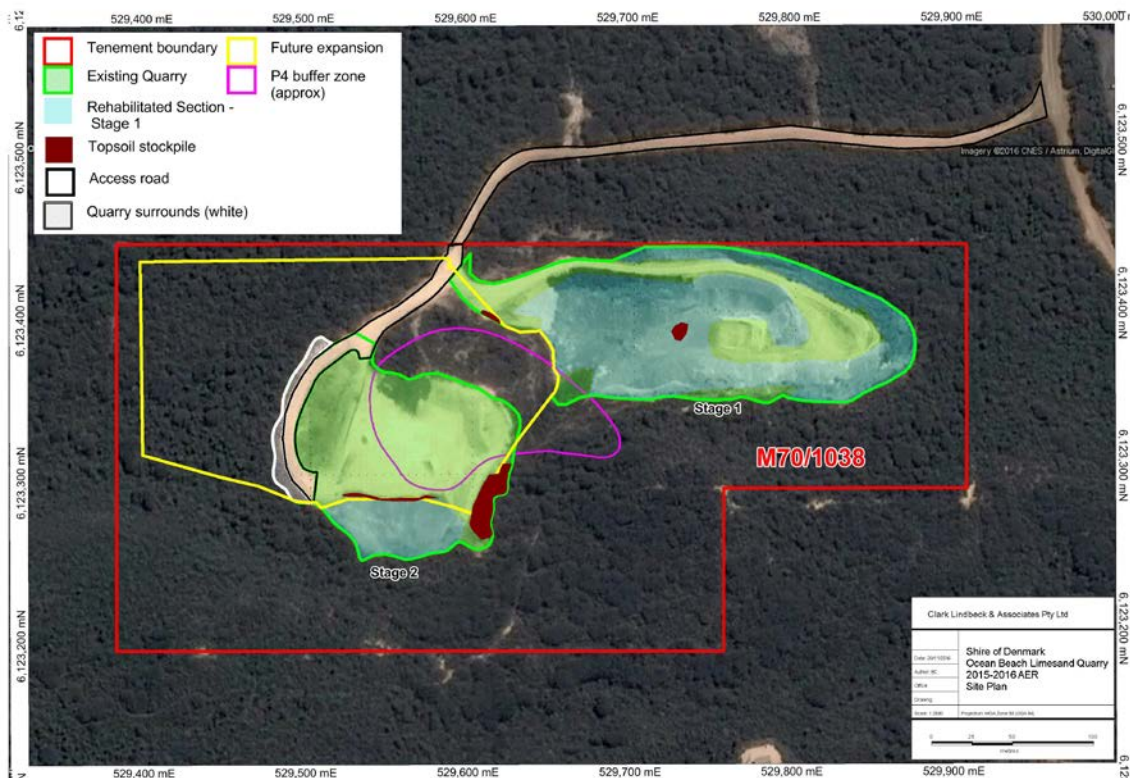


Figure 3: Mining Envelope and Rehabilitation Works Completed

Following preparation and release of the original EMP (DCS 1999), the mineral tenement was granted by the DMP (M70/1038). This lease has a surveyed area of 11.625 ha. The Minister has approved a total area of mining of 12 ha. In addition, SoD has committed to mining no closer than 5 m to the boundary of M70/1038. Consequently, with this 5 m boundary restriction taking up an area of approximately 0.8 ha, mining a total of 12 ha on this tenement is not possible. It is anticipated that the mining envelope over the period 2017-2026 will be 3.27 ha.

3.2 Future Schedules of Work

The completion of the Stage 2 mining will comprise the areas of disturbance as shown in Figures 4 and 5.

The rate of disturbance will vary according to the rate of production, which is impacted by demand from the agricultural (farming) industries for limesand as a soil ameliorant to reduce soil acidity.

Excavation and production of limesand will occur in accordance with the Key Proposal Characteristics Table.

3.3 Re-contouring Schedules and Diagrams

The quarry walls will be reshaped to an angle of less than 45° from the horizontal. This angle is considered safe for human pedestrian access and thus, with revegetation of the re-contoured walls, will therefore not require the final quarry to be surrounded by an abandonment bund or a fence. However, as re-contouring of the walls is further designed, the DMP District Inspector of Mines (DIM) will be consulted about the need for or no need for a safety abandonment system on closure of the site.

This proposed mining schedule and the associated rehabilitation program has been submitted to the DMP as a Mining Proposal for assessment.

The closure of the site has been approved in the Mine Closure Plan (MCP) submitted to the DMP in 2015. This MCP was entered onto the tenement register for M70/1038 on 20 April 2016. The DMP in the approval of this MCP listed a number of items that need to be addressed in the next revision of the MCP due to be submitted in October 2018.

3.4 Topsoil Management

The historic mining area was operated in such a manner that all materials were removed, with the Stage 1 quarry being mined before SoD resumed control, little to no topsoil was stockpiled for those two cleared areas. However, since commencement of mining in the Stage 2 quarry area, sufficient topsoil has been and continues to be collected and stockpiled, such that some has been able to be utilised in the rehabilitation of sections of the historic quarry and the Stage 1 quarry.

SoD is committed to stripping, stockpiling and returning all available topsoil. Topsoil will be stockpiled in the southern area of Stage 2 where it will not be impacted by future mining operations and will be close to areas requiring rehabilitation.

Figure 4 shows the location and approximate volume of the topsoil stockpiles currently retained at Ocean Beach Limesand Quarry.

The schedules for stockpiling of topsoil are based on the proposed land disturbance (and mining schedules) set down in Section 3.2 of this EMP.



Figure 4: Location of Topsoil Stockpiles and Volumes

3.5 Strategies to Improve Visual Amenity

3.5.1 Prior to 2016

Parts of this Section have been taken from SoD (2016c).

The revegetation of the top of the quarry walls was completed during the winter season of 1999. Seed was collected from the surrounding Reserve and direct seeded over brush that had been laid over the surface. The brush material was also obtained from the surrounding Reserve. A good germination rate was achieved using this direct seeding over brush technique. In-fill plantings of seedlings were also continued as new species were propagated in the SoD nursery.

Screening vegetation was a dense planting on the northern lip of the historic quarry with the assistance of construction of a soil “bund”. The species planted in the winter season of 2000, was tube stock of “Coastal Peppermint”, *Agonis flexuosa*. The rate of growth of the Coastal Peppermint has been slow because of the rocky nature of the strata underlying the soil bund and the exposure of the site to coastal winds and salt. This has shown to be an excellent visual screen for the quarry from Ocean Beach Road.

The growth rate of Coastal Peppermint tube stock has been rapid where they were planted on the southern rim of the historic quarry. The original proposal (CER) prepared by Hart, Simpson & Associates Pty Ltd 1998) provided no commitments on treatment of the existing walls or the angles of the finished walls to be mined under the provisions of MS521.

However, the CER did commit the SoD to plant screening vegetation on the bund located on the northern boundary of the Stage 1 area to be mined with the objective to screen operations and the exposed southern face. The most appropriate species were considered to be *Agonis flexuosa*, *Acacia litoria* (presumably should be *A. littorea*), *Spiridium globulosum* and *Hakea oliefolia*. The CER also states that the seedlings will be planted into a prepared organic medium of less alkaline pH and will be locally fertilized using slow release phosphorus tablets to facilitate more vigorous growth.

For Stage 2, the CER committed SoD to again plant seedlings on a constructed bund along the northern boundary using the same species. Mining was not going to occur on the steep north faces in order to limit the visual impact.

The original EMP (DCS 1999) committed SoD to reduce (or construct) the quarry walls to less than 45° from the horizontal with benches (or berms) installed 0.5 m wide. There was no indication in the EMP of the frequency down the slope that these benches would be installed.

SoD (2016c) also states that the slope (wall) in the southwest (Stage 2) was planted and direct seeded in 2000. This site is the fenced area directly to the south of the P4 species buffer zone. Benches were not required in this area as the slope angle was approximately 45° with some topsoil present. In 2002, brush was installed. Planting and direct seeding over this area has been continued.

The SoD has attempted to revegetate eroded areas of the walls with little success, even using brushing, plantings of seedlings and direct seeding. The lack of topsoil and the rocky nature of the slope have impeded growth.

The basal areas of the steep slopes (approximately 60°) have been planted with cuttings from *Pelagonium capitatum*. Success has been mixed because of a lack of topsoil. To assist growth, direct seeding of *Ficinia nodosa* has been introduced.

3.5.2 Post 2016

The MCP (Aurora 2015) quotes the status of the rehabilitation of the Stage 1 walls as at September 2015, in relation to the benched walls at 45°, that “this commitment from 1999 has been superseded by the fact that there was virtually no overburden/topsoil left for slope modification and benching. However, now that the Stage 1 area has been completed, there is material in the base of the pit which can be used to reduce the slope in key areas to facilitate rehabilitation and will either meet or sufficiently comply (*sic*) the 45 degree criteria. Discussion with DMP indicates that even if 45 degree slopes cannot be achieved, stabilisation through rehabilitation is acceptable”.

An assessment of the stability of the walls undertaken by Infra Tech Consulting Pty Ltd (2016). The report is attached as Appendix 2.

This report indicated that overall, the planned slopes of 45° or less are stable. The exception is the near vertical slope on the southern side of the Stage 1 quarry. This slope will continue to erode and be impacted by carbonate dissolution processes. Infra Tech (2016) recommended that a surface water drain be installed above the slope to remove rainfall run-on and thus reduce dissolution or the installation of an abandonment bund.

SoD (2016b) mentions that the installation of a deflection barrier or swale drain above the southern slope may be difficult due to the site’s topography in the suggested location. Furthermore, the SoD is of the opinion that the contributing upstream catchment is relatively small with minimal positive impact on the effectiveness of the deflection barriers.

This closure item relating to bunding will be discussed with the DIM from DMP and presented in the MCP.

To address the slope angle along the southern wall, SoD (2016b) advises that ground control management has been recommended to be implemented in terms of weighted toe slope displacement monitoring and drainage diversion measures (Infra Tech 2016). Examples of proposed measures include installation of fences, deflection barriers and toe weight. Infra Tech also proposed that the slope displacement monitoring works be carried out using prisms as part of the annual rehabilitation program. The SoD has pushed spoil materials against the southern quarry wall to implement the required weighted toe and arrest progressive slope failure.

3.6 Species to be used in Revegetation of the Quarry

The following native seedling species will be used in revegetation programs for the quarry:

- *Ficinia nodosa*
- *Spyridium globulosum*
- *Lepidosperma gladiatum*
- *Lepidosperma squamatum*
- *Hakea oleifolia*
- *Phylanthus calycinus*
- *Platysace compressa*
- *Billardierra fusiformis*
- *Thomasia quercifolia*
- *Banksia sessilis*
- *Acacia littorea*
- *Scaevola crassifolia*
- *Banksia grandis*
- *Allocasuarina humilis*
- *Olearia axillaris*
- *Agonis flexuosa*.

It is anticipated that retention and re-use of the stockpiled topsoil will result in natural regeneration of species from the stored seeds in the topsoil.

SoD is committed to the use of provenance seedlings and seed sourced locally by the SoD's Revegetation Officer from on-site or in the coastal reserve adjacent to the site.

Table 1 lists the year, amount of seed and areas of the Stage 1 quarry treated from 1999 to 2016. The areas rehabilitated are shown in Figure 5.

Table 1: Stage 1 Quarry Seeding and Plantings - 1999-2016

| Year | Quantity | Areas of Stage 1 Quarry |
|------|--------------------------------|--|
| 1999 | 1.3 kg seed | East-southeast rim |
| 2000 | 1071 seedlings | Southwest rim |
| 2001 | 252 advanced plants | North rim |
| 2001 | 2.2 kg of seed and 97 plants | South top |
| 2004 | 2111 plants | North top slope |
| 2005 | 1.5 kg of seed and 2085 plants | North and west slope |
| 2006 | 0.3 kg of seed and 2460 plants | North area below road |
| 2007 | 0.24 kg of seed and 690 plants | North area below road |
| 2010 | 1010 plants | North and west |
| 2011 | 916 plants | Southwest corner |
| 2012 | 150 plants | Infill all sites |
| 2013 | 800 plants | Infill all sites |
| 2014 | 653 plants | East and southeast rim |
| 2016 | 3000 plants | Subject to site preparation. Lower north and west slopes |

SoD will continue the extensive planting and seedling programs at this site using the species listed above and local provenance seedlings and seed.

3.7 Weed and Rabbit Controls

3.7.1 Weed Control

SoD is committed to a weed management strategy for the quarry operations. This strategy includes:

1. Limiting the introduction of weed seeds to the quarry by prohibiting the use of materials for rehabilitation works being sourced from outside A Class Reserve 24913
2. Removal by hand of all weeds during mining operations, rehabilitation works and monitoring inspections.

Weeding has been ongoing and thorough.

SoD (2016c) mentions that hand removal of weeds has occurred in revegetated areas and on the topsoil stockpiles as well as establishment of a 300 mm cover of inert fill with 50 mm of topsoil. The use of chemical herbicides has been implemented in areas where native plants are not present.

3.7.2 Vermin (rabbit) Control

- *“Rabbits are present on site (Hart et al 1998), but inspection reveals that little or no damage to regenerating vegetation has occurred as a result. The pioneer flora species endemic to the site (Acacia littorea, A. pulchella, Agonis flexuosa, Olearia axillaris) are hardy shrubs which appear not to be favoured by rabbits. Based on these observations, these vermin need not be excluded from the site for rehabilitation to succeed. Monitoring of rehabilitation areas will determine the need to exclude rabbits in the future.*

At the present time, rabbits are no longer an issue at OBLQ.

3.7.3 Type and Frequency of Monitoring for the Rehabilitation

DCS (1999) states that:

“Pre-mining vegetation community surveys are currently being conducted to determine completion criteria for rehabilitation. Four quadrats each of 100 m² have been established to determine structural and compositional elements of the vegetation. The results of these surveys will be detailed in the first annual Rehabilitation Performance Review.

Following mining, re-contouring and re-spreading of topsoil and stockpiled vegetation, two Rehabilitation Monitoring Quadrats each of 100 m² will be established on the post-mining landscape to gauge the progress and success of regeneration of endemic vegetation structure and composition. Data from the vegetation community surveys will provide baseline information with which to compare the success of rehabilitation procedures.

The ongoing monitoring of the vegetation in control sites outside the proposal area will determine environmental changes which are not the direct result of clearing and extraction of the resource, such as climate change.”

Although monitoring using scientific parameters has not commenced at this stage, the SoD Revegetation Officer has maintained a comprehensive diary of activities with associated photographs. The MCP (Aurora 2015) states that the implementation strategy / key activities for monitoring at the quarry will involve reporting on:

- Area planted/seeded (m²)
- Need for additional seeding/planting
- Health and species diversity (density and number of species in rehabilitated areas) – quadrats will be established in rehabilitated areas and adjacent uncleared areas in Spring 2017
- Photo records of visual impacts from Ocean beach and Mt Hallowell area
- Assessment regarding stability of benches, slopes and other landforms constructed to facilitate rehabilitation
- Analysis of air photos and site inspection to determine status of protection of environmental values of neighbouring Reserve 24913 (e.g. access tracks, damage to vegetation)
- Safety of mining and rehabilitation areas

- Protection of Priority 4 flora species *Thomasia quercifolia* – GPS extent of population.

SoD will install quadrats in analogue sites in the adjacent A Class Reserve and in rehabilitated areas of the quarry to commence monitoring of revegetation success.

3.8 Completion Criteria

SoD is committed to the following completion criteria related to vegetation at rehabilitated sites:

- o 1 shrub every m², one herb every 0.8 m² and 9 rushes/m² (where applicable)
- o Species richness of between 10-20 local native species (depending on conditions of planting area).

3.9 Review of the EMP

SoD is committed to an internal annual review of this EMP with an outline of the results of the review reported in the triennial Rehabilitation Performance Review (RPR) forwarded to the OEPA.

4 PARKS AND RECREATION RESERVE MANAGEMENT

Condition 4-1, Part 2, of MS521 requires the SoD instigate management procedures to protect the environmental values of the surrounding Reserve. These procedures are to include:

1. methods to control human and vehicular access from quarry areas to environmentally sensitive portions of the Parks and Recreation Reserve; and
2. minimisation of the impacts of quarrying activities on native fauna in the adjacent reserve.

SoD propose to:

- 1 Fencing the quarry so that third parties cannot travel from the quarry into the surrounding bush
- 2 Closing off all tracks that may inadvertently be started by third parties around the quarry (using big trees or bundies) so that vehicles cannot access the tracks. There are no tracks leading from the quarry at the present time.
- 3 A mobile fire unit is located onsite during quarrying.
- 4 A recommended speed restriction of 40 km/hr to protect fauna.

5 EMP PROVISIONS

This section of the Condition EMP identifies the management actions that the SoD proposes to implement to manage the key environmental impacts.

5.1 Environmental objective

This EMP has been developed to manage the environmental impacts of the project, and to fulfil the requirements of the conditions and procedures in MS521, prior to ground disturbing activity.

5.2 Management actions to be implemented

Risk-based management actions have been identified and prioritised to achieve the condition environmental objective (Table 2). These management actions focus the greatest management effort on protection of flora and vegetation, groundwater protection, dust emissions and visual amenity.

Table 2: Risk-based Management Actions that will be Implemented to meet the Environmental Objective

| Risk and key impacts | Management actions | Risk-based priority | Timeframe/ Project phase |
|----------------------|---|---------------------|--------------------------|
| 1 | Excavation of Limesand will occur in accordance with the Key Proposal Characteristics Table. | 2 | Ongoing |
| 2 | Stripping, stockpiling and returning topsoil | 1 | Ongoing |
| 3 | Progressive rehabilitation of the quarry will occur, especially on the southern face to reduce the visual impact looking to the quarry from the north | 1 | Ongoing |
| 4 | Making site safe at abandonment | | TBA |

5.3 Review and Revision of Management Actions

Where the management actions are not met or exceeded, SoD will review and revise the risk assessment, review and revise management actions and identify additional management actions where necessary.

Reviewed and revised management actions will be implemented by SoD to mitigate and manage impacts so they once again will meet the management target and the condition environmental objective.

6 STAKEHOLDER CONSULTATION

6.1 IDENTIFICATION OF STAKEHOLDERS

Over the years, the SoD has recognised that the Key Stakeholders listed in Table 3 need to be provided with regular updates or reporting.

This project has been operating under the control of the SoD since approval was granted in 1999. Since that time a range of issues have arisen (from both statutory authorities and the local community/ratepayers) which have been appropriately dealt with by the Shire.

Table 3: Key Project Stakeholders

| Group | Stakeholder |
|-------------------------------------|--|
| Adjacent or Concurrent Land Holders | Department of Parks and Wildlife |
| State Government Agencies | Office of the EPA Department of Mines and Petroleum Department of Environment Regulation Department of Parks and Wildlife Department of Aboriginal Affairs |
| Local and Regional Community | Shire Ratepayers Local and regional farmers (product purchasers) Local Community |

6.2 STAKEHOLDER ENGAGEMENT REGISTER

The records from SoD are not sufficiently comprehensive to provide a table of stakeholder involvement over the last (nearly) two decades.

At nearly every SoD Council meeting, the Director of Infrastructure Services reports to Council members and the local community on the status of the operations at OBLQ.

Consultation with stakeholders will continue throughout the life of the Project to ensure stakeholder concerns and objectives are accounted for and the Minutes of Council Meetings are the official record of input from stakeholders.

6.3 STAKEHOLDER ENGAGEMENT STRATEGY

6.3.1 Stakeholder Engagement Activities

The SoD responds immediately to all concerns or issues raised in relation to the OBLQ. The response is either by direct correspondence or by referral to Council if the matter requires a decision by that authority. The new management at SoD intends to implement an engagement program which will involve meetings or correspondence with the DMP, DER, DPaW and the Department of Aboriginal Affairs (DAA) (Table 4).

6.3.2 Communication with Stakeholders

The SoD admits that it has not been efficient in developing and maintaining successful relationships with its stakeholders, particularly statutory authorities. The new Executive Management at SoD recently has taken steps to rectify this inefficiency and intends to develop good relationships with all stakeholders associated with the OBLQ.

All communications with stakeholders are reported in the official Minutes of the Council Meetings which outline the nature of the communication and the outcomes.

6.3.3 Resources

The SoD has sufficient financial and human resources to ensure active stakeholder engagement continues throughout the life of the Project.

Table 4: Stakeholder Consultation Strategy

| Stakeholder | Action | Timing |
|---------------------|--|---------|
| OEPA | <ul style="list-style-type: none"> Compliance Assessment Report | Ongoing |
| DPaW | <ul style="list-style-type: none"> Communication/consultation on mine status, especially in relation to the P4 species | Ongoing |
| DMP - Environment | <ul style="list-style-type: none"> Communication/consultation on mine status Annual Environmental Reports Submission of revised MCP (in 2018) and incorporation of feedback | Ongoing |
| DAA | <ul style="list-style-type: none"> Request for advice and assistance if archaeological material is found Communication/consultation on mine status | Ongoing |
| DMP Resource Safety | <ul style="list-style-type: none"> Communication/consultation on mine status | Ongoing |
| Shire Residents | <ul style="list-style-type: none"> Communication on mine status through Shire publications. | Ongoing |

APPENDIX 1

Letter dated 1st December 2016 from DPaW concurring with request from SoD to remove 202 individuals of P4 species, *Thomasia quercifolia*, with removal of the buffer zone and incorporation of the zone into the future mining envelope



Government of Western Australia
Department of Parks and Wildlife

Warren Region

Your ref: OCR161042790
Our ref: PRS40314
Enquiries: Peter Bamesse
Phone: 97 717 988
Email: peter.bamesse@dpaw.wa.gov.au

Mr Jesse Pietersen
Shire of Denmark
enquiries@denmark.wa.gov.au
Attention: Mr Clint Daw

Hi Clint

Thank you for your letter dated 27 October 2016 regarding the removal of priority species *Thomasia quercifolia*, in the Ocean Beach Limesand Quarry, Mining Lease 70/1038, Shire of Denmark.

In reference to the Shire of Denmark's request for advice, the Department of Parks and Wildlife can provide the following comments.

1. The Department has no objections with the removal of the 202 individuals identified in the 1999 buffer zone.
2. The Department has no objection to the removal of the buffer zone from the approved Consultative Environmental Review (CER) and Environment Management Plan (EMP) and incorporation of the buffer zone into the proposed mining area in the revised EMP.

The removal of these plants will not adversely impact on this population and the overall conservation of this species.

Please contact Mr Peter Bamesse on 97 717 988 if you have any further enquiries.

Yours sincerely

Luke Bentley
Regional Manager Warren Region

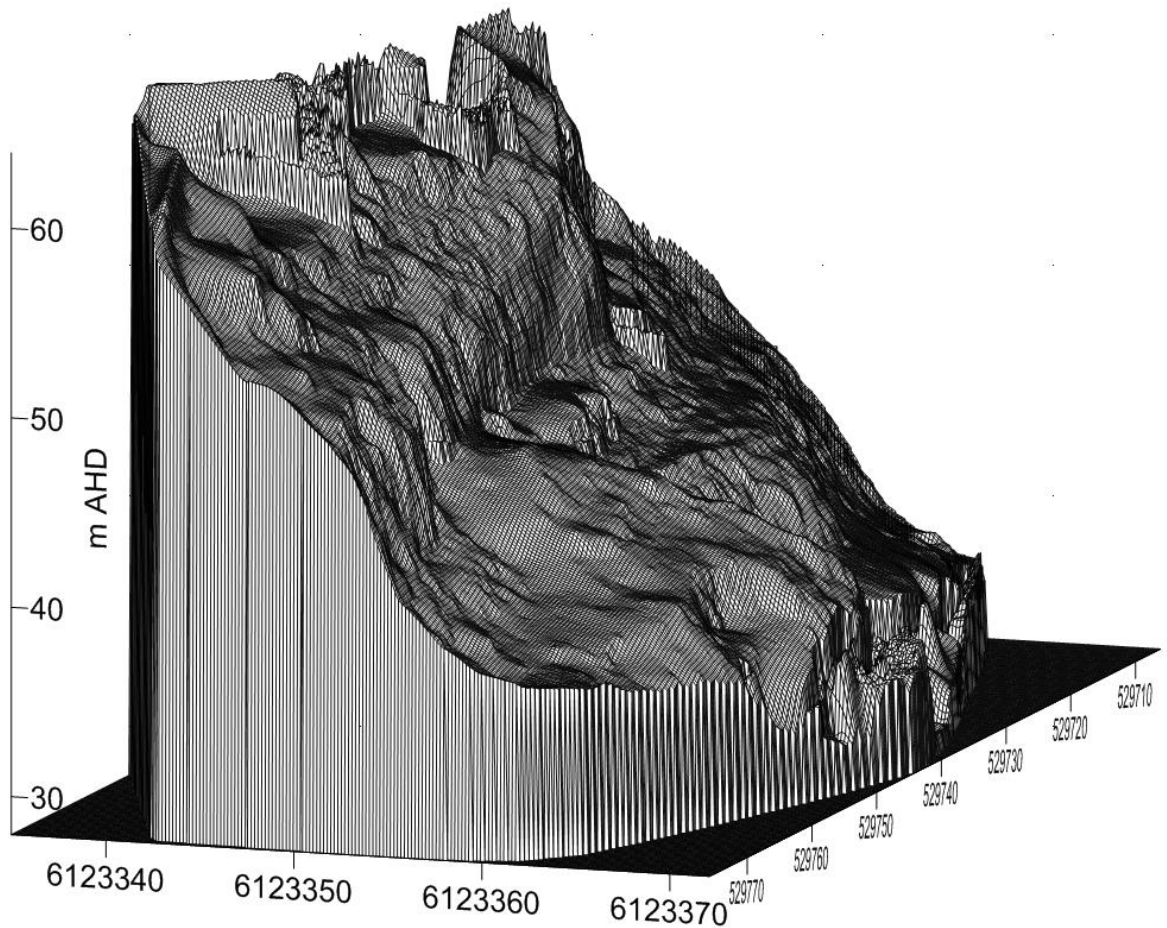
1 December 2016

APPENDIX 2

Wall Stability Geotechnical Study (Infra Tech Consulting Pty Ltd (2016))

Ocean Beach Lime Quarry, Denmark

Report on Geotechnical Investigation and Mine Closure



Prepared for: Shire of Denmark
Prepared by: Infra Tech Consulting Pty Ltd

Ref: 1692-PO-ENG-RPT-001

Date: 30/06/2016

Infra Tech Pty Ltd

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30th June 2016

our ref: 1692-PO-ENG-RPT-001

Shire of Denmark
953 South Coast, Highway, Denmark
6333
Western Australia
Attention: Mr Gilbert Arlandoo

REPORT ON GEOTECHNICAL INVESTIGATION AND MINE CLOSURE AT OCEAN BEACH LIME QUARRY, DENMARK

1 INTRODUCTION

Infra Tech Consulting Pty Ltd (Infra Tech) was requested by Mr Gilbert Arlandoo from Shire of Denmark to undertake a geotechnical survey and associated design work at Ocean Beach Lime Quarry, Denmark. The study will be aim to address the slope stability aspects raised in DMP letter ref AI-518-846. Work has been carried out in adherence with industry guidelines (Department of Mines and Petroleum - Geotechnical Considerations in Open Pit Mines). This includes:

- Geological, structural and rock mass models
- Geotechnical model
- Hydrology considerations
- Pit Wall Design
- Post Monitoring

2 PROJECT APPRECIATION

Site Location

The Ocean Beach quarry is located at 906 Ocean Beach Rd, Ocean Beach in the Shire of Denmark (Refer to Figure 1).

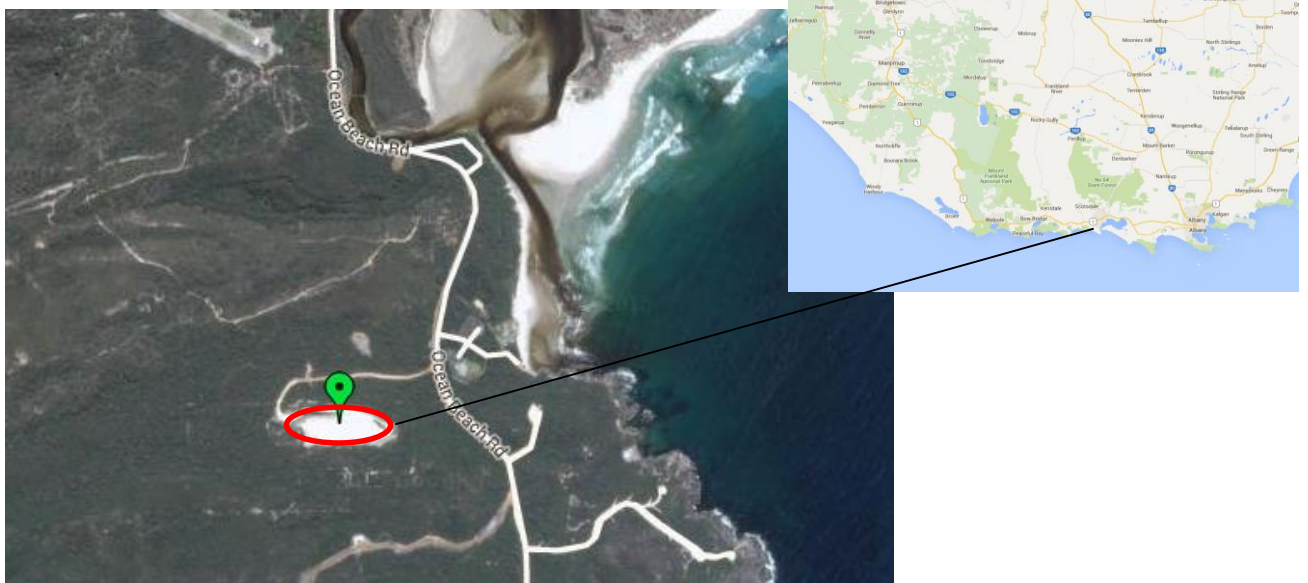


Figure 1: Regional View of Ocean Beach Lime Quarry, Denmark

Denmark – Ocean Beach Lime Quarry is approximately 7 km southwest of the Denmark town centre on M70/1038. The mine is wholly located on Crown Reserve 46273 allocated to the Shire of Denmark for the purpose of mining.

Mining

The operation involves the excavation, sieving and crushing of lime sand. Stage 1 and stage 2 mining can be seen in Figure 2. Mining takes place using front-end loader for all mining and loading whilst a bulldozer with a ripper attachment is used to break down cemented material.

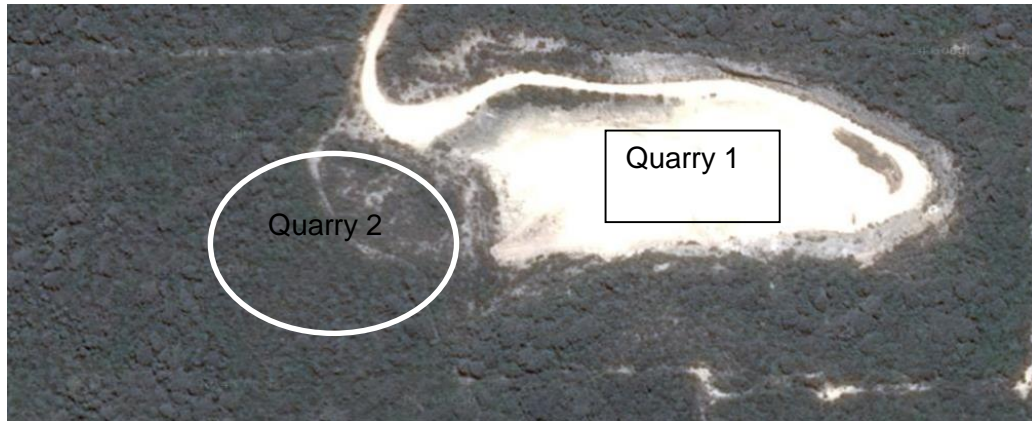


Figure 2: Plan View of Site - Quarry 1 and 2

3 SCOPE OF WORKS

Infra Tech scope of works (SoW) is as follows;

- Undertake a photogrammetric survey of existing pit walls
- Undertake geological interpretations to determine base line shear strength parameters for the in-situ limestone.
- Undertake an iterative back analyses of stable and unstable section of the quarry to determine in-situ material parameters (peak and residual)
- 3D mapping of the current pit crest against the site boundary

Deliverables

The deliverables of this report include the following items:

- Findings from the site survey and desktop study
- 3D survey mapping of the current pit crest against the site boundary
- Geotechnical Material Parameters derived from back analysis of slope failures
- Recommendations on the slope support measures that will need to be put in place to satisfy the requirements as per the DMP report.
- Provide technical justification to demonstrate that the “stable” sections of quarry will not need to be “cut back” to 45 degrees.
- Provide recommendations on surface water management to reduce / mitigate pit wall erosion.
- Pit Wall Design Recommendations
- Report summarising the findings of the above

4 DESKTOP STUDY

Geology

The regional geology comprises of white quartz sand and limestone. (Refer to Figure 3).



Figure 3: Site Geology – Ocean Beach Lime Quarry (<http://www.geoscience.gov.au>)

Hydrology and Hydrogeology

Annual rainfall is typically between 800-1200mm with wettest season between April and September (Refer to Figure 4 and 5).

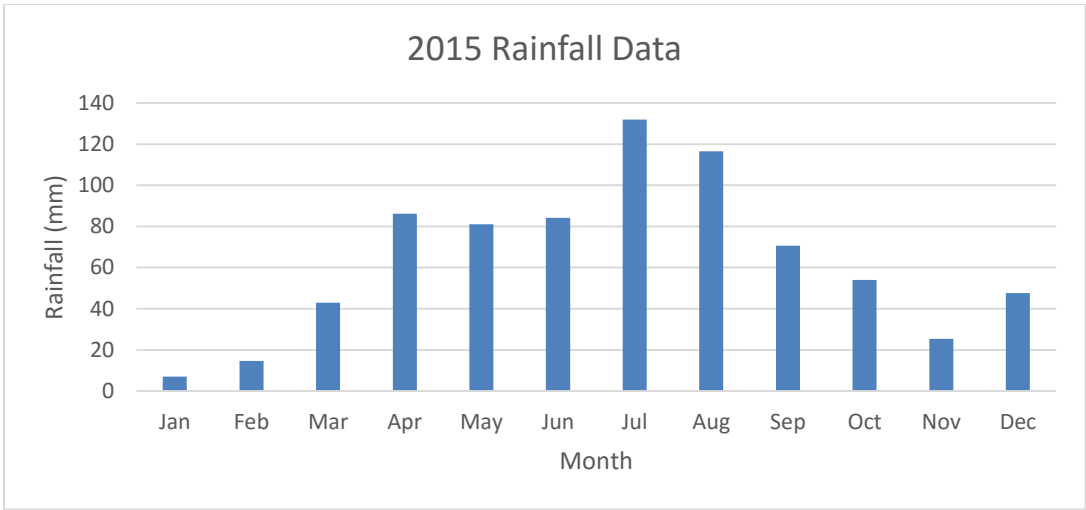


Figure 4: Monthly rainfall data 2015 – Denmark station 009531, 117.36°E, 34.96°S

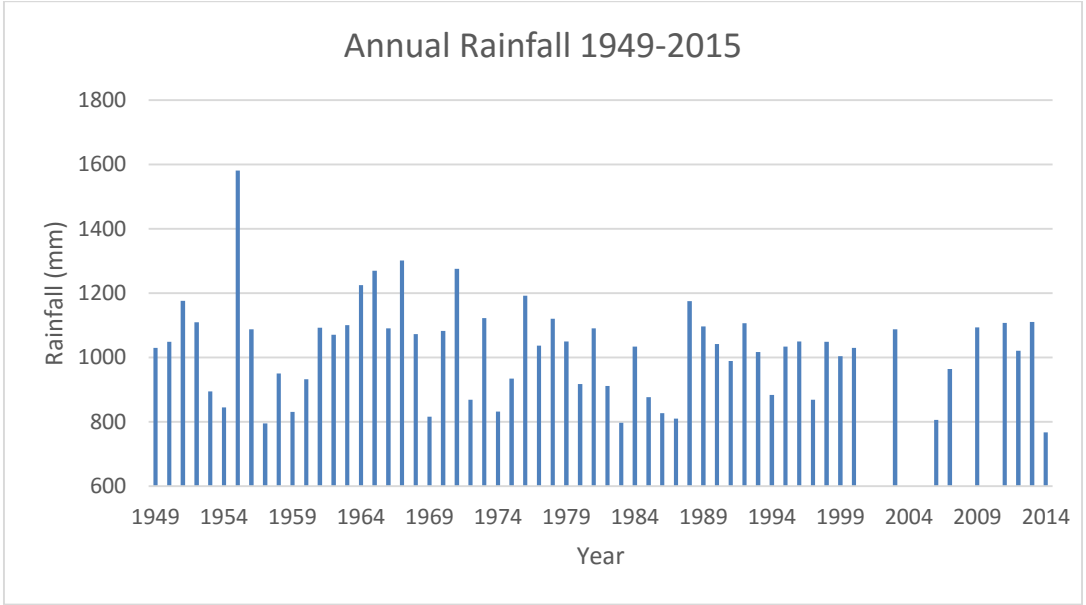


Figure 5: Annual rainfall data 1949-2015 – Denmark station 009531. 117.36°E, 34.96°S

No information on groundwater levels are currently available for the site.

5 PHOTOGAMMTERY SURVEY

A digital photogrammetry survey was used to collect data for 3D modelling of current pit wall geometry. Photogrammetry was undertaken using CONTEXT CAPTURE (Bentley) software (230 mm x 230 mm photography). This analytical stereoplottter uses a photogrammetric scanner for the creation of digital orthophotos. It enables the software to create vector maps and generate fully rectified digital orthophotos in order to assess geometry.

Survey location

The fieldwork was carried out between 25th and 26th May. The survey was undertaken on the South and West walls of Quarry 1 and the North, East and Southern walls of Quarry 2 (Refer to Figure 6).

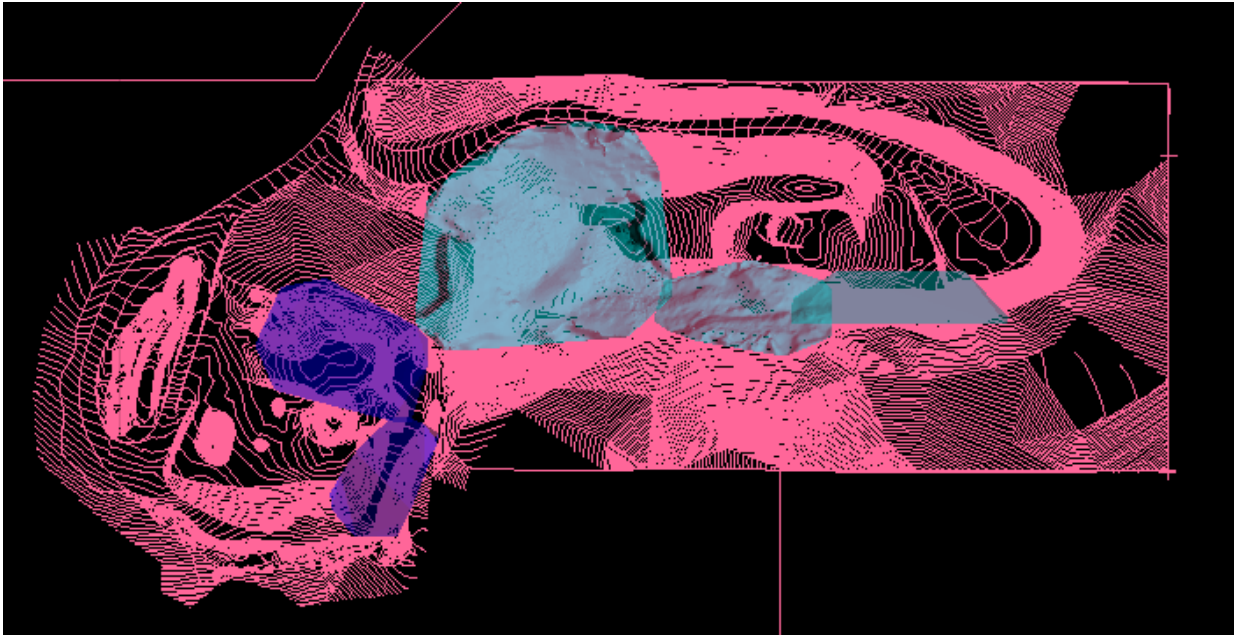


Figure 6: Location of photogrammetry survey – Quarry 1 (turquoise) + Quarry 2 (purple)

3D Models

3D models were generated using the orthophotos to analyse the slope geometry in further detail and select critical sections of the slope to model. Typically, 3D models indicate overall slope angles of between 40-53 degrees in Quarry. In quarry 2, overall slope angles between 25-40 degrees.

The quarry has been divided into two (2) domains based on slope angles greater than forty five degrees ($>45^\circ$) and slope angles less than 45 degrees ($<45^\circ$) which can be seen in Figure 7. The critical section in domain 2 (worst case slope angle) can be seen in drawing 1.

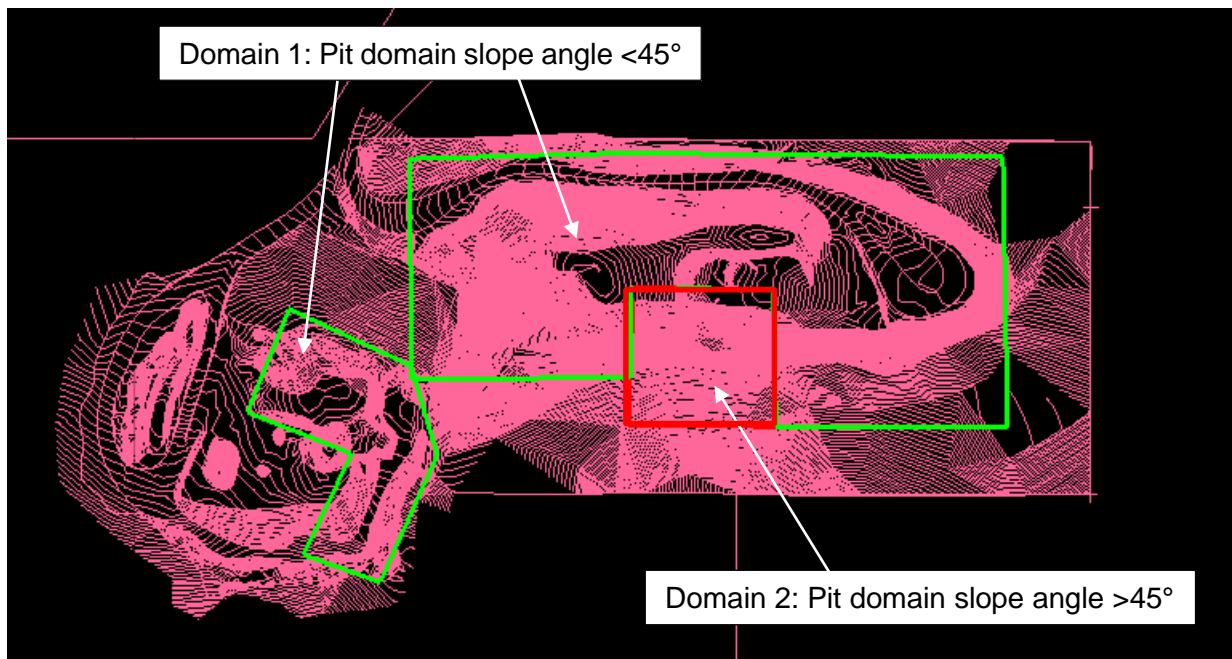
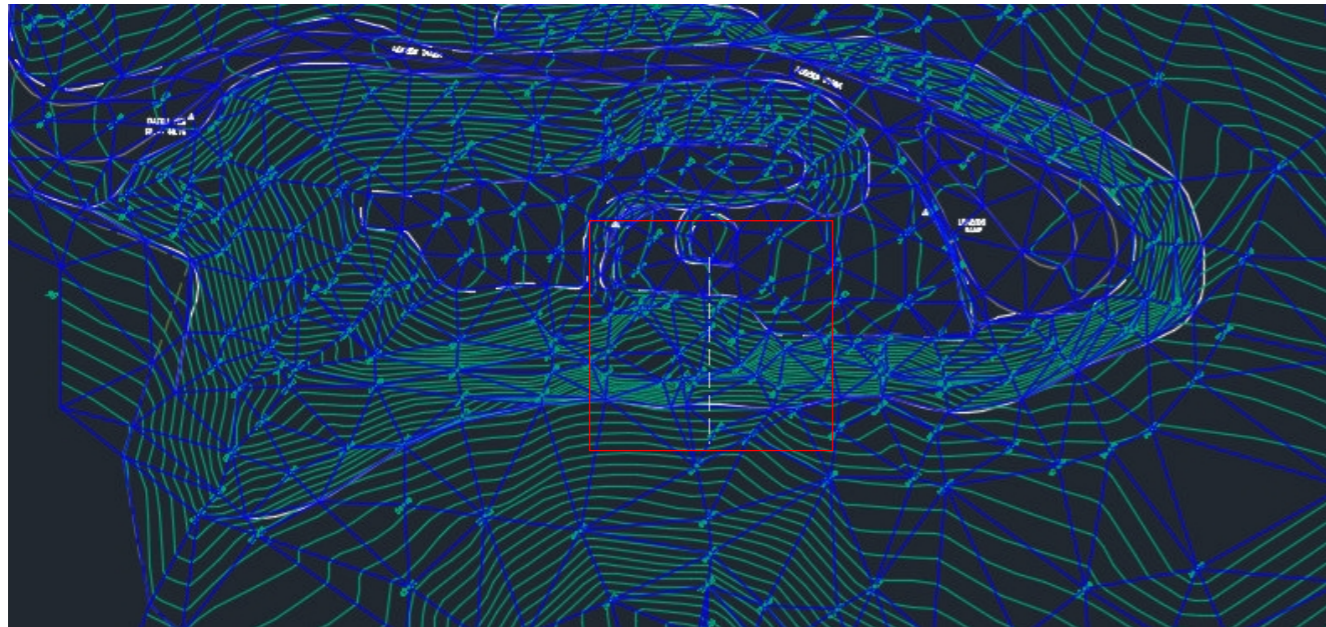
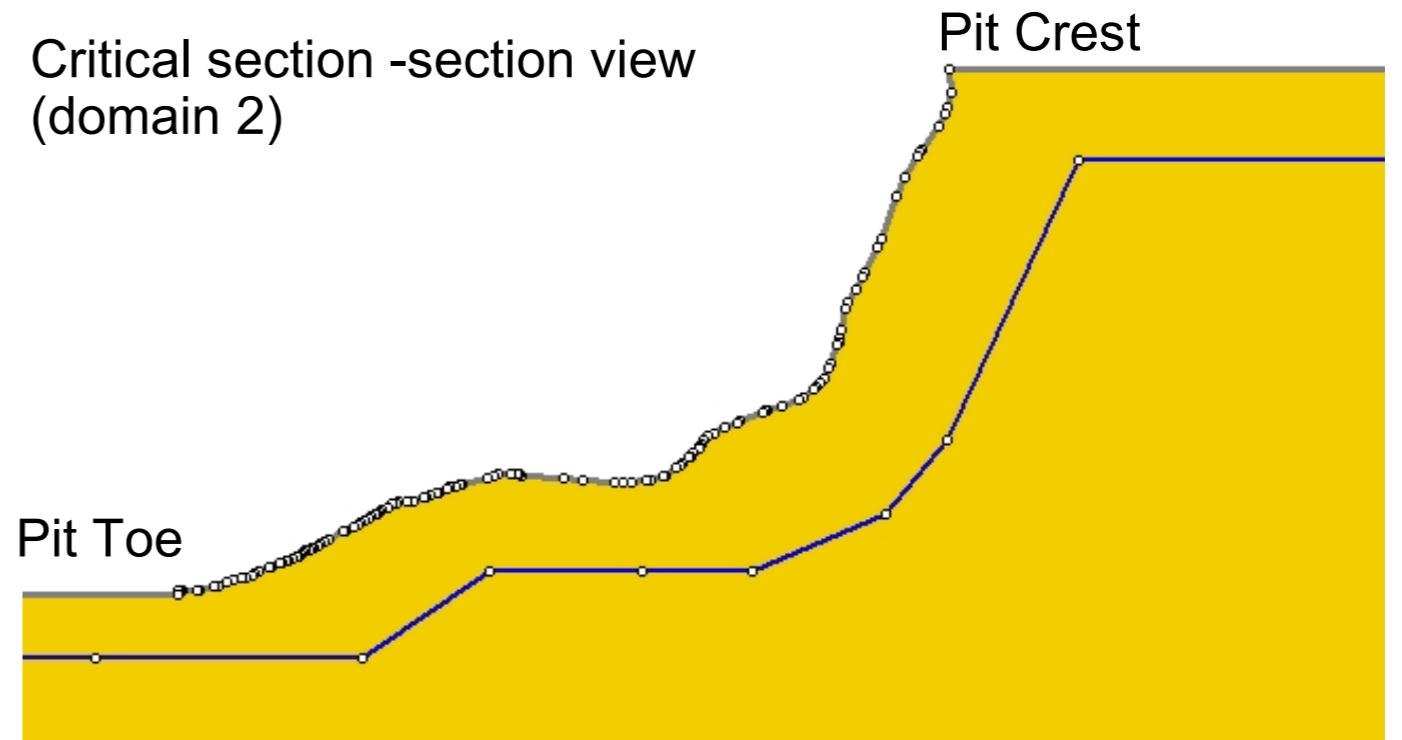


Figure 7: Quarry domains based on slope angles $<45^\circ$ ad $>45^\circ$

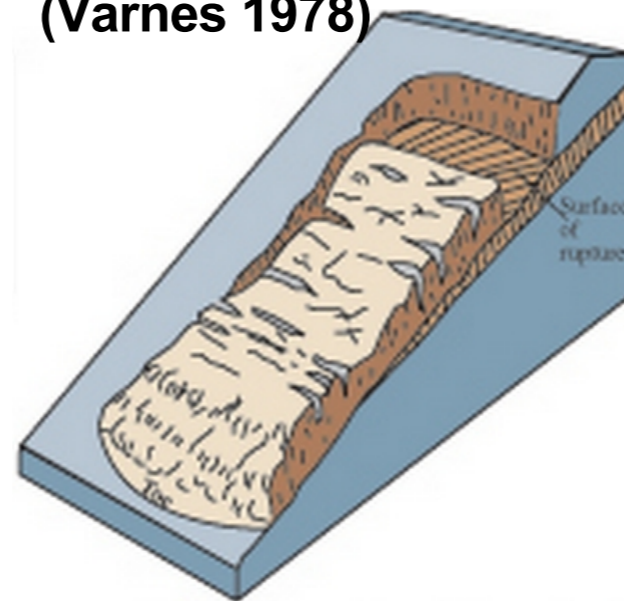
Critical section planview (domain 2)



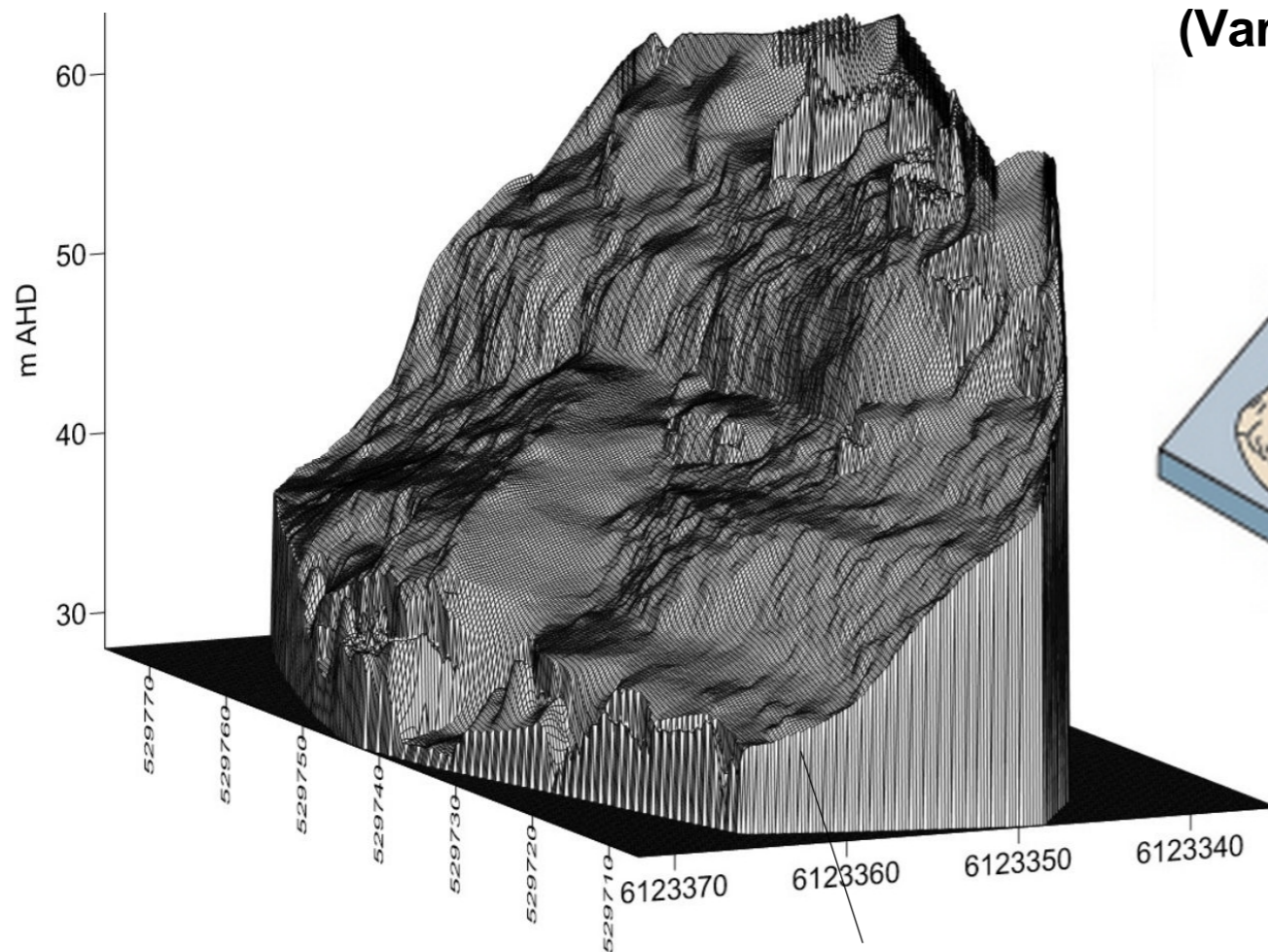
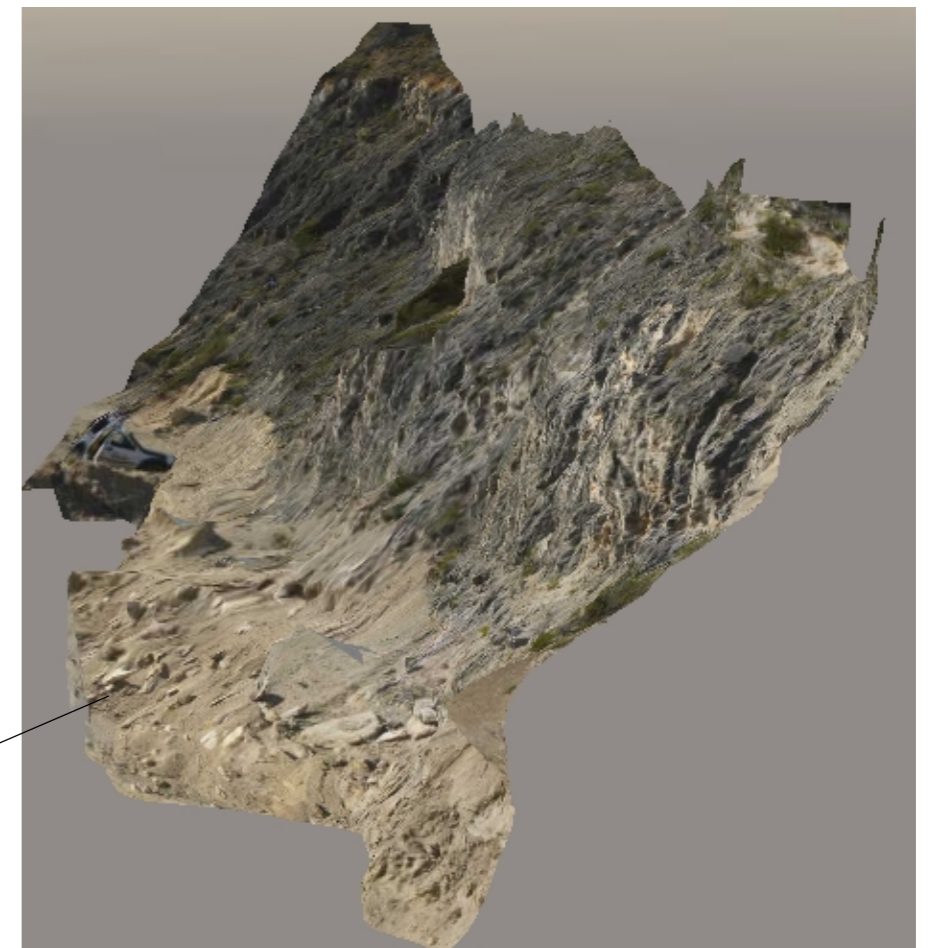
Critical section -section view (domain 2)



Progressive translational slump failure mechanism (Varnes 1978)




3D model developed from photogrammetry survey (domain 2)



3D model in wireframe format Domain 2

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| | | | | | | |
|---|--|------|-----------|-----------|------|-----------|
|  | TITLE | | DRAWN | PE | DATE | 30/6/2016 |
| | Ocean Beach Lime Quarry Critical Section - Quarry 1 | | CHECKED | NL | DATE | 30/6/2016 |
| | | | SCALE | NA | | A3 |
| | PROJECT No | 1692 | FIGURE No | Drawing 1 | | |

6 GEOTECHNICAL MODEL

Geology

Field observations and information from the desk top study indicate material on site comprises a weakly cemented quartz sand.

Weathering

General weathering observations on site indicate that the respective quarry walls will comprise only weathered material. It appears the quarry walls are formed of material which is predominantly highly weathered to completely weathered. Progressive failure is occurring due to material to progress to this stage is critical for stability of the quarry walls. Materials have been classified on weathering based on definitions from International Standards Rock Mechanics (refer to Table 1).

Table 1: Weathering grade definitions

| | |
|-----------------------------|---|
| Highly weathered | More than 50% of the rock material is decomposed and/or disintegrated to a soil. Fresh or discoloured rock is present either as a discontinuous framework or as corestones. |
| Completely Weathered | 100% of rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact. |

Highly weathered to completely weathered quartz sand / limestone can be seen in the critical section (domain 2) in Figure 8.

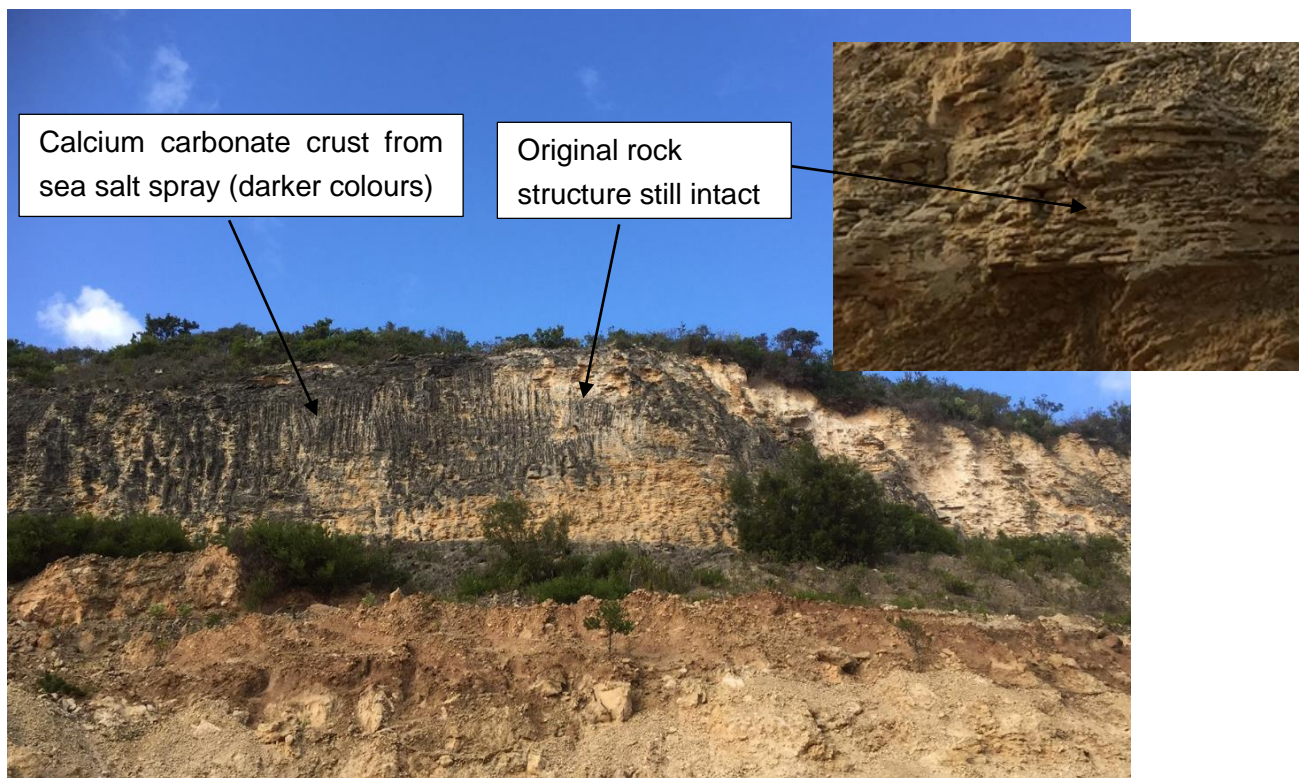


Figure 8: Weathering at Ocean Beach lime quarry – Critical section – quarry 1

Weathering will take place through predominantly chemical (dissolution) processes due to carbonates in the material. This will leave the soil surface in an unstable state and susceptible to erosion by wind and water. Current slope geometry is indicative of multiple translational slumping (Varnes 1978). This has led to a near vertical back scarp. Evidence of this process can be seen in Figure 8. The time it takes for weathering to occur and subsequent loss of rock mass cohesion is dependent on a number of variables. Weathering timeframes are difficult to predict on an engineering timescale and often occur over long periods or geological time (Miscevic 2001). Also of note is that this process is being slowed down in specific areas by a calcium carbonate crust likely developed from sea salt spray (Refer to Figure 8).

7 SLOPE STABILITY ANALYSIS

Failure mechanism

Based on the assessment of pit wall geometry, a non-circular failure plane has been selected as most the appropriate mechanism to represent translational slumping (Varnes 1978). The cuckoo search algorithm was used as it reduces constraints for the non-circular failure plane. Morgenstern and Price and Spencer method was used accounting for inter-slice forces.

Back Analysis of Material Parameters

Back analysis was carried out on critical section to determine appropriate material parameters. This section was considered the most critical section due to highest vertical slope and slope geometry. Friction angle was set at 35 degrees based on empirical evidence for sub angular fine to coarse SAND (Craig 2007). The process of weathering will not affect the friction angle. Sensitivity analysis was therefore carried out on cohesion to achieve a factor of safety of 1.1 which represents conditions close to or near to an unstable condition. Results indicate value of 19.0 kPa (Refer to Figure 9).

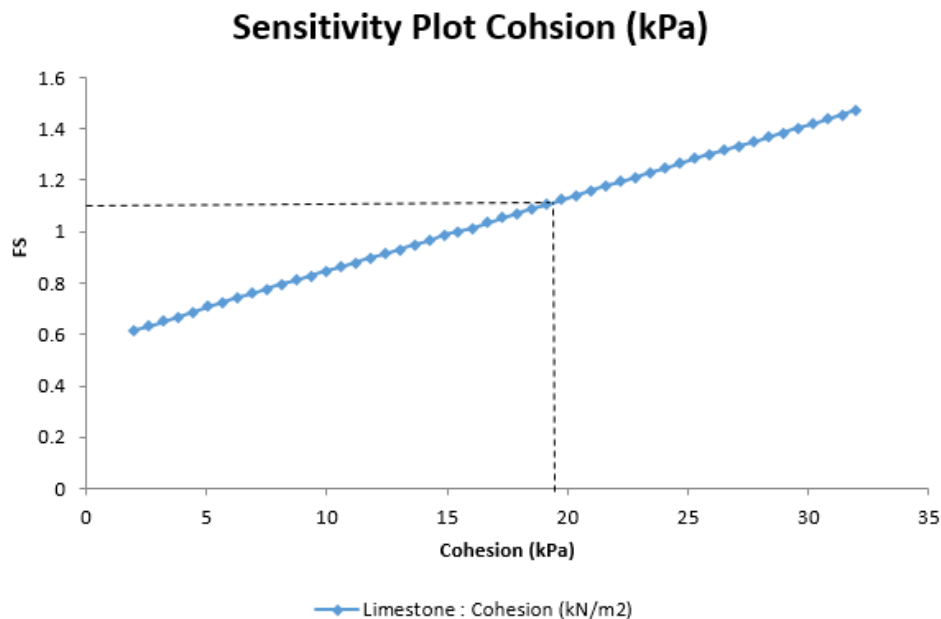


Figure 9: Sensitivity analysis on cohesion

Material parameters can be seen in Table 2.

Table 2: Material parameters

| Material | Friction Angle (phi) | Cohesion (kPa) |
|--|-----------------------------|-----------------------|
| Highly to completely weathered - quartz sand and limestone | 35 | 19 |

Design Acceptance Criteria

The following design acceptance criteria were applied based on DMP guidelines (Refer to Table 3):

Table 3: DMP design acceptance criteria

| Wall Class | Consequence of failure | Design FoS | Design PoF | Pit Wall examples |
|-------------------|-------------------------------|-------------------|-------------------|---|
| 1 | Not serious | NA | | Walls (not carrying major infrastructure) where all potential failures can be contained within containment structures |
| 2 | Mod serious | 1.2 | 10% | Walls not carrying major infrastructure |
| 3 | Serious | 1.5 | 1% | Walls carrying major mine infrastructure (eg treatment plant, ROM pad, tailings structures) |
| 4 | Serious | 2.0 | 0.3% | Permanent pit walls near public infrastructure and adjoining leases |

- A FoS of 1.1 where all potential failures can be contained within containment structures
- A FoS 1.5 where walls are carrying major mine infrastructure (ie. Access ramps)

The acceptance criteria applied in this study have been quoted as being applicable for overall slopes due to a low consequence of failure (i.e., no significant infrastructure on the quarry wall or immediately behind the slope crest).

Critical Sections

Critical sections can be seen in Figure 10 and were selected to gain a representative view of stability across the quarry.

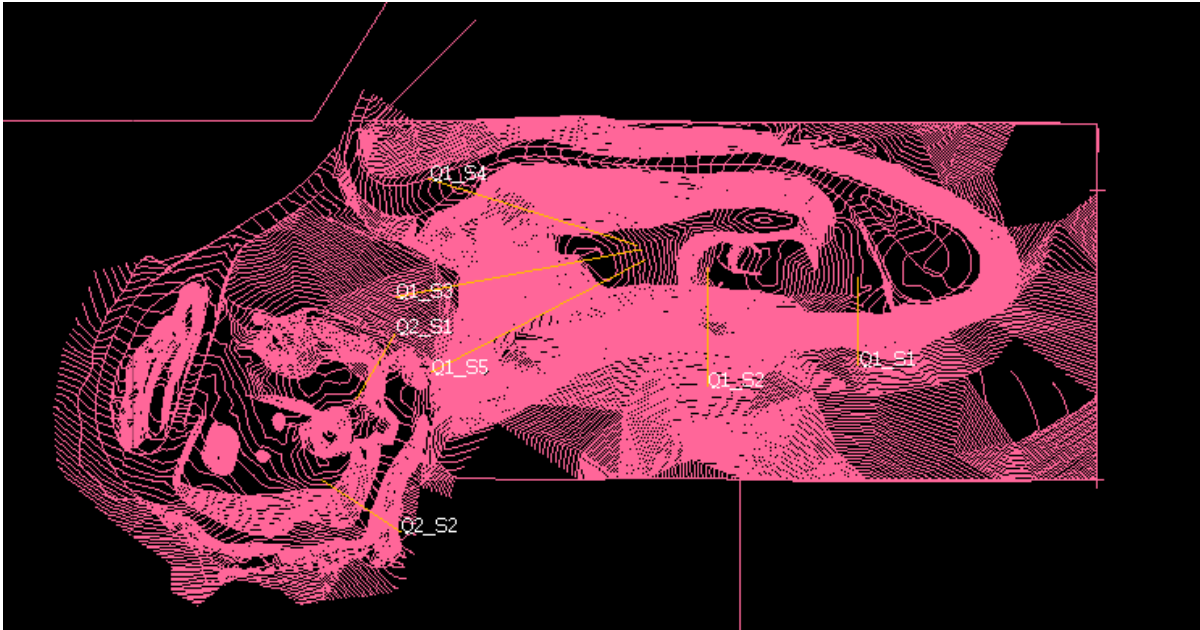


Figure 10: Critical sections at Ocean Beach Lime Quarry

Limit equilibrium modelling

Limit equilibrium modelling can be seen in Figure 11 for overall slope stability.

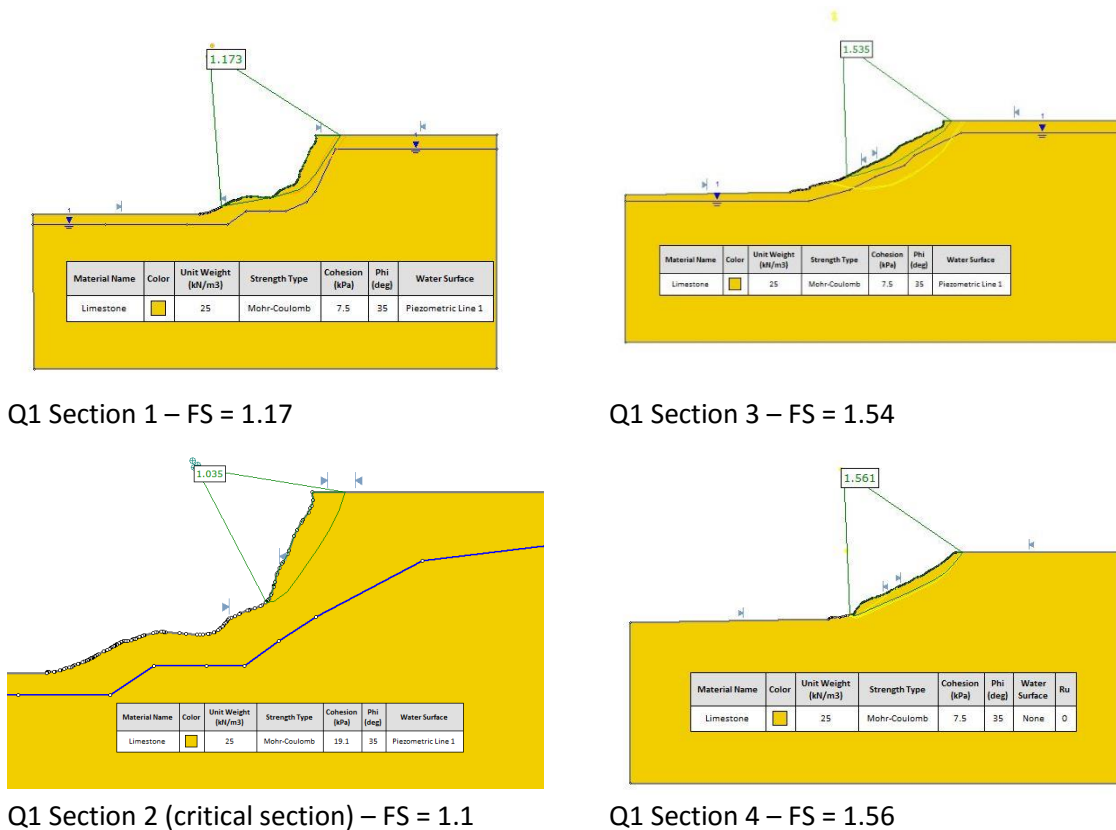
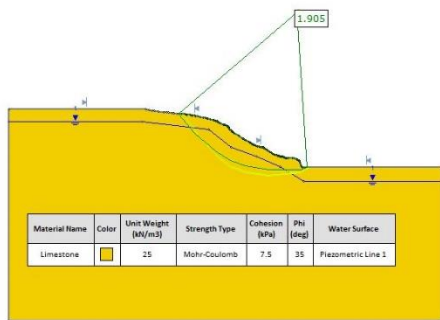


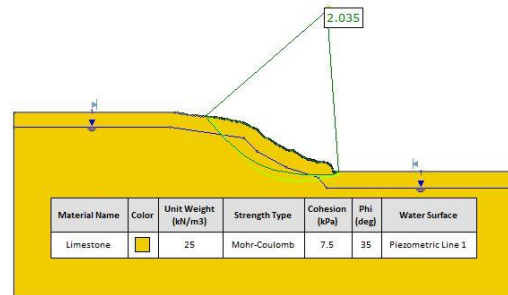
Figure 11: Modelling results overall slope stability

Results indicate that all areas of quarry 1 have a Factor of Safety greater than 1.2 for overall slope stability (excluding section 2). Section 2 walls do not contain any major infrastructure and therefore have a low consequence of failure so are therefore with design acceptance criteria.

Results for quarry 2 can be seen in Figure 12.



Q2 Section 1 – FS = 1.91



Q2 Section 2 – FS = 2.04

Figure 12: Modelling results overall slope stability

Results indicate that all areas of quarry 2 have a Factor of Safety greater than 1.5 for overall slope stability which is within the acceptance criteria where major infrastructure is positioned.

8 DISCUSSION

Typically, 3D models generated from photogrammetry indicate overall slope angles of between 45-53° in quarry 1 and between 25-40° in quarry 2. A section of the South wall in quarry 1 has been subject to progressive translational failure resulting in a back scarp of 53° (overall slope angle). Chemical weathering (dissolution) and subsequent erosion by water has been identified as the likely cause of this progressive type failure. Limit equilibrium modelling has been carried out using back analysis of the failed section to derive material parameters. Modelling indicates that all zones have factors of safety within the DMP's acceptance criteria as the critical section has a low consequence of failure. Ground control in this area of the quarry is recommended to arrest the progressive failure mechanism. The area where ground control is recommended can be seen in Figure 13.

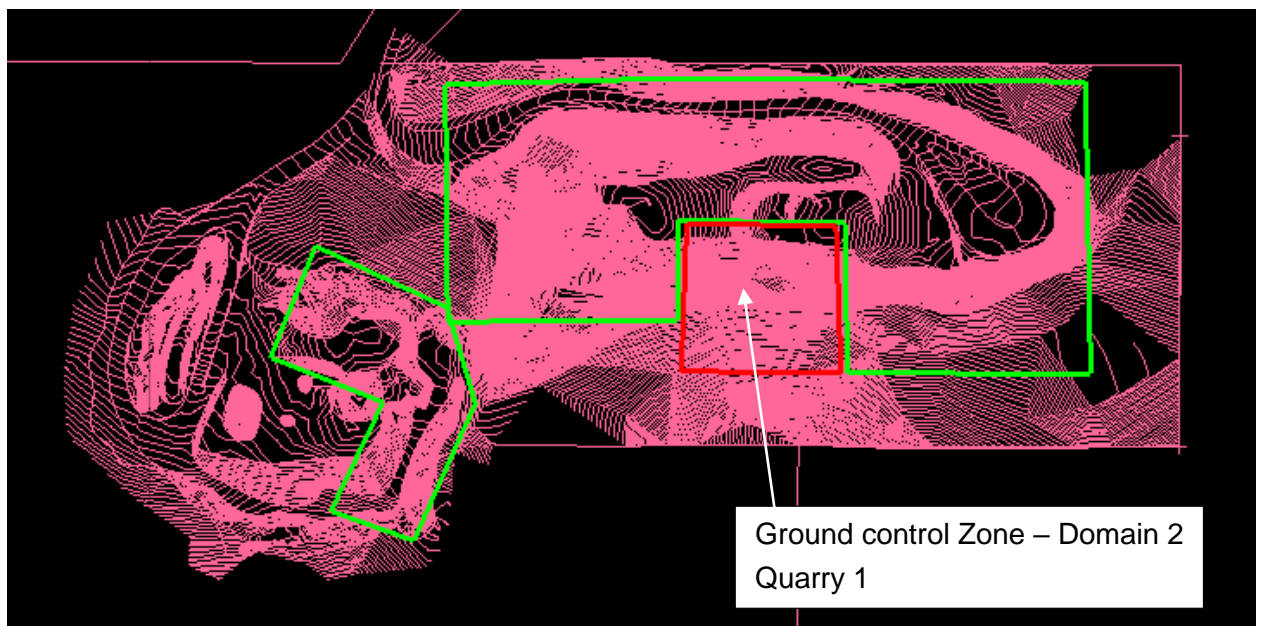


Figure 13: Ocean Beach Quarry –area where ground control management plan is recommended

9 RECOMMENDATIONS

Ground control management in the form of monitoring slope displacement using prisms, a deflection barrier or drain to divert water away from the crest of the slope and a weighted toe are recommended to arrest progressive type translational failures targeted in domain 2 – quarry 1.

Fence or abandonment berms



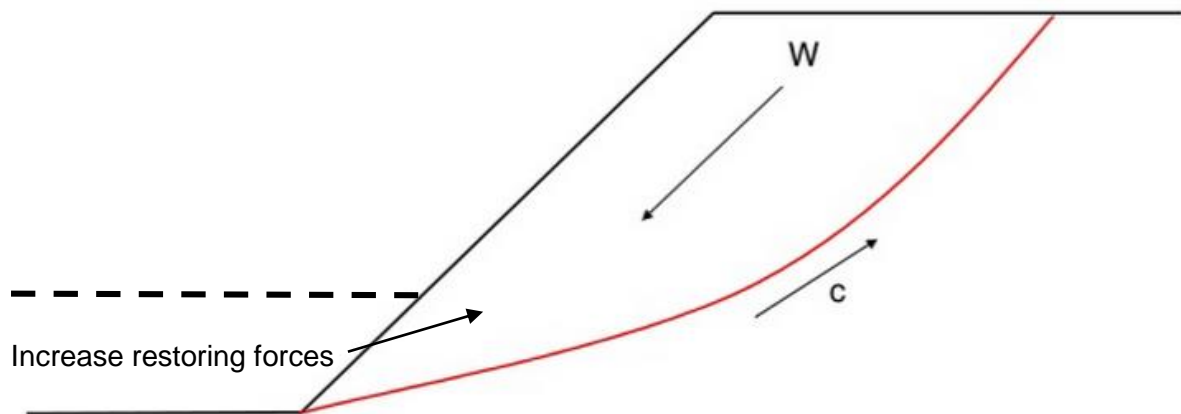
A fence or abandonment bund to prevent public access to quarry 1 (also include appropriate signage).

Deflection barrier OR Swale drain



Positioned at crest of slope to redirect excess water and reduce erosion

Weighted Toe



Increase design level to weight toe and increase restoring forces and arrest progressive slope failure

Monitoring



Monitoring inspections to assess progressive failure and / or monitoring using prisms.

Further work

It is recommended that detailed drawings / schematics for the ground management strategy targeted in domain 2 – quarry 1.

10 RISK ASSESSMENT

A risk assessment has been carried out by identifying potential hazards and assessing their risk rating by multiplication of the consequence by the likelihood (refer to Table 4 and 5).

Table 4: Risk Rating

| | Consequence | | | | |
|-------------------|--------------------|--------------|--------------|------------|--------------------|
| Likelihood | 1 - Rare | 2 - Unlikely | 3 - Possible | 4 - Likely | 5 – Almost certain |
| A – Severe | Medium | Medium | High | Extreme | Extreme |
| B – Major | Low | Medium | Medium | High | Extreme |
| C – Moderate | Low | Moderate | Medium | Medium | High |
| D – Minor | Low | Low | Low | Medium | Medium |
| E – Minimal | Low | Low | Low | Low | Low |

| Hazards | Scenario | Current Risk | | | Further Recommendations | | | |
|--------------------------------|--|--------------|--------------|-------------|--|-------------|--------------|-------------|
| | | Consequence | Likelihood | Risk Rating | Recommended Mitigation Measures | Consequence | Likelihood | Risk Rating |
| Overall Slope failure | Safety risk to personnel and equipment | 1 – Major | E-Likely | High | Monitoring, slope management including drains / deflection barrier, weighted toe | 1 – Major | E-Rare | Low |
| Localised batter scale Failure | Safety risk to personnel and operation equipment | 2- Minor | E - Likely | Medium | Monitoring using prisms and bi annual site inspections | 2 - Minor | E – Possible | Low |
| Risk to public | Public enter site | 3- Major | C - Possible | Medium | Prevent access by installing fence /abandonment bunds, signage | 3- Severe | E - Rare | Low |

Table 5: Risk Assessment for Ocean Beach Lime Quarry

11 CLOSURE

We thank you for the opportunity to submit this report. Please do not hesitate to contact the undersigned should you have any further queries.

Yours Sincerely

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