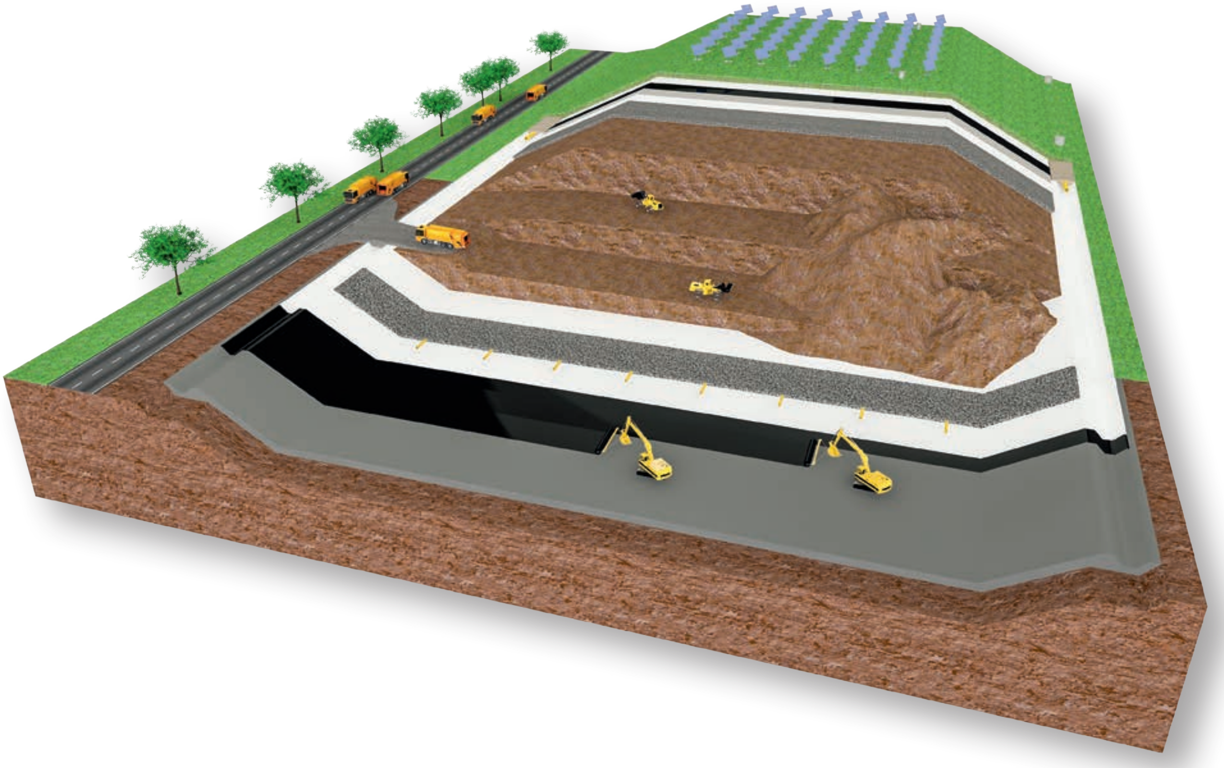
# Landfill Engineering

Naue



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Building on sustainable ground.

# Content

# History

Fifty years ago, the waste stream was quite different. Organics were mostly recycled, composted or incinerated. Packaging was made of wood or paper. Plastics were still largely unknown. At that time around the world as well as in Germany – where geosynthetics from Naue were born – waste legislation had not been established, so disposal practices were determined by basic administrative bodies. Municipalities were concerned more with the appearance of appropriate practice. The 1960s' industrial boom, however, created an unprecedent increase in the volume of waste needing to be managed. The need for a formal, standardized and engineered disposal system could no longer be ignored.

The experience in Germany is representative of how waste management regulations have emerged around the world. More stringent rules have been created to answer the environmental challenge presented by increased volume and the changing nature of waste streams.

Another common factor throughout the world has been the addition of geosynthetics as options or required components for engineered landfill systems.

In Germany, the movement towards geosynthetic protections began with the 1972 passage of the country's first true waste management regulations. These provided mandatory minimum protections for the environment and basic responsibilities on how the waste stream needed to be handled. Old "dumps" needed to be closed.

In the United States, waste management began to change substantially with the passage of the Resource Conservation and Recovery Act (RCRA) in 1976. The RCRA Subtitle D code pertained to municipal solid waste and by the early 1980s the US Environmental Protection Agency (EPA) was moving Subtitle D to require geosynthetics for long-term lining protection of soils and groundwater beneath landfills. Regardless of global region, waste regulations ultimately can only provide a framework for managing waste, precisely because the types of waste being collected change, as do the technologies for and innovation in waste containment systems. Products utilised to provide the essential protection must, subsequently, be qualified by standardized processes to ensure state-of-practice suitability and safety.

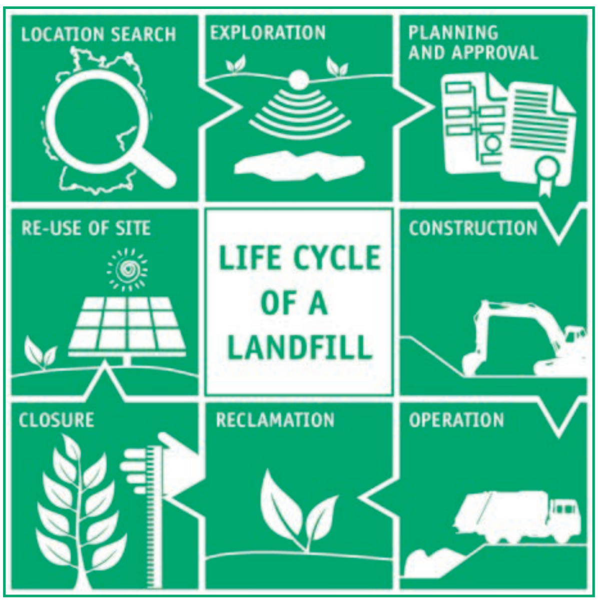
Geosynthetics have excelled not only in performance in landfills but in their amenability to standardized testing and data collection that can be replicated.

Naue has supplied geosynthetics into these more stringent modern landfill projects since 1989. Key products have included Carbofol® geomembranes, Bentofix® geosynthetic clay liners, Secudrain® drainage composite products, Secutex® nonwoven geotextiles, Secugrid® and Combigrid® geogrids and Secumat® for erosion control.

These highly engineered materials provide efficient, cost-effective and long-term stability to landfill and contaminated site applications.

In this modern waste management approach, geosynthetics provide significant advantages, such as cost and time savings in construction, greater airspace for waste burial, enhanced environmental performance, service lives exceeding 100 years and a better carbon footprint.

Naue's geosynthetics, supported by independent approvals and suitability assessments, are engineered to meet all of the waste management and affiliated brownfield remediation sectors' stringent requirements and ambitious goals.



# Regulations

Regulatory agencies around the world have long accepted geosynthetics as an alternative design solution or have outright required their use in certain applications. The waste management sector has benefited more than any other sectors, through the requirement to use geosynthetics in municipal solid waste containment and closure systems. Europe, Germany and the United States provide exemplary cases for the incorporation of geosynthetics into environmental regulations to prevent or reduce as much as possible, any negative impact from landfilling on surface water, groundwater, soil, air or human health. This is achieved by introducing stringent technical requirements.

## Europe: The Landfill Directive

The Landfill Directive on the landfill of waste (Council Directive 1999/31/EC of 26 April 1999) is a directive issued by the European Union to be implemented by its Member States by 16 July 2001. The Directive is applicable to all waste disposal sites and divides them into three classes: (I) landfills for inert waste, (II) landfills for hazardous waste and (III) landfills for non-hazardous waste. The EU Landfill Directive requires the protection of soil, groundwater and surface water, achieved by the combination of a geological barrier and a bottom liner (where these barriers can be completed artificially and reinforced by other means giving equivalent protection, e.g with a GCL) and in addition to the geological barrier a leachate collection and an artificial sealing system (e.g. HDPE 2mm geomembrane) for hazardous and non-hazardous landfills.

## Germany: BAM & LAGA

Since the late 1970s, Germany's LAGA (State Working Group on Waste) has issued recommendations for landfill liners. The administrative provisions of the Technical Guidelines on Waste (1991) and Technical Guidelines on Municipal Waste (1993) oversaw, inter alia, federal uniformity in landfill sealing system requirements. LAGA's work has included harmonization between 40 relevant approval authorities in Germany to create uniform national quality standards (BQS) and product-specific suitability assessments. Alongside LAGA's work, BAM (Federal Institute for Materials Research and Testing) released the NRW Directive for Geomembranes in 1986 and the Niedersachsen Barrier Code in 1989. The 2009 Landfill Directive helped to establish full governing authority for BAM within the landfill sector's use of geosynthetics. Today, BAM oversees the relevant suitability assessments for geosynthetics, regulations which are enforced nationally. Geosynthetic products in German landfill lining systems must offer a minimum of 100-year service lives.

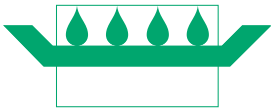
## USA: Subtitle D Regulations

The passage of the Resource Conservation and Recovery Act (RCRA) in 1976 was bound to influence international waste management to some degree, in part because of the enormous buried waste sector in the United States. RCRA's Subtitle D code pertained to municipal solid waste, and by the early 1980s the US Environmental Protection Agency (EPA) was moving Subtitle D to require geosynthetics for long-term lining protection of soils and groundwater. This provided a strong connection between the fields of waste management and geosynthetics, one which would provide a significant scale for projects and study.

Double liner systems (primary and secondary liners) have become common and highly effective solutions for containment in municipal solid waste and hazardous waste cells. The effectiveness of geosynthetics in base lining systems and cover systems has led to waste management being the most highly rated sector of infrastructure in the United States (ASCE Report Card on American Infrastructure). Also, the strong record in solid waste has led the US EPA to require similar geosynthetic-based systems for containing the nation's large coal ash deposits.

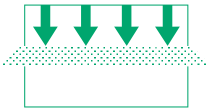
Overall, the experiences of Germany and the United States underscore why geosynthetics are so welcomed in regulation. They are supported by an extensive record of performance, have demonstrated steady improvements in installation efficiency and techniques and provide quantifiable, repeatable testing and data to support confidence in the chemical compatibility, design suitability, economical selection and more for waste management.

# Functions



## Sealing

Acting as liquid and gas barriers, geomembranes have become a fundamental component in landfill engineering as well as in civil engineering, due to the heightened need for groundwater protection. High density polyethylene (HDPE) geomembranes, specifically those with a certification by government regulators and thicknesses of more than 1.5mm, are most commonly used. Personnel from those companies that have been approved by the certifying agency, are employed to both deploy and weld the geomembranes where an area needs to be sealed. For sealing purposes HDPE geomembranes and geosynthetic clay liners are gaining use due to the importance of a quality seal.

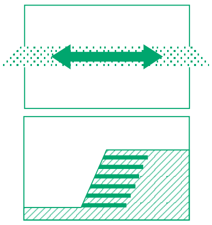


## Protection

Geomembranes, structures, coated materials as well as related construction elements must often be protected from potential mechanical damage. Without suitable protection, damage may occur from sharp-edged objects such as stones, from the unevenness of the subsoil or even by the cover material. Needle-punched nonwovens as well as composite materials manufactured from polypropylene (PP) are commonly used for protection layers. Specific to nonwoven geotextiles, the protection function is directly related to the thickness and mass per unit area, as a heavier and thicker nonwoven is more likely to provide better protection.

## Drainage

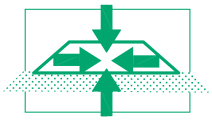
Drainage materials are required for the surface collection of precipitation, the subsurface collection and diversion of groundwater and the general collection of fluids and their discharge into a drainage system. Drainage systems are typically designed with individual material layers or in combination with other components to create preformed composite drainage elements. Composite drainage elements consist of at least one filter layer and one drainage collection layer. The drainage collection layer is required for the flow and discharge of fluids at a collection point, without the build-up of hydraulic pressure. Single and multiple component geosynthetic drainage systems made from high density polyethylene as well as polypropylene will often replace the conventional thick mineral drainage layer.



## Reinforcement

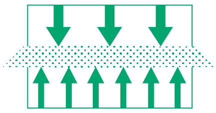
Geosynthetics are installed beneath or between soil layers to improve the mechanical properties of soil layers by absorbing the tensile forces and minimizing deformation. Geotextiles, geogrids and composite synthetic materials are used in applications such as retaining structures according to the principles of “reinforced soil“, slope stabilisation or for foundation reinforcement of earthen dams where the subsoil exhibits poor bearing capacity. The use of geosynthetics for reinforcement applications minimizes expensive constructive measures, can reduce soil intermixing and eliminates the need for additional soil layers.

## Stabilisation



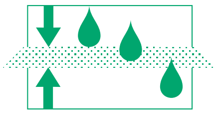
Due to the interlocking of the base course material with the apertures of the geogrid the granular particles are locked into the geogrid structure and are thus stabilised. By stabilising the base course material, the stresses resulting from cyclic and dynamic loads are absorbed and the horizontal and vertical movements within the unbound material are reduced. This counteracts loosening within the base course and increases the service life of infrastructure schemes.

## Separation



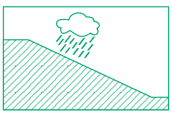
As a separation layer, geotextiles are used to prevent adjacent soil layers or fill materials from intermixing. Synthetic nonwovens that exhibit an elongation capacity, are the materials of choice in most applications. The selection of a suitable product is dependant upon the base course grain size and the operational loads to be expected. The main use of separation nonwovens are road and railway construction, hydraulic engineering, landfill engineering and sport fields.

## Filtration



In filtration applications and drainage systems, nonwoven geotextiles are employed to retain soil particles while allowing the vertical passage of liquids through the filter media. There are two aspects to filtration that should be evaluated when designing. The mechanical filter efficiency (does the fabric have sufficient soil retention capacity) and the hydraulic filter efficiency (does the water discharge without building up hydraulic pressure).As with mineral filter layers, the geotextile thickness directly benefits the long-term mechanical and hydraulic efficiency of the filter.

## Erosion control



Geotextiles or three-dimensional open structured geosynthetics can be used to minimize the movement of soil particles due to flow of water. By preventing soil particles from being washed off slopes or channels, rapid vegetation is ensured when erosion control mats are employed.

# Base Liners

Landfill base lining systems provide permanent protection of soils and groundwater from the pollutants in a waste mass. Lining system requirements are often specified in national regulations and geosynthetics have become common components of these systems.

Geosynthetics fulfill the stringent containment parameters of landfill liner regulations. Geosynthetics provide an efficient, significantly effective and durable barrier for long-term environmental protection. But achieving this effectiveness requires proper design, specification and installation of the geosynthetic system. To remove waste for repair or remediation of an improperly designed or executed barrier system is technically difficult and expensive.The geosynthetics utilised in a base lining system must be made from high-quality raw materials. The geosynthetics must be highly resistant to chemical and biological attack. For side slopes, the polymeric barrier must have the proper frictional characteristics for geosynthetic-geosynthetic and geosynthetic-soil. Understanding how to properly evaluate and select these materials will prevent unacceptable creep or the development of tensile stresses in the system. Creep and unpermitted stresses could lead to slope instability and possible failure.

The thickness of geomembranes in a base lining system is generally established in regulations. In the United States, for example, primary commonly call for 1.5mm HDPE geomembranes. In Germany, 2.5mm is standard, in other European countries such as the UK 2mm thick HDPE geomembranes are used. Compared to general construction solutions like an asphalt layer, both of these geosynthetic thickness ranges are significantly more cost-effective and they are far more impermeable and durable in containment.

In many countries, geosynthetic clay liners (GCLs) are also permitted to be used in a landfill lining system as an alternative to clay mineral layers. Systems may also include nonwoven geotextiles to protect impermeable barrier materials from installation damage and ballast-related overstressing. Protection layers are determined by the height of the landfill and the grain size and configuration of the drainage layer. Nonwoven geotextiles may also act as a separation and filtration layer between the mineral drainage layer and the waste.

| System component | Inert waste | Municipal solid waste | Hazardous solid waste |
|---|---|---|---|
| Geological barrier | $t \geq 1.00$m<br>$k \leq 1x10^{-7}$m/s | $t \geq 1.00$m<br>$k \leq 1x10^{-9}$m/s | $t \geq 5.00$m<br>$k \leq 1x10^{-9}$m/s |
| *alternative* | BENTOFIX® geosynthetic clay liner and 0.5m thick geological barrier | BENTOFIX® geosynthetic clay liner and 0.5m thick geological barrier | BENTOFIX® geosynthetic clay liner and 0.5m thick geological barrier |
| Artificial sealing layer | not required | Geomembrane<br>CARBOFOL® * | Geomembrane<br>CARBOFOL® * |
| Drainage layer | mineral aggregate<br>$t \geq 0.50$m | mineral aggregate<br>$t \geq 0.50$m | mineral aggregate<br>$t \geq 0.50$m |

* e.g. UK thickness ≥ 2.0mm
Germany thickness ≥ 2.5mm

## Naue Solutions

Carbofol® HDPE geomembranes provide high chemical and biological resistance and exceptional long-term service lives for landfill security. Smooth-surfaced Carbofol® geomembranes may be used on slopes up to approximately 1:9. Structured (textured) Carbofol® geomembranes are used for steeper slopes.

Bentofix® geosynthetic clay liners are composite materials made of two layers of geotextile (cover and carrier layers) that encapsulate a core of highly swellable powder sodium bentonite. Needle-punching of the geotextiles in manufacturing firmly bonds the layers across the entire surface of the GCL. This prevents bentonite erosion and increases the durability of the material. Bentofix® GCLs are used as a mineral sealing layer in geosynthetic barrier designs.

Secutex® nonwoven geotextiles are mechanically bonded (needle-punched) to provide highly durable protection and long-term separation and filtration functionality. A variety of geotextile weights, such as 1.200g/m$^2$ and 300g/m$^2$, provides robust protection and optimal separation and filtration design usage. Secutex® enables engineers to specify the appropriate nonwoven to meet landfill performance needs and product approval authority guidelines.

Secugrid® and Combigrid® geogrids redistribute loads to stabilize and strengthen soil layers. This includes enabling the construction of steep embankments.

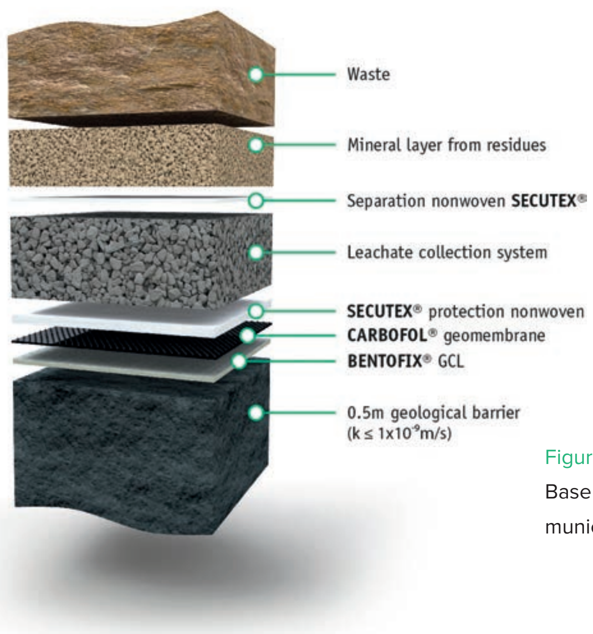



Figure 1:
Base sealing system for municipal solid waste landfills

# Intermediate system

An intermediate seal separates adjacent landfill cells. It is used when the landfill, to be abutted, does not have a sufficient seal to serve as base or an appropriate fill due to differing landfill classifications between the neighbouring cells. Thus, the intermediate seal can serve upper or closure layer of one cell and simultaneously, the base seal for the next.

Intermediate seals are not clearly described in most landfill regulations, so permitting authorities often call for typical base liner requirements. Historically, zoning decisions in municipal solid waste landfills have been issued in which the intermediate sealing should be constructed with the current state of the art barriers, e.g. with an approved geosynthetic clay liner (GCL) serving in place of a traditional mineral seal in combination with an approved geomembrane.

The advantages of this approach are clear: the geosynthetic barrier system is significantly easier to install and takes up less landfill space than a conventional mineral seal (e.g., conventional compacted clay or large-scale ground improvement methods). Furthermore, the flexibility of geosynthetic barriers enables them to adapt to the site-specific conditions and far greater strain acceptance in settlement. Geosynthetics save considerable time and money here, reduce the need for soil and aggregate harvesting and disturbance and greatly reduce transport cost for site materials (as geosynthetics require far fewer truckloads than heavy aggregates). Also, geosynthetic layers, in being substantially thinner, open up revenue-generating airspace for a landfill.

Where the old waste cell does not provide enough stability to support the construction of the new cell, geogrid reinforcement may be required. This approach may also create a more efficient, space-saving design, such as outlined in national regulations.

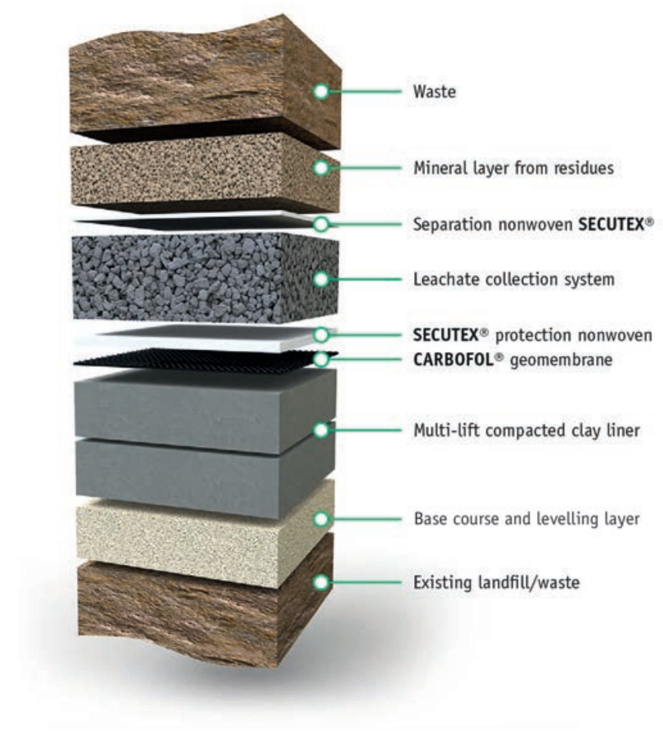



Figure 2: Intermediate sealing system for municipal solid waste landfills

## Naue Solutions

## Barrier Systems

Carbofol® HDPE geomembranes are used with BAM approval or other national approvals in Class 1-rated landfills (inert waste) as the sole sealing element. In Class II (municipal solid waste; non-hazardous waste) and III landfills (hazardous waste) Carbofol® is used in combination with a mineral/clay layer. This geomembrane meets the stringent chemical and physical requirements that are necessary for a safe, long-life-designed landfill. The surface of Carbofol® is smooth (for slopes up to about 1:9) or homogeneously structured/textured (for steeper slopes). This solution provides a strong barrier against rainwater infiltration and methane migration.

Bentofix® geosynthetic clay liners (GCL) are composite materials made of two layers of geotextile that encapsulate a core of highly swellable powder sodium bentonite. Needle-punching of the geotextile in manufacturing and a proprietary Thermal Lock process firmly bond the geotextile fibres across the entire surface of the materials. This prevents bentonite erosion and increases the durability of the material. Bentofix® GCLs replace thicker, more complex-to-construct, traditional mineral seals. The geosynthetic approach provides a barrier that is more resistant to desiccation and self-seals against installation damage. The internal shear strength and frictional characteristics of Bentofix® are also sufficient for steeper slopes.

# Landfill cap barriers

Upon closure, landfills must be capped. The specific requirements for permanent sealing systems for Class I (inert waste), II (municipal solid, non-hazardous waste) and III (hazardous waste) landfills are typically outlined in the national regulations.

High safety requirements are imposed on all components of the sealing system. Each geosynthetic should typically be approved by the federal authority or a national agency. Part of the approval process should show, in testing data, that sealing system components can provide at least 100 years of service life.

Additionally, interest in potential redevelopment of a former landfill has grown substantially, making the closure controls even more important. Geosynthetic capping systems provide a safe, cost-effective, environmentally sound solution for repeatable, high-quality seals.

Surface sealing of Class I landfills typically needs only a single geosynthetic component, such as a geomembrane or geosynthetic clay liner. This underscores the performance quality of and trust in these materials.

According to several national and international landfill regulations, e.g. the European Landfill Directive, Class II designs must have two sealing components. These elements must check one another, so they must be of different compositions. The combination of a geosynthetic clay liner (GCL) with a geomembrane is a safe, qualifying, well established and recognized approach for successful, long-term designs.

To achieve a better ecological, economical and performance-related GCL for landfill applications a multi-component Bentofix® GCL with an impermeable polyethylene coating can be used in a landfill cap. It helps make GCL installations even more effective, safer and longer lasting as two barrier systems are installed in one step. The multi-component Bentofix® GCL improves the overall performance and reduces the risks of a single lining system.

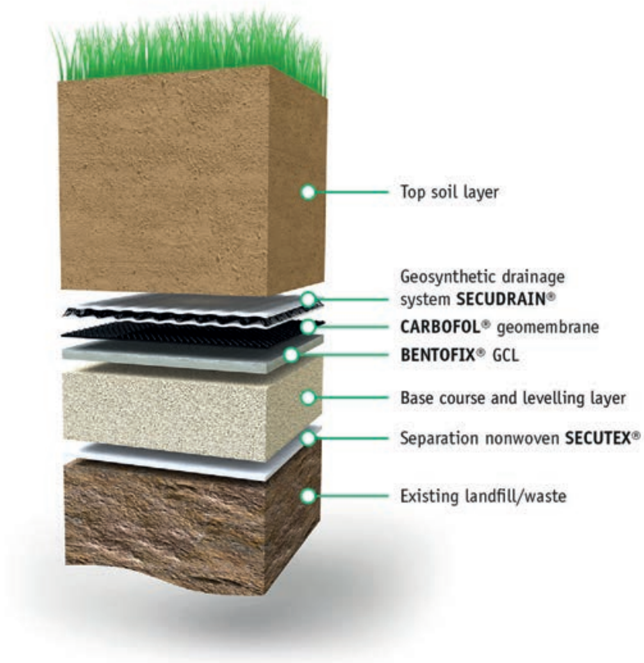



Figure 3: Cap/closure system for municipal solid waste landfills

## Naue Solutions

Carbofol® HDPE geomembranes are used with BAM approval or other national approvals in Class 1-rated landfills (inert waste) as the sole sealing element. In Class II (municipal solid waste; non-hazardous waste) and III landfills (hazardous waste), Carbofol® is used in combination with a mineral/clay layer (e.g. compacted clay liner). This geomembrane meets the stringent chemical and physical requirements that are necessary for a safe, long-life-designed landfill. The surface of Carbofol® is smooth (for slopes up to about 1:9) or homogeneously structured/textured (for steeper slopes). This solution provides a strong barrier against rainwater infiltration and methane migration.

Bentofix® geosynthetic clay liners (GCL) are composite materials made of two layers of geotextile that encapsulate a core of highly swellable powder sodium bentonite. Needle-punching of the geotextile in manufacturing and a proprietary Thermal Lock process firmly bond the geotextile fibres across the entire surface of the materials. This prevents bentonite erosion and increases the durability of the material. Bentofix® GCLs replace thicker, more complex-to-construct, traditional mineral seals. The geosynthetic approach provides a barrier that is more resistant to desiccation and self-seals against installation damage. The internal shear strength and frictional characteristics of Bentofix® are also sufficient for steeper slopes.

# Landfill cap functions

Typically, a drainage layer is required for all major landfill classes (I, II, and III). This layer sheds precipitation directly, to avoid the buildup of a hydraulic head on the capping system. The drainage layer must be permanently protected against clogging from the cover layer's soil particles. Drainage geocomposites with three-dimensional matrices and filter geotextile cover layers control seepage and properly designed fulfil design requirements in landfill caps.

Geosynthetic drainage systems of this nature are sufficiently protected against the damage risk posed by cover soil installation. This enables the geosynthetic system to ensure the requisite long-term drainage function.

When installing a mineral drainage layer over a geosynthetic seal, a needle-punched nonwoven geotextile can replace the otherwise necessary sand protective layer atop a geomembrane. In these situations, one should also evaluate whether a filter/ separation geotextile would be an optimal solution between the drainage layer and cover soil.

In landfill closure projects, it is increasingly important to utilise steeper slopes to minimize the soil-disturbing footprint of the site. The multi-layer nature of sealing systems, however, complicates this space-saving goal. It represents a particular challenge to the shear strength between layers. Here, textured geomembranes provide enhanced frictional characteristics for slope stability. Additionally, geogrids can be used to enable cost-effective, safe engineering of steeper slopes.

| System component | Inert waste | Non hazardous solid waste | Hazardous solid waste |
|---|---|---|---|
| Top soil layer | required a) | required (> 1m) | required (> 1m) |
| Drainage layer | mineral aggregate a)<br>or SECUDRAIN® GDS* | mineral aggregate<br>t ≥ 0.50m<br>or SECUDRAIN® GDS* | mineral aggregate<br>t ≥ 0.50m<br>or SECUDRAIN® GDS* |
| Artificial sealing layer | not required | Geomembrane<br>CARBOFOL® *** | Geomembrane<br>CARBOFOL® *** |
| Impermeable mineral layer | Compacted clay liner a)<br>or BENTOFIX® GCL** | Compacted clay liner<br>or BENTOFIX® GCL** | Compacted clay liner<br>or BENTOFIX® GCL** |
| Gas drainage layer | not required | required<br>or SECUDRAIN® GDS* | not required |
| Leveling layer | where required a) | where required | where required |

a) requirements set by member states
*GDS - Geosynthetic drainage system | **GCL - Geosynthetic clay liner
*** e.g. UK thickness ≥ 2.0mm | Germany thickness ≥ 2.5mm

## Naue Solutions

## Protection, Filtration, Separation, Drainage, Reinforcement

Secudrain® is a composite material with a polymeric drainage core and at least one nonwoven geotextile outer layer to provide filtration functionality. The geotextile prevents soil particles from disrupting the pressure and flow of draining liquids. Installed atop a geomembrane, the geotextile side of the composite can act simultaneously as a protection layer. In Germany, the use of Secudrain® has been approved by BAM for Landfill Directive-guided systems.

Secutex® is a mechanically bonded (needle-punched) nonwoven geotextile that can be used as protection/cushioning or as a separation geotextile in landfill sealing systems. In Germany minimum requirement for the mass per unit area for a protection geotextile is 800g/m$^2$. For separation and filtration, the nonwoven must be 300g/m$^2$.

Secugrid® geogrids minimize or eliminate settlement and redistribute loads. They also enable the construction of steeper embankments. For reinforcement applications in landfill projects, Naue Secugrid® meets BAM requirements.

# Reclamation and redevelopment of contaminated sites

Former landfills and contaminated sites are often capped and remediated. These engineering works may also include beneficial reuse of the sites. On-site contaminants and the uneven settlement in the ground above these former waste cells present a number of geotechnical challenges. As such, capping measures generally are selected for their ability to isolate and contain contaminants. Closure measures may also be evaluated on their ability to increase the site's load bearing capacity for safer reuse.

Capping systems for former waste cells and contaminated sites must be of the highest quality. This is especially true when land reuse is planned (e.g. for playgrounds, public gardens, sport fields). If a more commercial reuse is targeted, such as a parking lot, or if a trafficked route will pass over any part of the land, a higher load capacity is required. Not infrequently, steep slopes must be rebuilt to save space or to properly function within a reuse design. Geosynthetic capping systems allow for the efficient use of local soils. When considerable land might need to be reformed if external soil sources are required, the ability to use the local site's soils can provide considerable savings in the construction process, both from a materials acquisition standpoint and in terms of greatly decreased construction timelines. Expensive decontamination measures might be avoided. The reduction or elimination of heavy transport of external material saves not only on cost but on a project's carbon footprint.

Geomembranes and geosynthetic clay liners encapsulate contaminated areas safely and permanently, mitigating or eliminating pollutant discharge.

These geosynthetic barriers, as rolled goods, can be installed efficiently. Their many product variations, supported by high quality raw materials, allow them to be targeted to site-specific challenges, such as the aggressiveness of the contaminants to be contained, the site topography, precipitation variations and much more. And, compared to traditional sealing solutions (e.g., compacted clay and other in-situ ground improvement measures), geosynthetic systems are significantly thinner yet provide as great or more security. This advantage presents savings in capping costs and enables a site to maximize its storage volume prior to closure.

Geogrid reinforcement is used on these sites as well to enable traffic or construction atop soft soils or to stabilize zones against collapse. Nonwoven geotextiles, including nonwovens embedded within a geogrid, maybe also be used to provide separation and stabilization of soils.

To achieve a better ecological, economical and performance-related GCL for encapsulating contaminated sites a multi-component Bentofix® GCL with an impermeable polyethylene coating can be used. It helps make GCL installations even more effective, safer and longer lasting as two barrier systems are installed in one step. The multi-component Bentofix GCL improves the overall performance and reduces the risks of a single lining system.

## Naue Solutions

Carbofol® HDPE geomembranes encapsulate contaminated areas. They are chemically resistant to contaminated soils. Textured (structured) Carbofol® geomembranes allow strong seals on challenging grades, such as with steep slopes. Smooth Carbofol® is used in slopes up to 1:9 while the homogenously textured varieties are used for steeper installation zones.

Bentofix® geosynthetic clay liners (GCL) are needle-punched and fixed with Naue's Thermal Lock process. This firmly bonds the two layers of geotextile and the internal core of high-swelling sodium bentonite powder. The bentonite is encapsulated and protected against piping, as Bentofix® is needle-punched across its entire surface. Bentofix® replaces more expensive, thicker mineral sealing components. These GCLs are resistant to drying and installation damage. The bentonite core's swelling characteristic gives it a self-healing property. The internal shear strength of Bentofix® also enables its use in steeper slope designs.

Secutex® nonwoven geotextiles protect geomembranes from damage, such as from improperly coarse and angular aggregate layers. Secutex® prevents the mixing of different soil layers and provides filtration of leachate.

Secugrid® and Combigrid® geogrids bridge voids in subsoils and redistribute loads efficiently. They enable space-saving steep slopes and construction atop soft soils.

Combigrid® is a composite reinforcement material, featuring a nonwoven geotextile embedded within a geogrid. This construction provides separation and filtration functions of Secutex® and the high-strength reinforcement of Secugrid® in a single product.

Secudrain® is a powerful, durable drainage material with additional filtering and protection functions.


Figure 4: Cap/closure system over contaminated material to allow a future re-use of the site

Approvals for the Naue Group

Bentofix® BFG 5000
Bentofix® X2 BFG 5300

Secugrid® Q6 and R6

Secugrid® HS R6



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