KAYTECH
ENGINEERED FABRICS

Johannesburg +2711 922 3300
Pinetown +2731 717 2300
Cape Town +2721 531 8110
East London +2743 727 1055
Port Elizabeth: +2744 453 0755

enviroFIX®

# Geosynthetic Clay Liner

## Contents

# 1 INTRODUCTION

**EnviroFix**® is a needlepunched Geosynthetic Clay Liner (or GCL) produced in South Africa in accordance with the ISO 9001:2008 Quality Management Systems. In addition **Envirofix**® carries the CE marking which serves to ensure that all **Envirofix**® products are manufactured in compliance with the applicable European directives for specific functions.

**EnviroFix**® consists of natural sodium bentonite powder, which acts as the swelling and sealing component, embedded and sandwiched between two or more geotextiles. The composite is then needlepunched through all layers developing high connection strength. Thus, **EnviroFix**® is a shear strength transmitting GCL.

**EnviroFix**® is generally fast and easy to install; however, the performance of the GCL is dependent on the quality of its installation. It is the installer's responsibility to follow these guidelines and the project specifications and drawings whenever possible. It is the engineer's and owner's responsibility to provide Construction Quality Assurance (CQA) for the installation to ensure that the installation has been executed properly. Variance from this guideline is at the engineer's discretion. Kaytech highly recommends that these guidelines are applied and strictly adhered to.

Recommended further reading:

1. ASTM D5888 – Standard Guide for Storage and Handling of GCLs
2. ASTM D6102 – Standard Guide for Installation of GCLs
3. ASTM D5889 – Standard Practice for Quality Control of GCLs
4. ASTM D6072 – Standard Guide for Obtaining Samples of GCLs

## 2 PACKAGING, TRANSPORTATION & UNLOADING ON SITE

**EnviroFix**® rolls are packed in moisture tight plastic wrapping. The standard roll dimensions and weights are listed in Table 1. Every **EnviroFix**® roll has a unique roll number on the wrapping, conformance certificate label and complete traceability is ensured by printing the product code, date and time of manufacture on the GCL panel.

Table 1 – **EnviroFix**® standard grade roll dimensions and mass

| Grade | Width (m) | Length (m) | Diameter (cm) | Rolls per 20 foot container | Mass (kg) |
|---|---|---|---|---|---|
| X800 | 5.35 | 40 | 58 | 16 | 1 040 |
| X1000 | 5.35 | 35 | 60 | 16 | 970 |
| X2000 | 5.35 | 35 | 60 | 16 | 950 |
| X3000 | 5.35 | 30 | 58 | 16 | 920 |

**Note:**
Up to 15 % of rolls may contain two pieces over the length. These rolls are marked on the conformance certificate label indicating the number of pieces and the individual piece lengths. A minimum of 5m piece length and a maximum of two pieces per roll is the standard set for all **Envirofix**® products. Extra length is included to provide for the overlap.

**EnviroFix**® rolls are usually delivered to site in closed containers or covered trailers on flatbed trucks. At the point of unloading, the rolls need to be accessible either from the top of the trailer or the container opening.

Should any damage to rolls occur in transit it must be immediately brought to the attention of the Supplier, who will advise on the required course of action.

A flat, hard, dry and free-draining surface must be provided for unloading and storage. Rolls may be off-loaded using:

- The two slings provided by the manufacturer wrapped around the **EnviroFix**® roll at two points, fixed to an excavator bucket, front-end loader or crane. Slings should not be used for general lifting and transportation around the site. If excessive deformation or bending of the roll occurs, the integrity of the composite may be affected. A steel tube or similar reinforcement can be inserted into the core of the roll to prevent excessive deformation across the roll during off-loading.
- A Spreader Bar with a steel tube insert through the core of the rolls. Refer to Section 8 and the ***EnviroFix® Spreader Bar Safe Usage Guideline*** in the **EnviroFix**® product folder for detailed information.

or

- **EnviroFix**® may be unloaded and handled using a ‘carpet prong’ protruding from the front end of a forklift (> 3.5 tonne) or other equipment. The prong should be at least three-quarters the length of the core and must also be capable of supporting the full weight of **EnviroFix**® without significant bending.

Under no circumstances should **EnviroFix**® rolls be dragged, lifted by one end only, pushed to the ground from the delivery vehicle, or otherwise unloaded in a fashion that could damage the roll.

After transportation and unloading, the plastic wrapping should be checked. Minor damage should be repaired with weather-resistant adhesive tape. Wrapping should only be removed immediately before use. The maximum storage height is five (5) rolls.

The lifting slings are wrapped around each end of the roll and covered with a high visibility protective tape.

## 3 STORAGE

**EnviroFix**® rolls should be stored in their original, unopened packaging in a location away from construction traffic but sufficiently close to the active work area to minimise handling.

The designated storage area should be level, dry, well-drained and stable, and should protect the product from:

- Precipitation
- Chemicals
- Standing water
- Excessive heat
- Ultraviolet radiation
- Vandalism and animals

**EnviroFix**® rolls should always be stored lying flat, continuously supported, and should never be stored standing on one end. Enclosed indoor storage such as shipping containers or a warehouse environment is preferred if **EnviroFix**® is to be stored for long periods.

## 4 INSTALLATION REQUIREMENTS

- Excavator (tracked or wheeled) or front-end loader
- Spreader Bar / Loading Frame
- Bentonite Paste, available in two options:
  - > Option A – Premixed from the supplier in 25 litre buckets (undercoat and topcoat)
  - > Option B – Natural sodium bentonite powder to be mixed on site
    - Water (water container)
    - Heavy duty drill with industrial whisk (high shear force required)
    - Mixing containers
- Trowel
- Carpet knife or covered blade (for safety)
- Felt pens or chalk
- Measuring tape
- Broom

## 5 INSTALLATION TEAM

Before installing **EnviroFix**®, this guideline should be read thoroughly by the installation personnel. The installation team should be aware of their individual roles in ensuring a quality installation. Any questions raised by the installation team that cannot be answered by this document should be referred immediately to the Supplier.

## 6 SUBGRADE PREPARATION

The preparation of the subgrade before placement of any lining material is critical to the system's performance. The surface(s) upon which **EnviroFix**® is to be laid should be suitable for the intended application and function.

**EnviroFix**® will generally be placed on either an earthen (e.g., compacted clay) or geosynthetic covered (e.g. geotextile or geocomposite) subgrade.

### 6.1 Earthen Subgrades

The surface upon which **EnviroFix**® will be deployed should conform to the following:

- The subgrade should be firm and unyielding (typically compacted to > 90 % density), without abrupt elevation changes, and be proof-rolled with a smooth drum roller immediately prior to deployment of the panels. The subgrade should not be disturbed or rutted by the equipment deploying the rolls or other traffic. No foreign matter or stones loose on the surface or penetrating out of the subgrade > 10 mm should be allowed. The engineer's approval of the subgrade needs to be obtained immediately prior to roll deployment.
- In applications where **EnviroFix**® is the sole or primary barrier and will be subjected to constant or long-term hydraulic heads exceeding 300 mm, subgrade surfaces consisting of gravel or granular soils may not be appropriate due to their large void contents and puncture potential. In these applications, the top 150 mm of the subgrade should possess a particle size distribution where at least 80 % of the soil is smaller than 0.25 mm – unless the **EnviroFix**® grades X2000 or X3000 are being used (see below).
- It is recommended that the slopes on the embankments do not exceed 3H: 1V. For X2000 and X3000 grades (with a composite woven/nonwoven carrier geotextile) in high hydraulic head applications:
- Subgrade materials ***recommended*** without further investigation are:
  - > Clays or clay-based mixes
  - > Sandy clays (with > 20 % fines*)
  - > Silty or loamy clays (with > 20 % fines*)

    *Fines < 0.075mm
    (Fine-grained soils should be placed at suitable moisture contents for construction operations and roll deployment, and provide adequate bearing capacity to deploy the rolls without disturbance of the subgrade – i.e., no rutting or large deflections.)
  - > Well-graded sands and gravels ($d_{max}$ < 32 mm, d60 < 5 mm, d20 < 0.15 mm)

    (This material should bind and have good bearing capacity when compacted/rolled.)
- Subgrade materials ***not recommended*** without further investigation:
  - > Single-sized and gap-graded sands and gravels of any size or description
  - > Sands or soils that have low bearing capacity at the moisture contents during the construction/deployment operations (i.e., materials that do not bind when rolled, or will heave or shove under equipment or foot traffic during or after deployment)
  - > Subgrades that have a porous or bony appearance after compaction and rolling

### 6.2 Geosynthetic Subgrades

When deploying **EnviroFix**® over a geosynthetic material such as a geomembrane or geotextile, the surface should be firm and unyielding as per the requirements for ***Earthen Subgrades***. The equipment used to deploy **EnviroFix**® should be approved for use by the Design Engineer and/or the Supplier of the underlying geosynthetic material. Generally, the underlying geosynthetic and **EnviroFix**® rolls will be deployed consecutively such that each layer is side-cast from equipment tracking over the earthen subgrade – unless specialised light rubber tyre dispensers are available and approved by the Design Engineer that allow direct trafficking over the geosynthetics.

### 6.3 Anchor Trenches

Anchor trench and slope stability considerations should be assessed by the Design Engineer.

As a general guide:

- An anchor trench should be used at the top of slopes steeper than 7H: 1V. (See Figure 18 for a typical anchor trench detail). Long / steep slopes may require more detailed design of the anchor trench.
- The anchor trench should be constructed free of sharp edges or corners, and maintained in a dry condition.
- The **EnviroFix**® panels should be placed down the front face and along the base of the anchor trench. The base of the anchor trench should not contain large gravel or loose material and the trench backfill material should be well-compacted.

## 7 WEATHER CONDITIONS FOR INSTALLATION

Light rainfall(1) should not affect the installation of **EnviroFix**® provided deployed panels are covered and confined by 300 mm of cover soil (or equivalent) within two hours of first exposure to the light rain. Heavy direct raindrop impact should be avoided. The **EnviroFix**® panels can be covered during heavy rainfall events with a tarpaulin or plastic sheet if there is not enough time to complete soil cover placement.

Avoid placing **EnviroFix**® in areas where water is ponding unless panels can be confined immediately (with 300 mm cover soil or equivalent).

(1) Light rainfall is defined as < 5 mm/hr intensity

## 8 ENVIROFIX® GCL PLACEMENT

The **EnviroFix**® roll wrapping should only be removed immediately prior to installation. On site, **EnviroFix**® is unrolled along the prepared subgrade using the Spreader Bar assembly as shown in Figures 1 and 2.

Rolls must be laid without folds on the subgrade with a standard overlap of 300 mm in both the longitudinal and transverse directions. For longitudinal or “edge” overlaps, the black marker tape 300mm in from the edge on the underside of the panels can be used to ensure the correct overlap width. The edge of deployed or previously placed panels needs to coincide or match with the visible black edge marker line on the roll being deployed.

The transverse or end overlaps need to be sealed using bentonite paste that is applied in two layers with different consistencies. The treatment of end (transverse) overlaps is detailed in Section 10.

Rolls can be cut to length with a carpet or “Stanley” knife. When overlapping cut panels bentonite paste will need to be applied as per the requirements for end (or transverse) overlaps in Table 2 of Section 9.

No trafficking or walking should occur over the overlap region. The overlap must also be free from folds and foreign matter (e.g., soil). Any soil particles on the laps must be swept away carefully.

Overlaps should occur in the direction of ground slope or soil cover placement in a similar manner to roof tiles.

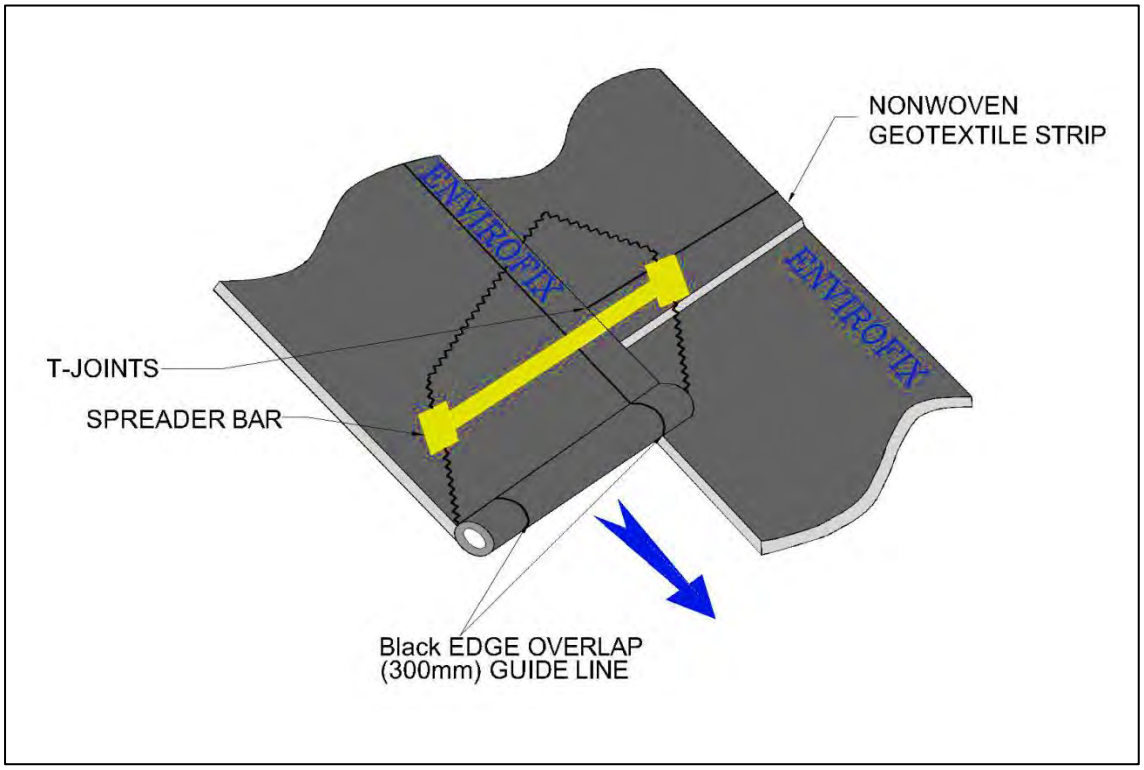



**Figure 1**: **EnviroFix**® deployment using the standard **EnviroFix**® Spreader Bar

Important:

Refer to the ***EnviroFix***® ***Spreader Bar Safe Usage Guideline*** prior to using the lifting equipment and ensure Occupational Health and Safety requirements have been met and potential hazards are eliminated.

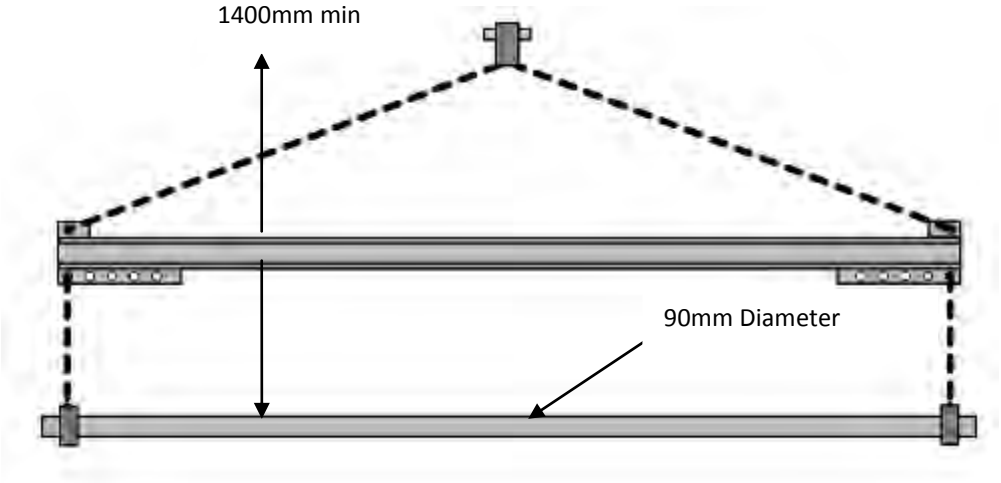



**Figure 2**: Spreader Bar Assembly – 1 250 kg safe working load

(Structural Engineer shop-drawings provided upon request)

## 9 TREATMENT OF ENVIROFIX® PANEL OVERLAPS

The compositions of the various **EnviroFix**® grades are not identical and as a result the treatment of the panel overlaps differs slightly. Figures 3 and 4 show the grades in cross-section and highlight how the panel edges in the roll (or longitudinal) direction differs. The treatment of the overlaps for each grade has been summarised in Table 2. Selection of the appropriate **EnviroFix**® grade should be discussed prior to installation with the Supplier.

Table 2 – Summary of **EnviroFix**® panel overlap treatment to be performed on site

| **EnviroFix**® Grade | | Minimum Overlap Length (mm) | End (or transverse) Overlaps | | | |
|---|---|---|---|---|---|---|
| | | | Undercoat | Topcoat | Fillet of Bentonite | **bidim**® A2 |
| X800 (Figure 3) | Composite Liner | 300 | ✓[1] | ✓[1] | ✗ | ✗ |
| | Primary Liner | 300 | ✓[1] | ✓[1] | ✗ | ✗ |
| X1000 (Figure 3) | | 300 | ✓[1] | ✓[1] | ✗ | ✗ |
| X2000 & X3000 (Figure 4) | | 300 | ✓[2] | ✓[2] | ✓[2] | ✓[2] |

**Notes:**
During the **EnviroFix**® manufacturing process, bentonite powder is encapsulated into the upper nonwoven geotextile along the edges of each roll to form and effective labyrinth-type seal. Subsequently, the edge (or longitudinal) overlaps do not require any additional treatment. See Figure 5.

[1] See Figure 10 for a cross section of treated end (or transverse) overlaps, X800 & X1000.

[2] See Figure 13 for a cross section of treated end (or transverse) overlaps, X2000 & X3000.

### 9.1 Cross-sections of the different EnviroFix® grades

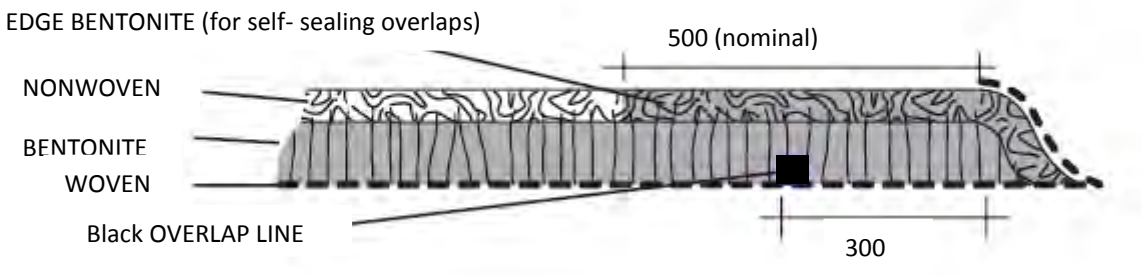



**Figure 3: EnviroFix**® X800 and X1000 roll edge

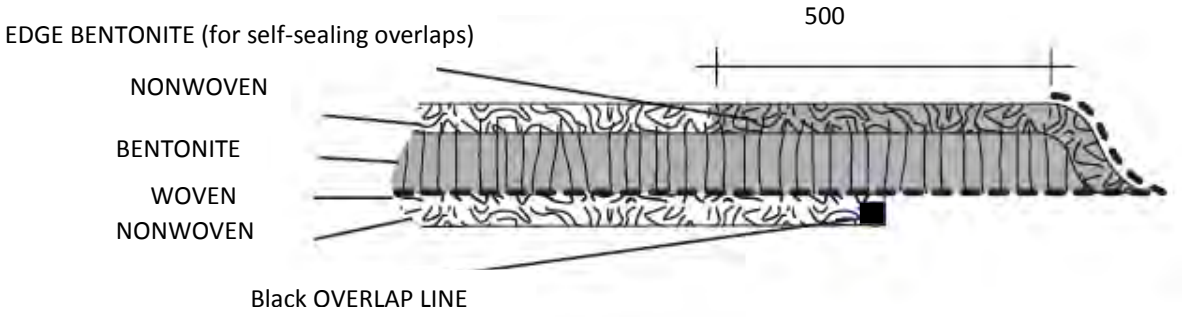



**Figure 4: EnviroFix**® X2000 & X3000 roll edges (Note: X3000 is approximately 10 % thicker than X2000)

### 9.2 Treatment of Edge (or Longitudinal) Overlaps

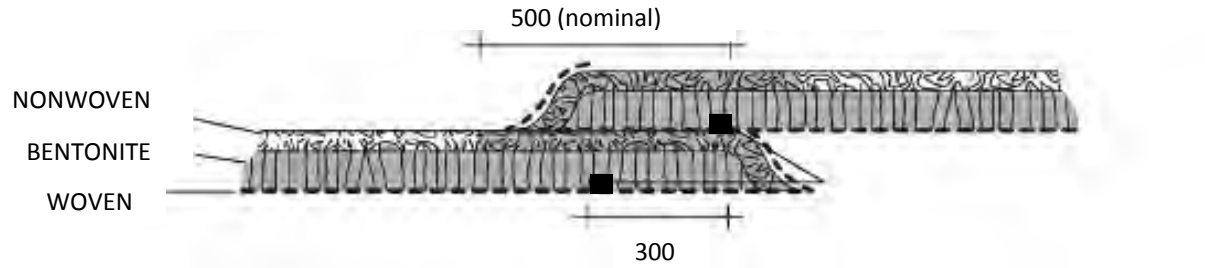



**Figure 5:** Edge (or longitudinal) overlaps, with self-sealing edges (X800/X1000 shown)

## 10 TREATMENT OF END OVERLAPS (TRANSVERSE DIRECTION)

To ensure the integrity of the **EnviroFix**® lining system it is essential that the treatment of end overlaps be carefully supervised. End overlaps in sumps or inverts are to be avoided.

All end overlaps must be sealed with bentonite paste.

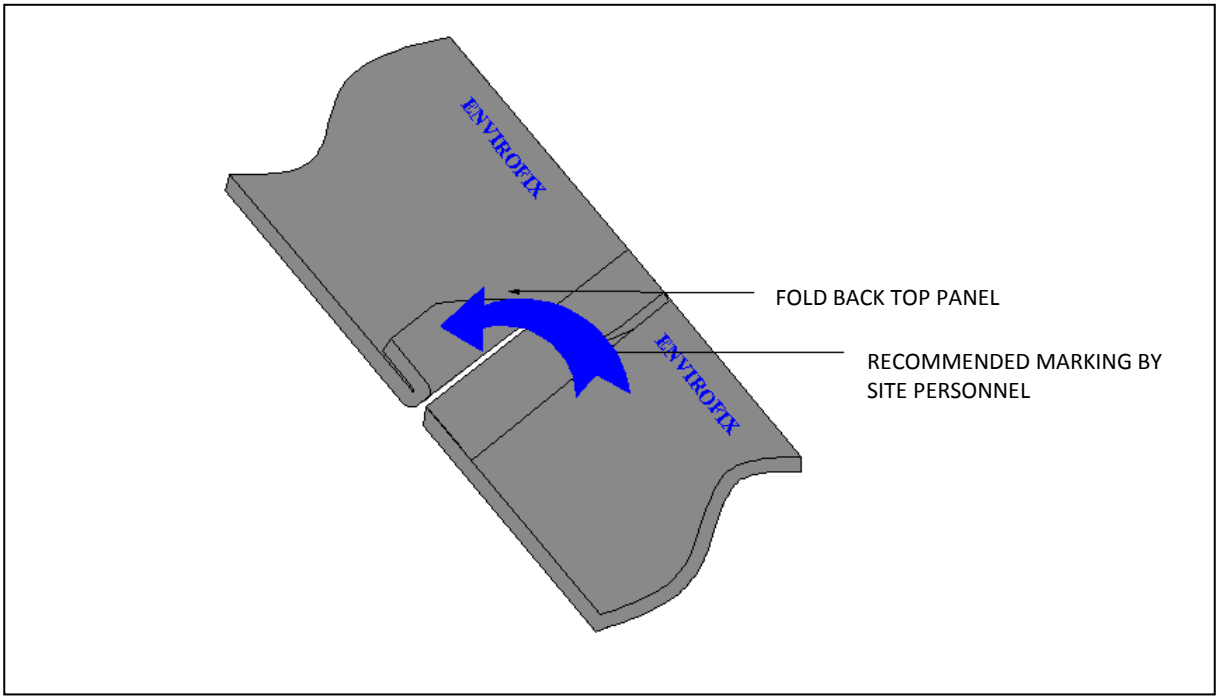



**Figure 6**: End overlap preparation

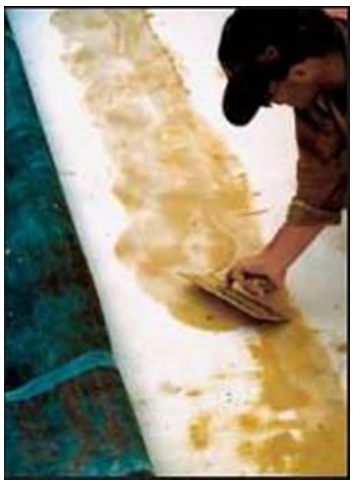
### 10.1 Preparation of End Overlap Area

It is recommended that the topside of the underlying **EnviroFix**® panel be marked (as per Figure 6) as a reference point for paste placement. The top **EnviroFix**® panel is then pulled back after marking.

### 10.2 Undercoat Application

A thin-fluid paste is applied as an undercoat in the overlap area. The aim is to fill the pores in the top nonwoven geotextile of the underlying **EnviroFix**® panel.

**Plate 1:**



a. Undercoat

b. Topcoat

The undercoat is prepared as follows:

A sufficiently big mortar tub or bucket is filled with water and bentonite powder added incrementally through a sieve whilst mixing: 9 parts water to 1 part natural sodium bentonite,

available from the Supplier (other bentonites will swell differently and may not be of the same quality). An electric drill with an industrial whisk is required to ensure a smooth paste is achieved. Alternatively, natural sodium bentonite paste can be purchased premixed in 25 litre containers from the Supplier.

The paste is spread with a trowel or broom into the overlap area as shown in Figure 7. The paste is applied into the cover nonwoven of the bottom **EnviroFix**® sheet to a width of 200 mm, at a rate of 1.23 litres/m, 150 mm behind the recommended marking and 50 mm in front of the marking. (See ***EnviroFix® Paste Calculator***)

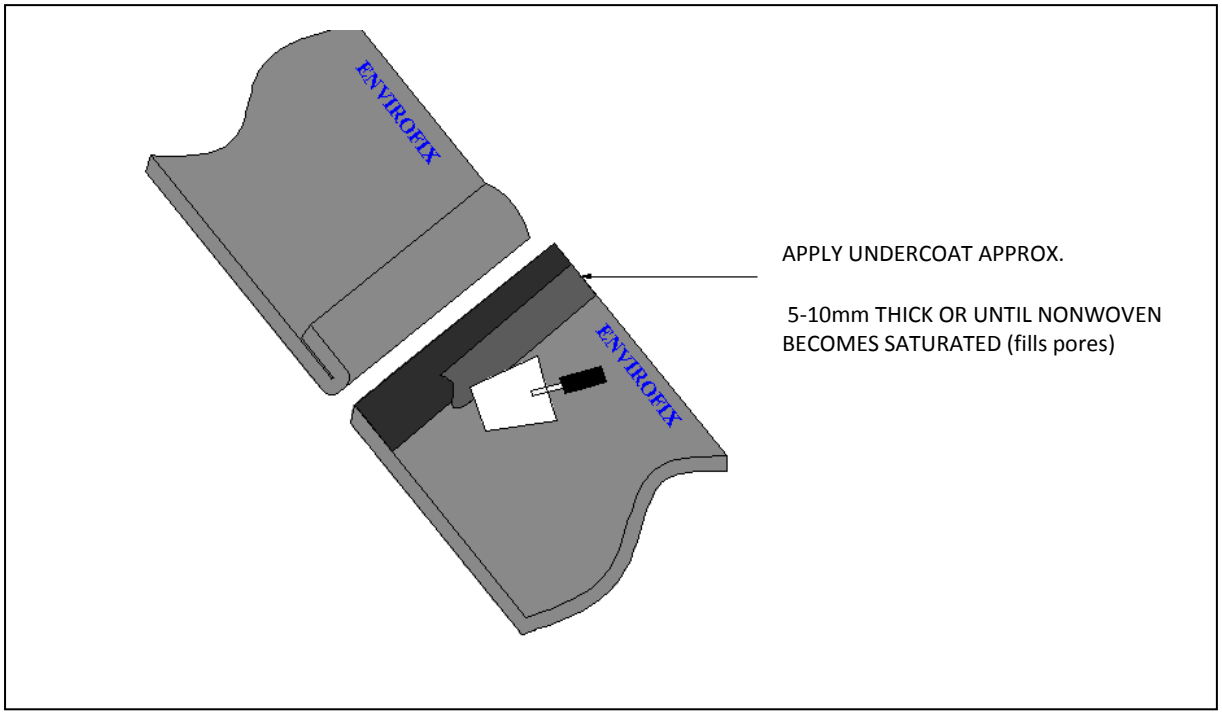



**Figure 7**: Applying the undercoat

### 10.3 Topcoat Application

A thick bentonite paste is required for the topcoat in the overlap area and is prepared as previously indicated, using a mix of 6 parts water to 1 part natural sodium bentonite. The aim is to fill the free pore space of the overlap area.

This paste is evenly spread using a trowel applied over the undercoat to a thickness of approximately 5 to 10 mm. The topcoat is spread to a width of 200 mm, at a rate of 1.87 litres/m, 150 mm in the overlap and 50 mm in front of the overlap area (Figure 8). (See ***EnviroFix® Paste Calculator***)

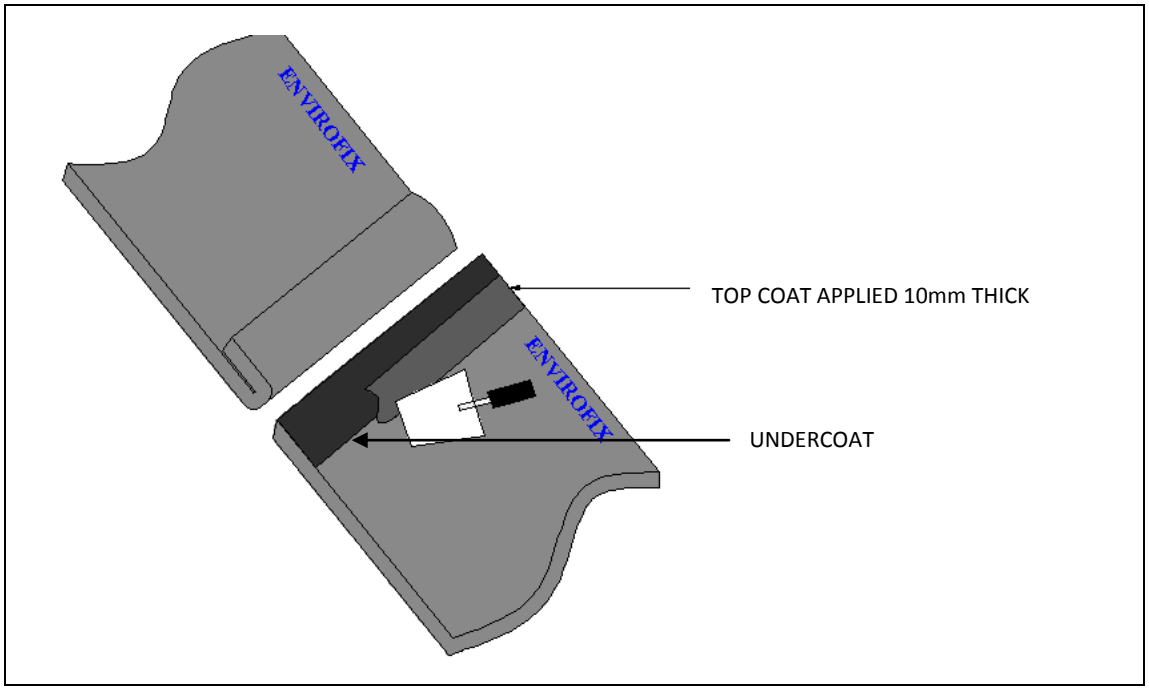



**Figure 8:** Applying the topcoat

Both the undercoat and topcoat can be purchased premixed in 25 litre containers from the Supplier.

### 10.4 Closing the Overlap

The top panel is then rolled back into place and pressed down (Figure 9). Care should be taken to prevent folds or creases. Fish mouth folds are easily pressed out with a soft broom. The completed end (or transverse) overlap is shown in Figure 10.

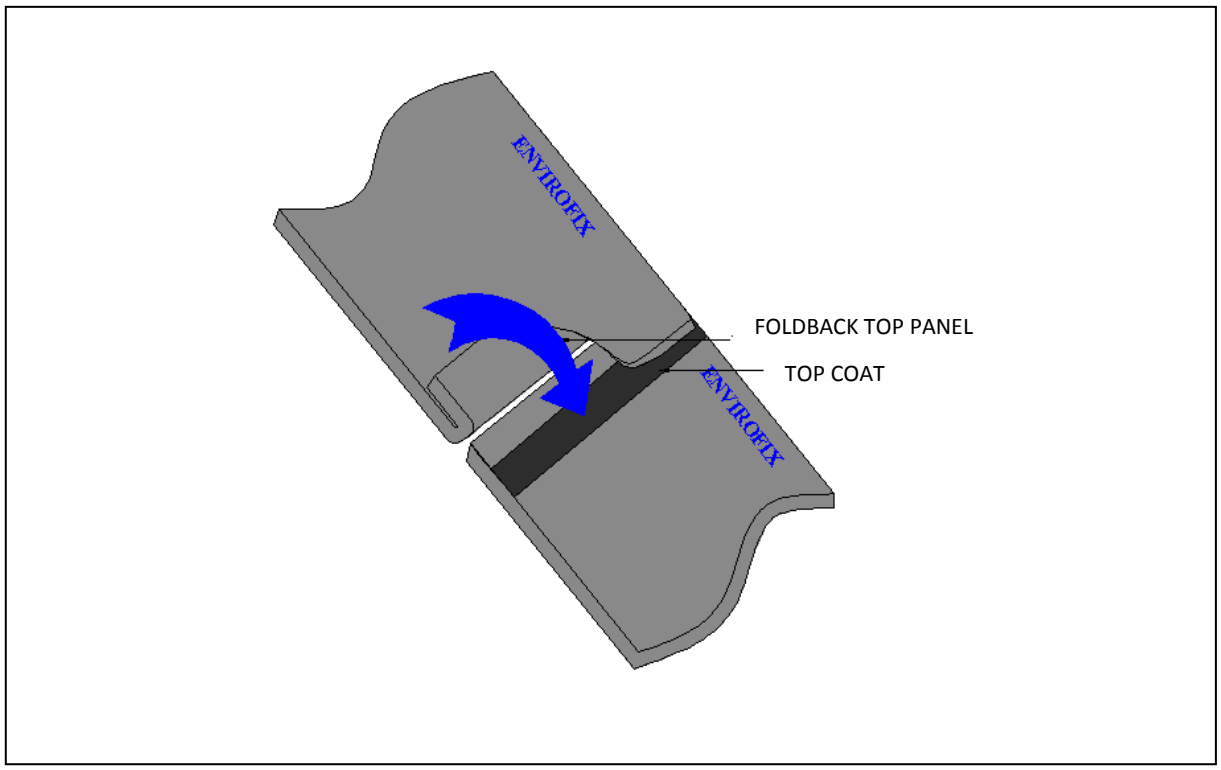



**Figure 9:** Closing the treated overlap

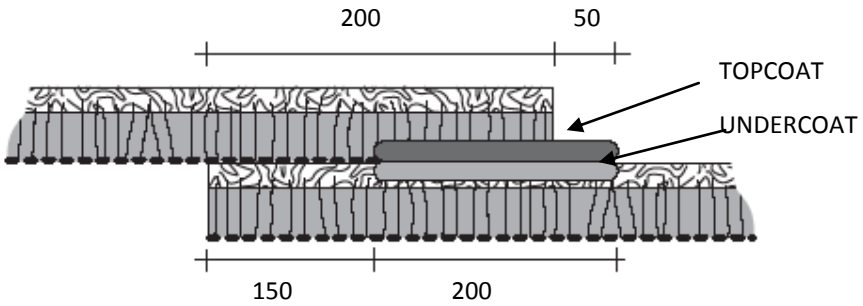



**Figure 10**: End (or transverse) overlaps treatment for X800 and X1000 only

### 10.5 Additional Requirements for EnviroFix® X2000 and X3000

**Plate 2:**

**EnviroFix**® X2000 and X3000 require an additional fillet of bentonite paste over the transverse seam area. After rolling back the upper **EnviroFix**® panel onto the treated overlap area, the overlap edge is covered with thick bentonite paste to a thickness of approximately 10–20 mm and to a width of 100 mm either side of the overlap (Figure 11). A nonwoven fabric strip (**bidim**® A2 – available from the Supplier) is then placed over the bentonite fillet to prevent cover soil ingress (Figure 12).

This step is not required with **EnviroFix**® X800 or **EnviroFix**® X1000

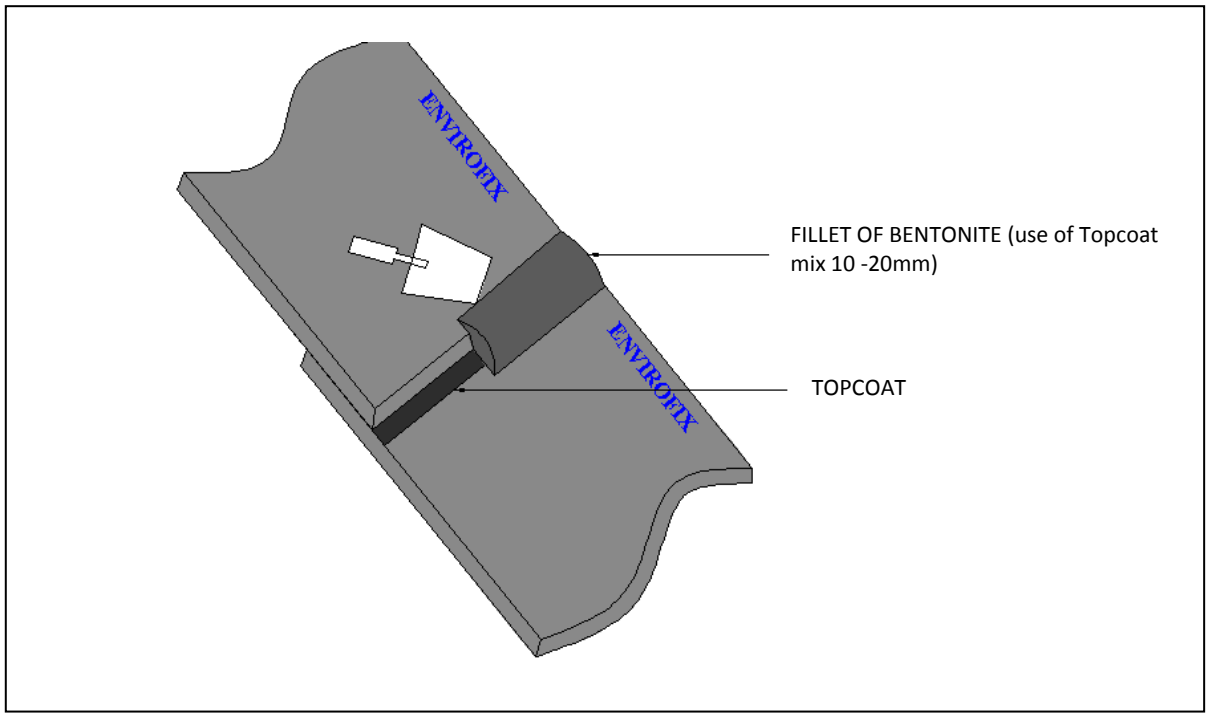



**Figure 11:** Additional bentonite fillet application (required for X2000 and X3000 only)

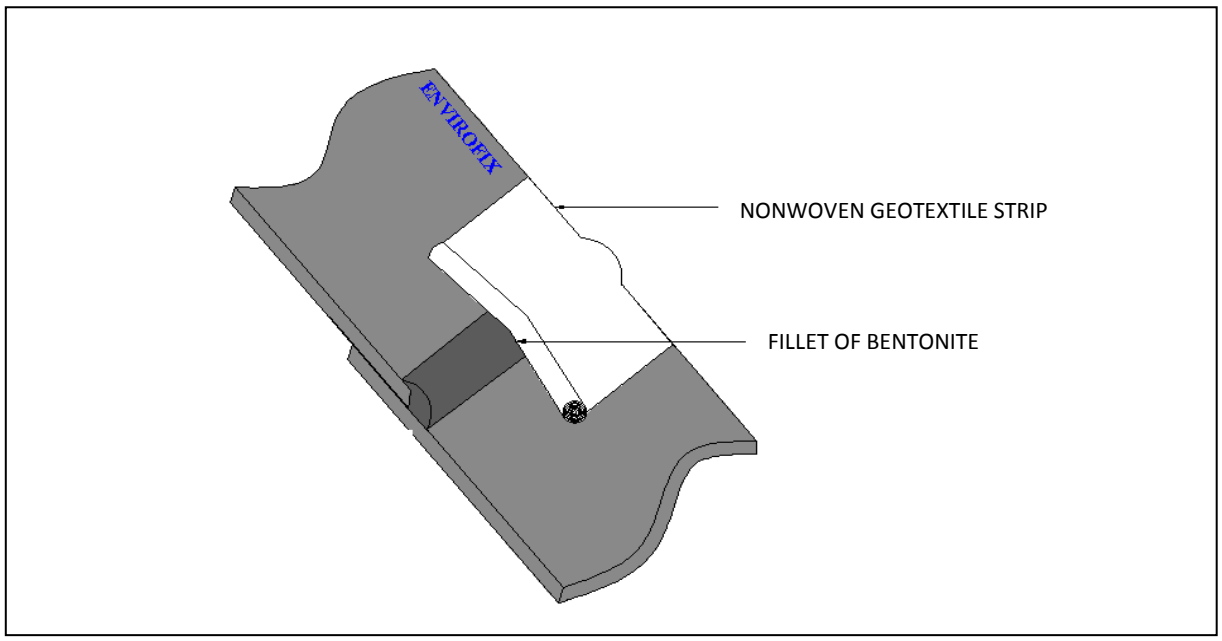



**Figure 12:** Cover the overlap with bidim® A2 geotextile strip (required for X2000 and X3000 only)

The completed end (or transverse) overlap for X2000 and X3000 is shown in Figure 13.

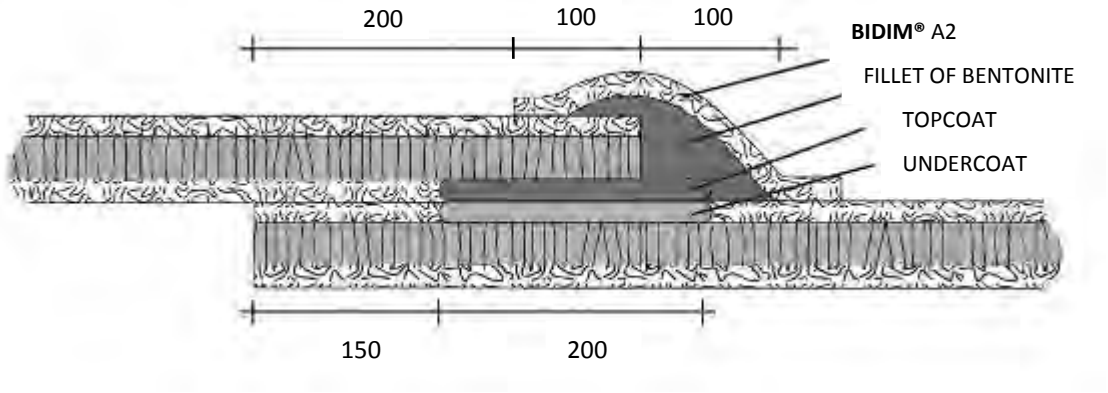



**Figure 13:** End (or transverse) overlaps treatment for X2000 and X3000 only

## 11 INSTALLATION ON SLOPES

The stability of lining system components on slopes should be assessed on a case-by-case basis. The Supplier can assist in this respect upon request.

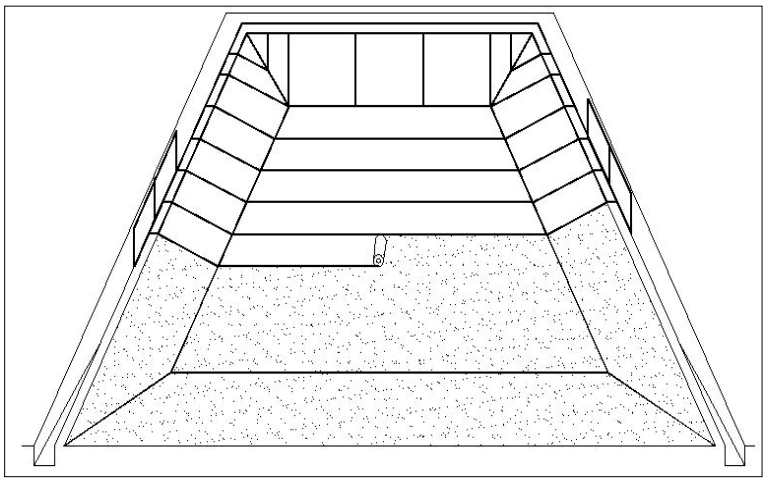


**Figure 14:** Recommended panel layout for sloping sites

**EnviroFix**® panels should be deployed in the direction of the slope as per Figure 14 and anchored at the crest of the slope (see Figure 18). End (or transverse) overlaps on steep slopes should be avoided. If they are unavoidable, the panels should be placed according to the roof tile principle and intermediate anchorage on the slope may be required.

Cover soil should be placed up the slope (starting at the toe). It must not be installed down the slope unless stability for this approach has been carefully investigated.

## 12 CONNECTIONS & PENETRATIONS

Overlaps around connections, penetrations and where panels have been cut should be carried out according to the principles outlined in Section 10. Most situations require site-specific design input; however, some commonly used details are shown below:

- Penetrations such as pipe ducts are typically carried out according to Figure 15.
- Integration with thick compacted clay liners is shown in Figure 16.
- Attachment and sealing against concrete structures can be achieved according to Figures 17a and 17b. The first detail (Figure 17a) is typical for newly constructed (impermeable) structures where a connection on the same plane as the **EnviroFix**® panel can be achieved (such as along the top of a footing). The second typical connection (Figure 17b) is appropriate where the structure needs to be waterproofed to a height above the maximum containment level. Temporary fixing of the vertical **EnviroFix**® panel to the structure (as shown) may be required to allow the backfill placement.
- Further connection methods and penetrations details can be discussed with the Supplier.

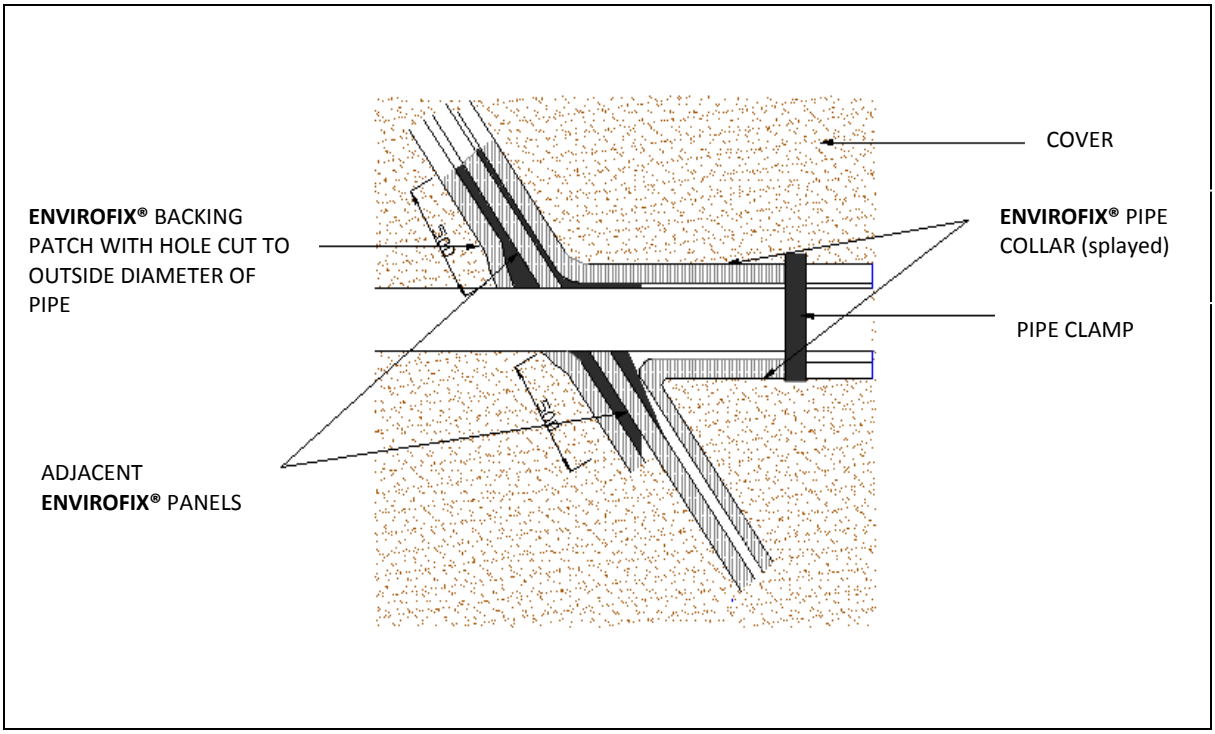



**Figure 15**: Typical pipe penetration detail

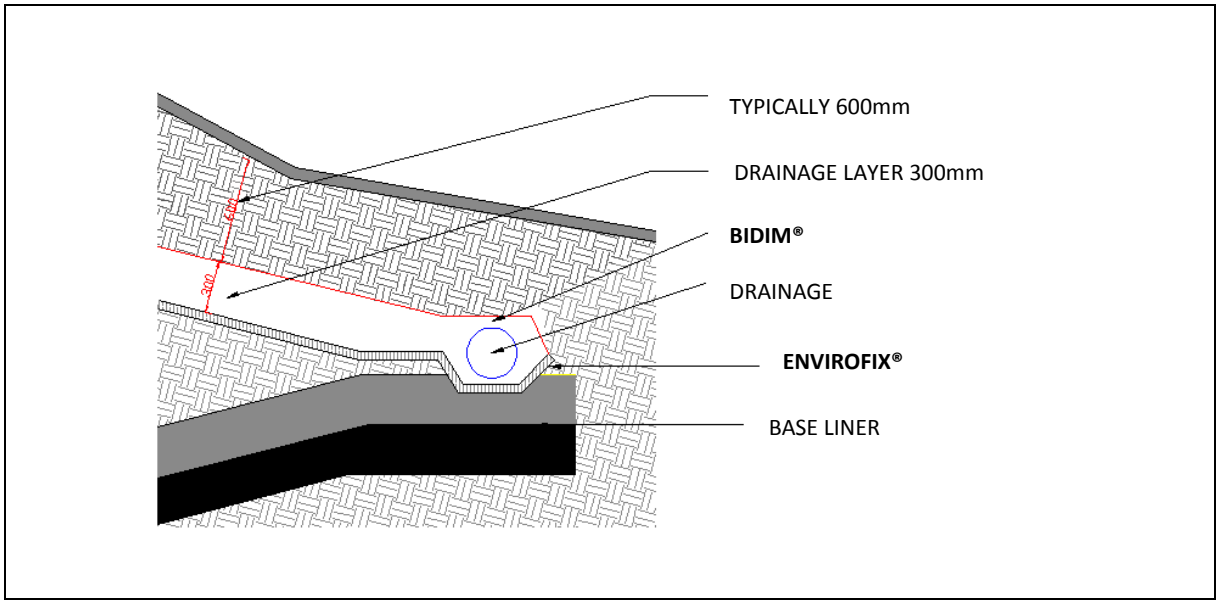



**Figure 16**: **EnviroFix**® cap connection with base liner

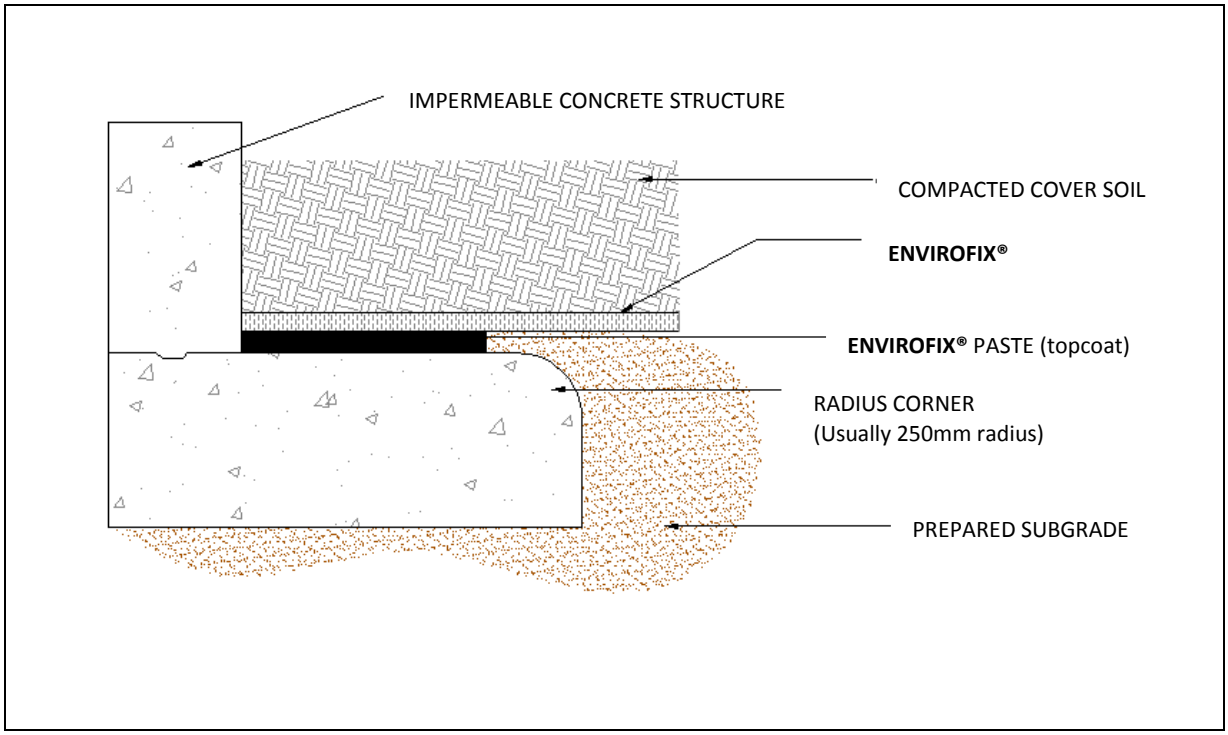



**Figure 17a:** Typical connection to an impermeable concrete structure where contact can be made on the same (horizontal) plane as the **EnviroFix**® panels

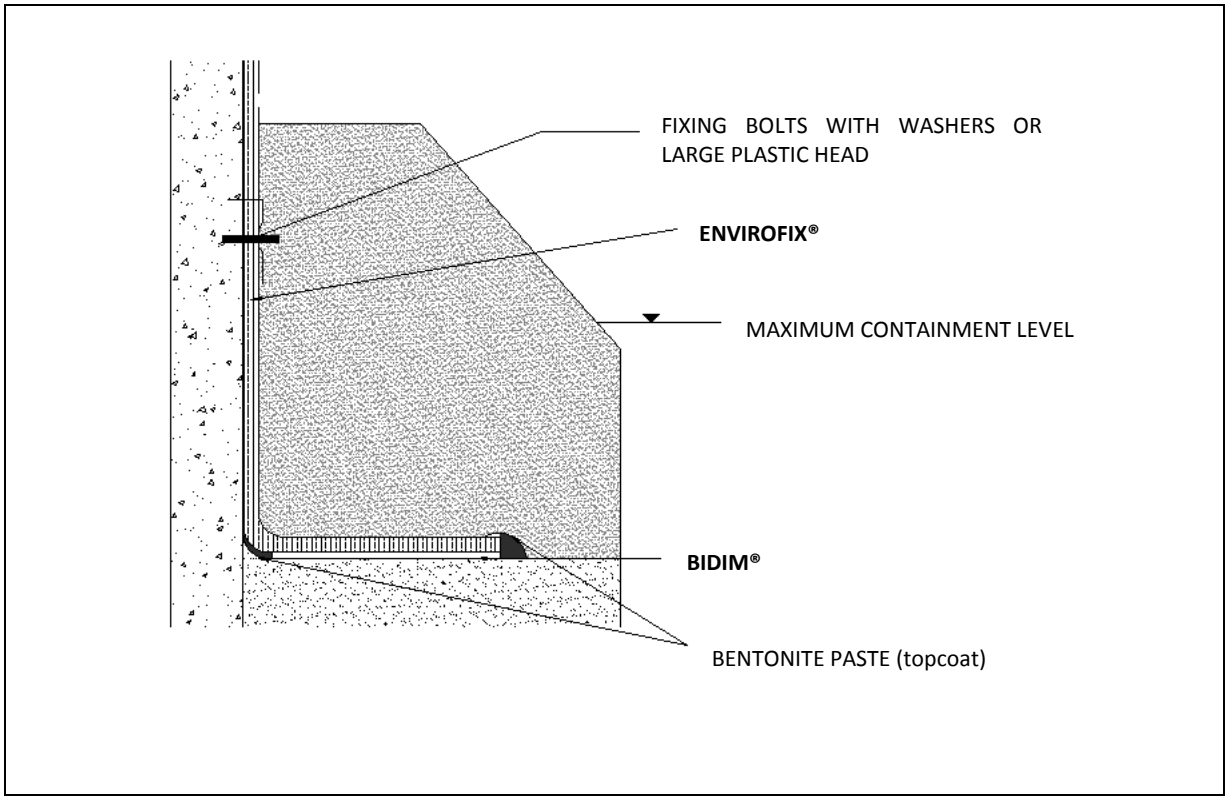



**Figure 17b:** Typical connection to a concrete structure where the **EnviroFix**® panel is required to extend above the maximum containment level

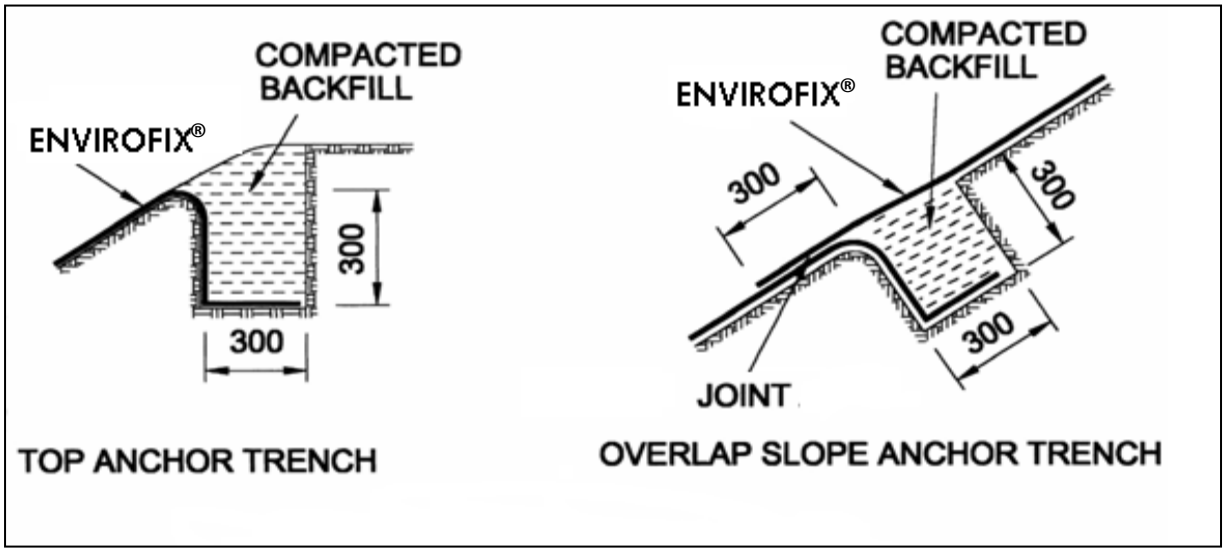



**Figure 18:** Anchor trench detail. (Long / steep slopes may require more detailed design of the anchor trench)

## 13 PREPARATION FOR PLACING SOIL COVER

Where the **EnviroFix®** is not confined by the cover soil the same working day as deployment, a temporary layer of plastic should be laid to protect **EnviroFix®** from prematurely hydrating (Figure 19).

If the deployed **EnviroFix®** panels have hydrated (for example during a rainfall event) without confinement, special operating conditions may need to be imposed during cover soil placement.

| | | |
|---|---|---|
| i.e.: | If **EnviroFix®** m.c. < 50 % | No special considerations |
| | If **EnviroFix®** 50 % < m.c. < 100 % | Avoid direct traffic (including foot traffic) on the panels. |
| | If **EnviroFix®** m.c. > 100 % | Contact the Supplier for further advice. |
| | m.c. – moisture content of the bentonite, % by weight | |

### 13.1 SOIL COVER PLACEMENT

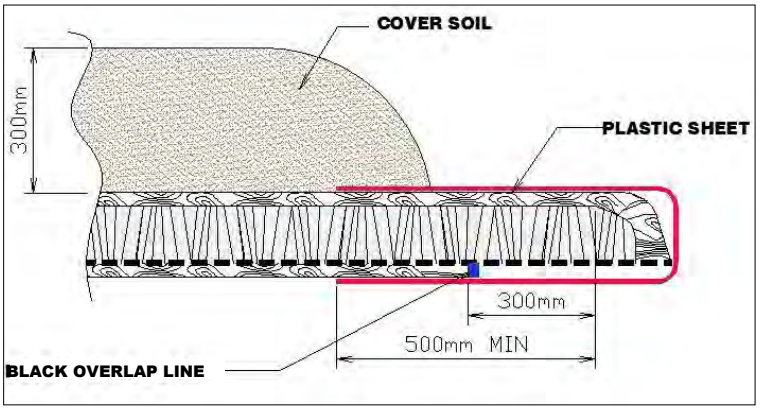



**Figure 19:** Covering **EnviroFix®** with plastic sheet overnight or during wet weather

A cover soil layer at least 300 mm thick (approximately 6 kN/m confining stresses) should be placed over **EnviroFix®** each working day immediately after the deployed panels have been inspected. In general, fine-grained cohesive material is recommended, although stones up to 32 mm are acceptable if the material is well-graded ($C_u$ > 5) or stones up to 16 mm if single sized. Silty soils or organic material is not recommended without further stability analysis.

Disturbance of the overlap area during placement (by means of vehicles spreading cover soil) must be avoided. It may be necessary to place the cover soil in this area manually or carefully using vertical placement by an excavator. The cover should not be pushed or graded in a direction that may cause the overlap to move (Figure 20).


**Figure 20:** Covering soil placement

**EnviroFix**® may not be trafficked directly. The cover material should be pushed in front of the construction equipment thus creating a safe working platform.

Overlaps should not be moved or squeezed during this process. In the case of an expected repeated dynamic load on **EnviroFix**®, a sand layer of at least 300 mm should be laid first on the **EnviroFix**®.

Generally, temporary access roads should not traverse deployed panels. These areas should be sealed last to minimise traffic volume over deployed material. Where site traffic cannot be avoided (e.g., the delivery of cover material by lorries) additional protection measures will be required. For temporary roads, a minimum road base thickness over **EnviroFix**® of 600 mm is acceptable without any further analysis. Shallower coverage or alternative cover materials may be allowed after further analysis or field trials to assess the damage potential.

## 14 REPAIRS

Where **EnviroFix**® has been damaged during installation, covering with an overlapping piece of **EnviroFix**® can repair such areas. The overlap should be at least 500 mm and should be completed in accordance with Section 10.

## 15 PRE-HYDRATION

Where **EnviroFix**® is to contain liquids or leachates that contain hydrocarbons, non-aqueous phase liquids, or saline (high EC) solutions, it may be necessary to hydrate the covered (confined) GCL with fresh water prior to contact with the liquid to be contained. Hydration with fresh water prior to contact can usually be accomplished by natural rainfall and/or absorption of moisture from the subgrade or cover soils. Accelerated pre-hydration can be achieved when required by using water-carts, irrigation systems, or through flooding of the impoundment once **EnviroFix**® has been placed under confinement. Normal pre-hydration post-manufacture may be considered.