

## Victorian Landfill BPEM Comparison Table - Appendices

Item	BPEM Requirement	Comment
<b>F</b>	<b>Geotextile Use as Protection in Landfills</b>	
<b>F1</b>	<b>Introduction</b>	
	No technical content	
<b>F2</b>	<b>Background</b>	
	Background information on geotextile usage	
<b>F3</b>	<b>Minimum Requirements for Geotextile Protection Layer</b>	
	The following parameters are considered minimum requirements for geotextiles used as a protection material for geomembrane liners:	
	1. The geotextile shall be 100 per cent polyester or polypropylene (with the exception of inhibitors and/or carbon black added for UV resistance) nonwoven needle-punched geotextile. It is important to select or specify a geotextile polymer that has been formulated to meet the specific, unique demands encountered by geotextiles protection material in landfill engineering. Geotextiles made from recycled materials shall be avoided as protection material.	Included in the construction specification.
	2. Other design requirements and technical specifications for the geotextile (such as mass per unit area, tensile properties, tear resistance, puncture resistance and UV resistance).	Included in the construction specification.
	3. A statement (with justification) on the chemical compatibility of the geotextile and the leachate. In particular, the ability of the geotextile to retain adequate strength and performance after exposure to leachate.	The proposed geotextile material is as recommended in the BPEM. No alternative material has been proposed. The specified geotextile material is deemed the most geotextile liner for modern putrescible landfill construction and as such, is commonly used and represent current best practise. Polyester or polypropylene has been reliably proven to be chemically compatible with leachate produced from low hazard putrescible landfills.
	4. The design of the liner needs to consider the various potential stresses imposed on the geotextile by the in-service configuration and conditions. It is necessary to include the calculations of the physical stresses due to: <ul style="list-style-type: none"> <li>• Strains imposed at the anchor trench.</li> <li>• Strains imposed over long, steep side slopes.</li> <li>• Differential settlement of the subgrade and foundation soils, if any.</li> </ul>	This assessment has been undertaken by Golder Associates and includes the required considerations.
	5. A statement on the effect of temperature during operation (for example, the effect of waste temperatures). Describe how the waste temperature will be taken into account.	Putrescible landfills generate some heat as a result of waste decomposition. There are numerous factors that influence heat generation, including the following: seasonal variations in temperature, placement of waste, age of waste, depth and location of waste and available moisture content.

		<p>Typically, temperatures at the liner are below 30 degrees, but in actively decomposing relatively fresh waste, these temperatures can be in the range of 30 to 40 degrees, 40 degrees being an extreme value. The liner materials that have been incorporated into the design are standard materials used in putrescible landfills and have been selected due to their ability to withstand elevated temperatures and retain long-term integrity. The landfill is not anticipated to have elevated temperatures above those normally found in other putrescible landfills. With the relatively low annual tonnage and low anticipated percentage of MSW (30%), the landfill temperature should be lower than the industry standard.</p>
	<p>6. A statement on the effect of equipment traffic during installation; in particular, discuss the stresses resulting from application of the overlying layers. Describe how these stresses will be taken into account.</p>	<p>It is not reasonably possible to construct the landfill lining and capping systems without having vehicles trafficking over previously laid liner layers. The construction specification provides guidance and direction to the contractor on how to traffic over previously placed liners. The CQA Plan also includes this aspect of the construction activity for the liner consultant to monitor. The landfill has been designed to ensure that all slopes are readily accessible to construction plant (max. 1 V in 3 H) so that there is no additional strain imposed on the liner by vehicles trying to track up steep slopes.</p>
	<p>7. A statement (with justification) on the effects of mineral precipitation on the geotextiles performance. In particular, discuss the ability of the geotextile to retain adequate strength and performance after exposure to the precipitates.</p>	<p>The cushion geotextile is below the leachate drainage layer and leachate collection pipework; hence, does not impact on the leachate extraction system ability to collect and transfer leachate. It is only the separation geotextile that has the potential to negatively impact on the performance of the leachate collection layer. Best practise is to install the separation geotextile on top of the leachate collection aggregate and not as a sleeve around the leachate collection pipes. The design incorporates this best practise.</p> <p>The geotextile used is high quality material in accordance with Geosynthetic Research Institute (GRI) standards.</p> <p>Effectively, the design is based on industry best practise and consequently should minimise the impact of mineral precipitation within the fabric, leachate aggregate and leachate collection pipes.</p>
	<p>8. A statement (with justification) on the effects of microbial growth on the characteristics and the polymer of the geotextile. In particular, discuss the ability of the geotextile to retain adequate strength and performance after exposure to microbial growth.</p>	<p>The cushion geotextile is below the leachate drainage layer and leachate collection pipework; hence, does not impact on the leachate extraction system ability to collect and transfer leachate. It is only the separation geotextile that has the potential to negatively impact on the performance of the leachate collection layer. Best practise is to install the separation geotextile on top of the leachate collection aggregate and not as a sleeve around the leachate collection pipes. The design incorporates this best practise.</p> <p>The geotextile used is high quality material in accordance with Geosynthetic</p>

		<p>Research Institute (GRI) standards.</p> <p>Effectively, the design is based on industry best practise and consequently should minimise the impact of microbial growth within the fabric, leachate aggregate and leachate collection pipes.</p>
	<p>9. A statement on the effect of exposure to ultraviolet (UV). Describe how UV exposure will be minimised.</p>	<p>The cushion protection geofabric will all be covered within two years of being place. The exception being the portion of the material on the side slopes higher up than the level to which the leachate aggregate has been placed on the northern side of Cell 1 and Cell 3 that will be exposed for up to 4 years. With the thickness of geotextile being specified to accommodate the maximum weight of waste at the deepest part of the landfill and the same material being used up the side slopes, it is effectively “over designed” as a protection layer the higher up the slope the material is laid. Consequently there is substantial material loss due to UV degradation that can occur before there is a potential negative impact on its ability to protect the liner below. In addition, the geotextile is also UV stabilised to resist UV decay. During the anticipated 4 years of UV exposure, there will be only minimal material loss and not sufficient to require any remedial action. With the material being exposed, it can easily be inspected to confirm the assumption that it will not be overly damaged by UV exposure during the period.</p> <p>A similar situation will occur at the northern edge of both Cell 5 and 6. These sections of the liner could be exposed for potentially up to 10 year while the Stage 2 landfill is filled from the north heading back towards Stage 1. This is likely to be excessive UV exposure resulting in significant material loss and as part of the Stage 2 development (Stage 2 is not part of this application) there will need to be an inspection of the geotextile to determine the extent of UV degradation and if deemed necessary, the geotextile is to be overlaid with a replacement layer of similar material.</p>
	<p>10. Demonstration through conformance tests that the selected geotextile minimises local strains in the geomembrane to accepted levels for both short-term and long-term conditions.</p>	<p>The CQA Plan includes the requirement for conformance testing of critical properties of the delivered liner material.</p>
	<p>11. Specification for the geotextile protection layer that will be placed between the geomembrane and the leachate collection system, including the method of placement.</p>	<p>Included in the construction specification.</p>
	<p>12. Demonstration that there is adequate friction between the various components of the liner system to prevent slippage or sloughing on the slopes during construction and waste placement. In particular, the following must be assessed:</p> <ul style="list-style-type: none"> <li>• The ability of the geotextile to support its own weight on the side slopes.</li> <li>• The ability of the geotextile to withstand downdrag during and after waste placement.</li> </ul>	<p>The assessment of the proposed design has been undertaken by Golder Associates and includes the required considerations.</p>

	<ul style="list-style-type: none"> <li>• The suitability of the anchorage configuration for the geotextile.</li> <li>• The ability to maintain a stable configuration when the geotextile is placed on top of the geomembrane.</li> <li>• The ability to maintain a stable configuration when soils and/or other geosynthetic.</li> <li>• Components such as geocomposites are placed on top of the geotextile.</li> <li>• The ability to maintain a stable configuration during construction and waste placement.</li> </ul>	
	<p>13. A specification for liner strength and the calculations defining the minimum strength requirements:</p> <ul style="list-style-type: none"> <li>• Stresses resulting from settlement, compression or uplift.</li> <li>• Installation stresses.</li> <li>• Operating stresses.</li> <li>• Thermal stresses.</li> <li>• Climatic conditions.</li> </ul>	<p>Included in the construction specification. In addition, the assessment of the proposed design has been undertaken by Golder Associates and includes the required considerations.</p>
	<p>14. Installation specifications should include details regarding:</p> <ul style="list-style-type: none"> <li>• Subgrade condition and suitability.</li> <li>• Geotextile labelling.</li> <li>• Methods of protecting the geotextile during shipping, storage and handling.</li> <li>• Procedures to deal with inclement weather.</li> <li>• Panel deployment layout plan, panel identification, method of deployment and placement, overlap orientation, jointing methods.</li> <li>• Methods of placement in a trench.</li> <li>• Procedures to be adopted to minimise the effect of trafficking by vehicles.</li> <li>• Procedures to minimise wrinkles and bridging.</li> <li>• Procedures to deal with damages and defects.</li> <li>• Methods of placement of the leachate collection layer.</li> </ul>	<p>Included in the construction specification.</p>
	<p>15. Inspection activities. Describe how the following will be taken into account:</p> <ul style="list-style-type: none"> <li>• Skill of the installation crew.</li> <li>• Supervision of installation.</li> <li>• Inspection and approval of the jointing.</li> <li>• Weather and temperature conditions during geotextile deployment and jointing.</li> <li>• Inspection of the surface of the geotextile.</li> <li>• Presence of wrinkles.</li> <li>• Presence of damages and defects.</li> <li>• Action on damages.</li> <li>• Repair methods.</li> </ul>	<p>Included in the construction specification and in accordance with the manufacturer's installation instructions.</p>

	<ul style="list-style-type: none"> <li>Control of panel uplift by wind.</li> </ul>	
	16. CQC/CQA plan.	
<b>F4</b>	<b>Minimum Requirements for the Installation of Geotextile Protection Layers</b>	
<b>F4.1</b>	<b>Transportation, Handling and Storage</b>	
	The geotextile rolls shall be delivered to the site, handled and stored in such manner that no damage occurs to the geotextile or its protective wrapping. The geotextile rolls shall be wrapped with weatherproof wrapping to protect material from ultraviolet degradation and moisture uptake. In the event that rolls are damaged, the CQA (construction quality assurance) engineer should assess the extent of the damage and consider possible rejection of the damaged rolls.	Included in the construction specification.
	The geotextile rolls should be stored in a location away from construction traffic but sufficiently close to the active work area to minimise handling. The storage area should be level, dry, well-drained and stable, and should protect the product from precipitation, chemicals, excessive heat, ultraviolet (UV) radiation, standing water, vandalism and animals.	Included in the construction specification.
	Geotextile roll stacks shall be limited to the height at which installation personnel can safely manoeuvre the handling equipment. The rolls should not be stacked on one another to the extent that deformation of the core occurs. Under no circumstances may the geotextile rolls be dragged, lifted with the forks of a forklift or pushed to the ground from the delivery vehicle.	Included in the construction specification.
<b>F4.2</b>	<b>Geotextile Installation</b>	
	In most cases the lining task involves large areas, so it is important to proceed stage by stage in the geotextile installation process. It is suggested that the installation be conducted in the following stages: <ol style="list-style-type: none"> <li>1. Installation planning and pre-installation conformance testing.</li> <li>2. Construction and preparation of the subgrade (i.e. geomembrane).</li> <li>3. Placement of the geotextile, including transport, unrolling and placing, anchorage.</li> <li>4. Jointing of the geotextile sheets.</li> <li>5. Placement of the overlying material.</li> </ol>	Included in the construction specification.
<b>F4.2.1</b>	<b>Planning and Pre-Installation Conformance Testing</b>	
	The installation process must be preceded by a planning phase, which should result in a detailed panel layout irrespective of the type of application. The layout should specify to scale the arrangement of the geotextile sheets in the area to be lined.	The specification includes the requirement for a pre-construction meeting before any liner works are carried out.
	Each roll of geotextile shall be labelled to provide the following identifying data, and the label shall comply with AS3705–2003: <ul style="list-style-type: none"> <li>Product name, grade and name of manufacturer.</li> </ul>	Included in the construction specification.

	<ul style="list-style-type: none"> <li>• Date of manufacture, batch number, polymer type.</li> <li>• Roll number.</li> <li>• Roll length.</li> <li>• Roll weight.</li> <li>• Roll width.</li> </ul>	
	Label information shall be affixed or attached to the roll at all times during deployment of the roll.	Included in the construction specification.
	<p>Manufacturer quality control (MQC) documentation from the manufacturer of the geotextile supplied must be submitted for approval by the CQA engineer. Submissions shall include:</p> <ul style="list-style-type: none"> <li>• Date of manufacture.</li> <li>• Lot number, roll number, length and width.</li> <li>• Polymer quality documentation used in the production of the rolls delivered.</li> <li>• Fibre quality documentation used in the production of the rolls delivered.</li> <li>• Manufacturer quality control documentation for the particular lots of geotextiles used in the production of the rolls delivered.</li> <li>• QC program laboratory-certified reports.</li> <li>• The manufacturer's approved QA stamp and the technician's signature.</li> </ul>	Included in the construction specification.
	The geotextile should be tested for all critical properties by a third-party accredited independent laboratory before installation.	The liner CQA consultant will carry out the necessary conformance testing on the material delivered to site to confirm the critical material properties against the specified material properties.
<b>F4.2.2</b>	<b>Underlying Surface</b>	
	The geotextile shall be placed above the finished geomembrane. The contractor shall ensure that all CQA testing and recording has been fully completed on the geomembrane surface and all independent test results have been received prior to the installation of the geotextile protection material. The geomembrane surface upon which a geotextile will be deployed shall be free of any sharp objects, stones, debris, standing water, or other potentially damaging objects.	Included in the construction specification.
	The geotextile shall not be installed until inspection of the geomembrane has been undertaken and deemed suitable and in accordance with the specifications by the CQA engineer.	Included in the construction specification.
<b>F4.2.3</b>	<b>Placement and Jointing</b>	
	The geotextiles shall be installed such that the sheets are anchored at the crest of the slope and are rolled down side walls/slopes, so as to keep the geotextile free of wrinkles and folds. The sheets should also be continuous across the base or the cover. The arrangement of the geotextile sheets should be according to a predetermined layout plan.	Included in the construction specification.

	The geotextile shall be deployed by hand or using vehicles on pneumatic tyres with low ground contact pressure to protect the underlying geomembrane. During placement, care must be taken not to entrap (either within or beneath the geotextile) stones, excessive dust or moisture that could damage the geomembrane or hamper subsequent seaming. Jointing between sheets shall be formed by overlapping by a minimum of 150 mm. The areas to be joined shall be clean and free of foreign matters.	Included in the construction specification.
	Jointing of the sheets shall be conducted by stitching or by heat bonding using an approved hot-air device. The joints shall be continuous along the full join length. On slopes they should be constructed parallel to the slope gradient. In case heat bonding is used, the contractor shall ensure that the bonding method does not pose any risks of damage to the underlying geomembrane. In case of stitching, the thread type must be polymeric with chemical and UV light resultant properties equal or greater than that of the geotextile itself.	Included in the construction specification.
	The geotextile protection material shall not have cross joints on slopes steeper than 1:5 (V:H).	Included in the construction specification.
	The entire surface area of each and every roll shall be inspected by the CQA engineer (for example, during unrolling/installation) to ensure that there is no damage or other faults in the material (such as significant and obvious variability in thickness/mass per unit area, tears, holes or presence of broken needles). If damage is identified, it will need to be repaired according to the specifications put in place for the site.	Included in the construction specification and the liner CQA Plan.
	Geotextiles installed on slopes must be fixed in anchor trenches. This is done to secure the geotextile and prevent it from sloughing or slipping down the inside side slopes during construction or service. A normal minimum requirement is that the anchor trench must be at least one meter back from the top edge of the slope. The front edge of the trench is to be rounded to prevent the development of stress concentrations on the geotextile, or any other geosynthetics for that matter.	Included in the construction specification.
	The geotextile should be laid on the inside wall and base of the trench only, the trench should be cleared of any debris, gravel or loose material before the geotextile is installed. The trench should be backfilled and compacted with low hydraulic-conductivity soils.	Included in the construction specification.
	If white-coloured geotextiles are used, precautions should be taken to prevent snowblindness of personnel.	Included in the construction specification.
	It is very important to ensure that the geotextile is not left exposed to ultraviolet (UV) light. It is essential that covering activities be coordinated with geotextile installation. In this respect, all geotextile shall be covered as soon as practical after installation to reduce exposure time to UV radiation.	Included in the construction specification.
<b>F4.2.3.1</b>	<b>Backfill Placement</b>	
	Where a drainage layer is placed directly on the geotextile, it should be done so that the geotextile is not shifted from its intended position and	Included in the construction specification.

	underlying materials are not exposed or damaged. Furthermore, deploying the overlying material should not mobilise excess tensile stress in the geotextile.	
<b>F4.3</b>	<b>Repairs</b>	
	If the geotextile has been damaged (by tears, holes or otherwise) during installation, it can be repaired by patching a new piece of geotextile made from the same material. Any soil or other material that may have penetrated the damaged geotextile shall first be removed before any repair could be conducted.	Included in the construction specification.
	On slopes, the patch shall be double-seamed into place with the seams 5 mm to 20 mm apart. Elsewhere a patch shall be spot-seamed in place with a minimum of 300 mm overlap in all directions.	Included in the construction specification.
<b>F5</b>	<b>Quality</b>	
<b>F5.1</b>	<b>Manufacturing Specification and Quality Control</b>	
	The quality of the geotextile shall be in accordance with the requirements of the Geosynthetic Research Institute (GRI) — GT12(b) or GT12 (a). The minimum specifications for quality geotextile products are contained in GRI Test Method GT12(b)/GT12(a), the standard specification for 'Test methods and properties for nonwoven geotextiles used as protection (or cushioning) materials'.	Included in the construction specification.
	A statement on the origin of the fibres and polymer must be included, as well as certified copies of the quality control certificates issued by the fibre suppliers and polymer manufacturers, as well as reports on the tests conducted by the manufacturer to verify the quality of the fibres and polymers used to manufacture the geotextile rolls assigned to the project. The geotextile must also have been through a quality control (QC) program including processes put in place to detect and remove broken needles.	Included in the construction specification.
	The manufacturer's geotextile QC program should be available for auditing. The manufacturer should also provide a written certification that the geotextile conforms to the material requirements for the project.	Included in the construction specification.
<b>F5.2</b>	<b>Construction Quality Control (CQC)</b>	
	Installation of the geotextile must be undertaken by geotextile installers with extensive installation experience and competence with the specified geotextile. In the case of installation of multicomponent liners composite, they shall provide sufficient evidence of installation experience and competence with other geosynthetics. In either case, they must provide experience records prior to any installation.	Included in the construction specification.
<b>F5.3</b>	<b>Third-Party CQA Consultant</b>	
	An independent third-party CQA consultant with experience with geotextile and knowledgeable of geotextile characteristics and other geosynthetics must be appointed to verify that the works have been carried out to the	An appropriately experienced third-party CQA consultant will be appointed to verify that the Works have been carried out to the agreed standards. The

	agreed standards.	Synthetic Liner CQA Plan sets out the aspect of the Works that are to be verified.
	The duties of the third-party CQA consultant include inspections, verifications, audits and evaluation of materials and workmanship, provision of advice on installation, testing, repair and covering of the geotextile protection, and issuing a final CQA report documenting the quality of the constructed facility.	Included in the Liner CQA Plan.
<b>F5.4</b>	<b>CQA Plan</b>	
	The CQA plan needs to provide procedures for identifying non-conformance and for corrective action.	Included in the Liner CQA Plan.
<b>F5.5</b>	<b>Conformance Testing</b>	
	Table F1 (refer below) provides guidance on the test properties and recommended minimum testing frequencies.	Included in the Liner CQA Plan.
<b>F5.6</b>	<b>CQA Report</b>	
	A CQA report must be prepared by the CQA consultant to demonstrate that all requirements of the project specifications and CQA plan have been complied with.	The CQA consultant will provide a CQA Verification Report, which will be included in the Works Approval Compliance Certification documentation sent to the DER on completion of the Works.

**Table F1: Guidance on CQA testing for nonwoven geotextile protection material**

<b>Item</b>	<b>Property</b>	<b>Standards</b>	<b>Frequency</b>
Conformance testing (upon shipment of geotextile to the site)	Thickness	AS 2001-2.15	1 sample per 2,500 m <sup>2</sup>
	Mass per unit area	AS 2001-2.13	1 sample per 2,500 m <sup>2</sup>
	Tensile strength	AS 3706-2	1 sample per 5000 m <sup>2</sup>
	Tear strength	AS 3706-3	1 sample per 5000 m <sup>2</sup>
	Burst strength	AS 3706-4	1 sample per 5000 m <sup>2</sup>
	Puncture resistance of geotextile	AS 3706-5	1 sample per 5000 m <sup>2</sup>
Destructive tests	Tensile tests for joints.	AS 3706-6	As required.
Visual inspection of geotextile	Colour, thickness, tears, holes, punctures, needle-punching, presence of needles or broken needles, and other faults in the material.		Each roll during placement.
Thickness of geotextile	On-site.		Each roll during placement. If thickness appears to be variable a check of the variability of the mass per unit area should be conducted.

**Note:**

All conformance tests must be reviewed, accepted and reported by a CQA consultant before deployment of the geotextile cushion material.

All testing must be performed on samples taken from the geotextile delivered to site under the CQA consultant's supervision.

All laboratory tests must be performed in an accredited, independent, third-party laboratory.

The required testing frequencies may be revised by the CQA consultant to conform with improvements in testing methods and/or in the state-of-the-art practice and/or to account for the criticality of the application (i.e. to account for the importance of the geotextile for the safety of works). Revisions must be approved by the relevant authorities before application.