Gladstone Harbour
Dredged Spoil Disposal
Area  Bund Wall- What went wrong?
Disclaimer

• This presentation is based on observations by the authors in their previous roles which were:
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  – Warren Hornsey – National Technical Manager - Geofabrics Australasia
• It must not be construed to represent the views of the previous employers of the authors
• The purpose of the presentation is to bring to the attention of engineers, various technical aspects of the bund wall project that went wrong, so that mistakes can be avoided in future. It is not intended as a criticism of personnel involved in the project.
Why was a bunded area required

- To provide for the export of LNG from the new gas terminals at Curtis Island Gladstone, it was necessary to dredge channels for the gas export ships
- The volume of material to be dredged was over 25 million cubic metres
- Disposal of this dredged material was to be partly off-shore (at an already approved disposal area, near the Great Barrier Reef Marine Park boundary) and partly “on-shore” into a new purpose-built bunded reclamation area.
The bunded Western Basin reclamation area
Environmental conditions

• Due to the proximity of the Great Barrier Reef, dredging of the harbour seabed and the disposal of the dredged material was subject to strict environmental conditions, both Federal and State
The design provided for sediment laden water to “pond” in the main basin to allow sediment to settle, then surface water to flow via weir boxes into the wetlands and then via a weir box into the polishing pond before discharge, via a weir box, into the sea.
Conditions under which the reclamation was to be constructed and managed - Federal

– Federal Requirements

The Federal Government conditions, dated 22 Oct 2010 – GPC(EPBC2009/4904)8 included:

• The design, construction materials, construction methodology and management for the outer bund wall of the Western basin land reclamation area must ensure appropriate design of the reclamation area to prevent water quality impacts from leaching material through the bund wall, decant waters and storm-water runoff.

It is noted that the Federal Govt required a significant reduction in the proposed reclamation “footprint” to minimise impact on nearby seagrass beds.
Conditions under which the reclamation was to be constructed and managed - State

- Qld State Govt conditions included:

  Condition 65

The proponent must ensure that the design, construction materials, construction methodology and management for the outer bund wall of reclamation area for the project:

a) Is structurally sound

b) Is designed for the purpose of preventing emissions from the containment area that may cause environmental harm

c) Has been certified as fit for purpose by a registered professional engineer of Queensland

d) Is maintained to the condition certified in (c)

It was also required that the quarried material used for bund construction contain no material <12mm, to minimise potential dirty water impacts on marine flora and fauna during bund construction.
## Concept design

![Concept design diagram](image)

The following table summarizes the properties (MARV) and their standards:

<table>
<thead>
<tr>
<th>Property (MARV)</th>
<th>Standard</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass</td>
<td>AS3706.1</td>
<td>≥1100g/m²</td>
</tr>
<tr>
<td>Wide width Tensile Strength</td>
<td>AS3706.2</td>
<td>≥30kN/m</td>
</tr>
<tr>
<td>Wide width Tensile Elongation</td>
<td>AS3706.2</td>
<td>≤70%</td>
</tr>
<tr>
<td>Trapezoidal tear Strength</td>
<td>AS3706.3</td>
<td>≥580kN</td>
</tr>
<tr>
<td>CBR Burst Strength</td>
<td>AS3706.4</td>
<td>≥7380kN</td>
</tr>
<tr>
<td>Flow Rate</td>
<td>AS3706.9</td>
<td>≤25L/m²/s</td>
</tr>
</tbody>
</table>
Accepted Design

• The design proposed by the Contractor used lighter than specified Bidim A64 material
• This differed from the 1200R (Australia) material (and a similarly labelled, but significantly different Canadian material) as shown in the table below:

<table>
<thead>
<tr>
<th>Property</th>
<th>Unit</th>
<th>1200R Australia</th>
<th>1200R Canada</th>
<th>Bidim A64</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mass</td>
<td>g/m²</td>
<td>1100</td>
<td>542</td>
<td>510</td>
</tr>
<tr>
<td>Tear Strength</td>
<td>N</td>
<td>720</td>
<td>644</td>
<td>770</td>
</tr>
<tr>
<td>CBR Burst Strength</td>
<td>N</td>
<td>7300</td>
<td>4600</td>
<td>6300</td>
</tr>
<tr>
<td>Flow Rate</td>
<td>L/m²/s</td>
<td>20</td>
<td>33</td>
<td>80</td>
</tr>
<tr>
<td>Pore Size</td>
<td>µm</td>
<td>&lt;75</td>
<td>150</td>
<td>80</td>
</tr>
</tbody>
</table>
Release of contaminants from only one discharge point

- Due to the potential porosity of the bund wall cross-section, resulting from the absence of fine material less than 12 mm, the geotextile layer was the critical feature that would provide for the ability of the bunded area to comply with the permit requirements—namely the important condition that “contaminants resulting from dredge spoil disposal ..must be released only to surface waters at the north-east corner of the reclamation area.” Should this geotextile layer not function correctly, the permit requirements could be compromised.
Invitation to tender

- Invitations to Tender were advertised, seeking offers on a “design and construct” basis, with the tender documents including the “concept design” which provided for a heavy weight geotextile, with a weight of at least 1100gm/m2, embedded in the core.
The accepted tender design

• The Design & Construct tender that was accepted provided for a design that differed from the concept design with respect to two important features, namely:

• a lighter weight geotextile
  – about 500gm/m2 continuous filament vs
  – 1100gm/m2

• the geotextile was to be laid on the inner face of the bund wall (i.e. not buried in the wall)
Cross-section of bund type A as designed by contractor
note: geotextile on inner face of core i.e. not buried in the
core
Cross section designed by contractor– internal bund at wetlands – note no geotextile on either face.
Cross section at paleo channel – note no geotextile at lower level
Any contaminant containing water within the bunded area can flow to the sea through any porosity in this lower section.
The geotextile arranged in this way failed to capture much of the sediment, due to:

1. The inflow of tidal water on a rising tide through the porous wall caused the geotextile to balloon away from the core, with results including:
   – In some cases the geotextile split horizontally
   – In other cases, where the geotextile was not secured at the bottom, it lifted up
   – In both these cases, when the tidal flow reversed, the displaced sections did not return to their original position – i.e. there were crumpled areas, tears, rips and holes due to the water movements
2. The lack of covering also lead to:
   • Movement and chafing due to lifting by wind
   • Movement and chafing on the rocks due to wave action, from waves and water movement within the reclamation

   – Resulting in holes in the geotextile

3. The uncovered geotextile was exposed to:
   • Ultraviolet radiation – with potential weakening of the fibres
Cross-section of bund type A as designed by contractor note: incoming tide caused geotextile to balloon away, and tear, and/or lift off at the bottom.
Geotextile ballooning away from wall on incoming tide – 10 Aug 2011, 4.20pm, incoming tide - about half tide
GEOTEXTILE DISPLACED AND CRUMPLED
Some of the rocks found towards the toe of the bund are large, being >500mm diameter.

If these rocks have fallen down the slope, it is highly likely that they have damaged the geotextile during the fall.
No holes – dredged material settles
Water draining through hole
Holes in the geotextile induce agitated flow of sediment laden water through the hole
Bund completion

• The bund was closed on 21 July 2011
• The bund was nominally completed on 1 August 2011
• Dredging material into the bunded disposal area commenced 5th September 2011
Weir box at outlet
Leakage of sediments into the sea through the bund wall
April 2012
due to the lack of geotextile between the main basin and the “wetlands” sediments streamed into this area, compromising its function as the second settling pond, from which water was supposed to flow into the polishing pond and then into the approved outlet to the sea.
Features to be aware of for future projects

• Reversal of water flow will displace geotextile if it is not properly secured to resist the associated forces

• Consider the use of heavier geotextile, such as 1100gm/m2 staple fibre geotextile, rather than lighter geotextiles as:
  – It is thicker – greater filtration capacity hence less fines loss
  – Has higher elongation – less likely to get damaged during placement of cover material
  – Has greater abrasion resistance – will not form holes if subjected to short term wave action
Dividing bunds to control the flow of sediment laden water (to ensure flow is controlled through the weir boxes) must be non-porous, either by the provision of properly secured geotextile of the correct grade and/or constructed out of material suitably graded to render the wall non-porous.
• The geotextile must cover the bottom of the porous wall. Ensure that sufficient geotextile is placed at the toe of the wall, so that the geotextile can “collapse” down the slope if rock or mud settles, i.e. “Dutch toe” design.

• Recognise that geotextile with a nominal pore size of 80 microns, when used in conjunction with a natural filter media, is capable of preventing the flow of sub-micron clay particles if it is secured in place. See next slide
• It was argued that as the geotextile has an “opening size” of 80 microns, it would not capture fines of less than that dimension, particularly fine clay particles of sub-micron size.

• That is not necessarily the case - as is shown in the following slides and the video.
Clumping of particles

- Sketch showing particles clumping on the face of the geotextile.

- And, of course the needle punched geotextile is not a single surface (like a net) so within its thickness, material accumulates (resisting displacement if there is reversal of flow).
• The video shows two tests – the test on the left has no fine material against the geotextile; the test on the right has fine sand particles against the geotextile, which cause fine material to agglomerate to form a skeleton that limits the sizes of material that can pass through.
Video of geotextile preventing the flow of fine material

- Cylinder 1
- Cylinder 2
Quality Assurance

• There must be a relevant, strict and robust Quality Assurance process in place, particularly for these three aspects of the project:

• The grading of the core materials on which the geotextile is placed and the material used for covering it. If the core material is gap graded, with little fine material (e.g. there appeared to be very little 12mm in this case) the porosity of the wall is larger and the potential incoming tidal flow is subject to less obstruction. In particular the QA of this aspect must include the method of testing of rock material, the frequency of testing, the test results and acceptance (including actions taken in the event of defects or non-conformance).

• The supply and installation of the geotextile. For example, the testing of the material prior to installation, the Work Method to be adopted for installation, QA type “Inspection & Test” process, or daily record sheets that are signed-off on a progressive basis at the end of each day, or at completion of each “Lot” (or similar significant milestone) in this part of the work.

• Damage identification, and repair activities – any holes or tears render the geotextile ineffective in the vicinity of such damage.
Concluding comment

“Geotechnical Engineers who do not learn from the mistakes made by others, will learn from the mistakes made by themselves”

• Dr J P Giroud (the father of geotextiles)
  • Member, The US National Academy of Engineering
  • Past President, The International Geosynthetics Society