Appendix D.1.1
Product Datasheets

PRODUCT DATASHEETS

Please note that these are samples, for indicative purposes only, of the types of products/equipment MEHL would propose to install. Variations may apply relating to specific products or suppliers.

Storage Systems

Portasilo®

M-Type Silo Range

Cost-effective solutions with reduced lead times

Portasilo M-type silos offer all the benefits associated with a silo from our standard range, along with the added advantages of a more cost effective solution with reduced lead times.

The M-Type silos are available in five different sizes with two different choices of cone outlet diameter. The range can store a wide variety of materials with a bulk density up to 1600kg/m³, making the range adaptable to suit a wide range of applications.

A selection of ancillary equipment is available if required allowing the silo to be supplied either bare shell or fully fitted ready for operation.

Portasilo Ltd. Huntington York,
England. YO32 9PR.
Tel: 44 (0)1904 624872
Fax: 44 (0)1904 611760

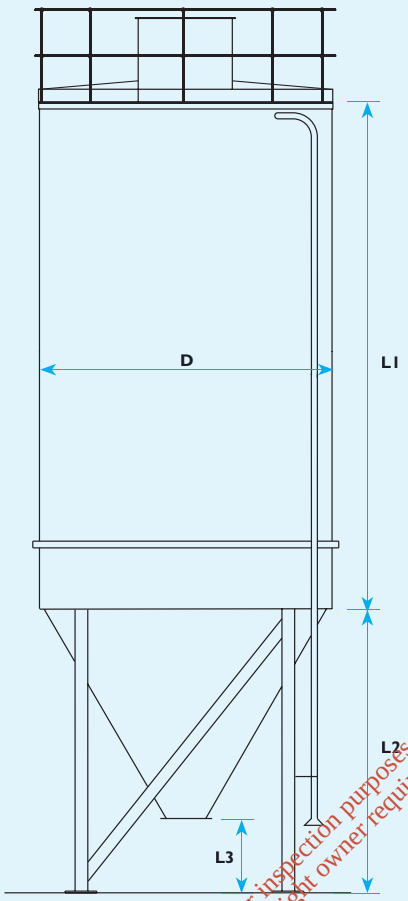
e-mail: bulk@portasilo.co.uk
Website: www.portasilo.co.uk

For more details on the Portasilo M-Type range of silos or for more details of the full range of Portasilo bulk handling solutions contact the Sales Manager.

Portasilo®
Bulk Handling Systems

M-TYPE SILOS

M-Type silos range are constructed from fully welded carbon steel and finished with Portasilo's standard paint finish. They are designed to store a range of materials with a bulk density up to 1600kg/m³



DO NOT SCALE

ROOF
Designed with a camber to shed rainwater. Includes access hatch and handrailing with upstands for filter unit, pressure / vacuum relief valve, high level probe.

SHELL
Cylindrical shell, with a length and diameter to suit the appropriate volume (see table). Includes a mounting for a refill level probe.

GALVANISED LADDER
Designed to BS4211, includes a backguard and intermediate rest platform where necessary.

INLET PIPE
100mm - complete with unicone coupling and 90° elbow

CONES
60° cone with a choice of 1200mmØ or 250mmØ flanged outlet

INTEGRAL BASE
Discharge height - as per table.

ANCILLARY EQUIPMENT
The following equipment can be supplied with the silo if required:-

- Reverse jet filter
- Pressure relief valve
- High and refill level probes
- Inlet pipe automatic shut-off valve
- Environmental protection fill panel
- Discharge aids
- Loadcells

Type	Working Vol. (m³)	D mm	L1 mm	L2 mm	L3 mm
M-28	28	2590	5430	3400	2000/1250*
M-39	39	3000	5430	3500	2000/1250*
M-48	48	3000	6650	3500	2000/1250*
M-60	60	3000	8460	3500	2000/1250*
M-78	78	3000	10860	3500	2000/1250*

* 1200/250mmØ outlet.

Portasilo®
Bulk Handling Systems

Portasilo Ltd. Huntington York, England. YO32 9PR.
Tel: 44 (0)1904 624872 Fax: 44 (0)1904 611760.
e-mail: bulk@portasilo.co.uk
Website: www.portasilo.co.uk

BRIDGEMONT BMS

The new force in
weighbridge design

Avery Weigh-Tronix

BridgeMont BMS

The Avery Weigh-Tronix *BridgeMont* series is a new generation in weighbridge design. As the market leader in the UK, US and Canada, *BridgeMont* delivers everything weighbridge users demand - strength, flexibility, economical ownership and easy installation.

- **Strong, safe, more cost-effective**
  BridgeMont offers quick and economical bolt-down installation, with simple foundations and no need for grouting. There are no mechanical movement restraints which means greater reliability. The full-width deck is easily accessible for vehicles and provides safer access for drivers. On top of all this, ***BridgeMont*** features the latest Weigh Bar® technology for new levels of performance and reliability.

- **Proven performance from a market leader**
  Every year, over 1500 Avery Weigh-Tronix weighbridges are successfully installed under some of the most arduous conditions on earth. The company has made substantial investment in new on-site facilities to manufacture ***BridgeMont*** to its renowned quality standards.

- **Strength by design**
  BridgeMont's innovative box construction results in lighter weight deck – with no compromise on strength. The platform typically comprises one four-Weigh Bar® base module with 'adder' units to provide platforms up to 24 m long and 100 tonnes in capacity. To aid safe access to the cab, the preferred standard width is 3.35 m with wider or traditional 3 m modules readily available. This modular design is easy and cost-effective to install, even in areas with restricted access.

- **Easy, bolt-down installation**
  BridgeMont offers bolt-down installation with no grouting and only simple foundations which means your weighbridge can be installed in a single day.

- **No mechanical restraints**
  The most common cause of load cell failure is a thing of the past. Unique Weigh Bar® technology absorbs braking/acceleration loads without the need for mechanical restraints – altogether simpler and more reliable.

- **Full width weighing for safer access**
  The width options offered by the ***BridgeMont*** range ensure a comfortable fit on the bridge for all vehicles and provides safe access to the cab without the need for steps.

- **Unrestricted platform**
  Side rails assist vehicle guidance without damaging wheels or creating dirt traps.

- **Heavy-duty options**
  BridgeMont is available in two options - ***BMS*** for standard loads or the premier ***XT*** range for specialist heavy-duty requirements.

- **Weigh Bar® technology**
  BridgeMont's Weigh Bar® technology offers a host of advantages over conventional load cells. Proven for 20 years in the field, Weigh Bars have a documented failure rate of just 0.3% - ten times the reliability of conventional load cells. In addition, Weigh Bars® are immune to end, side and torque load conditions that can affect the accuracy and life of conventional load cells. They also reduce foundation loads and absorb braking/acceleration loads without the need for mechanical restraints.

- **Ideal for restricted sites**
  The lightweight modular design is easy to manoeuvre and install - even under hoppers or inside buildings.

- **Outstanding protection**
  External surfaces are shot blasted and treated with a high performance paint system, providing excellent levels of corrosion protection and outstanding resistance to wear and site conditions. All internal box sections are continuously welded forming an effective seal to moisture ingress.

- **Indicating System**
  Any suitable Avery Weigh-Tronix indicator, PC or driver operated system may be fitted.
  See specification sheets for full details.

Specification

Platform Structure

The mild steel box section construction is the optimum design for strength. Close-spaced structural beams, full length top plates and lower stiffening plates, form a rigid monocoque style construction, minimising deflection and reducing stress. All steel components run in a longitudinal direction consistent with the flow of traffic ensuring that the weight is always applied directly on to the beams.

The unsupported span between beams is only 185 mm, compared to typically over 500 mm on high-sided single module designs. This gives a consistent well-drained weighing surface with reduced strain on the deck plates.

Modules are factory assembled with Weigh Bars ready installed for speedy installation and consistent quality. Full width end box fabrications house Weigh Bars and junction box. Both the Weigh Bars and junction box are mounted high in the installation, away from dirt and water with no trailing cables to damage.

Weigh Bars®
Braided stainless steel sheathed cables are provided as standard to prevent physical damage and rodent attack. The Weigh Bar cables terminate in an IP67 stainless steel junction box located in the weighbridge structure, with a single cable routed to the weighbridge office. Lightning protection is provided by surge arrestors in the junction box and earth rods located adjacent to each pair of Weigh Bars. Environmental protection standard of both Weigh Bar and junction box exceeds IP67.

Strength
Although the carrying capacity of the weighbridge is important, the most critical measure of strength and durability is its ability to withstand repeated high axle loads over many years. Avery Weigh-Tronix designs take account of both the weights of the axles and the punishing way the load is applied.

The ***BridgeMont*** range is designed in accordance with BS 5400 to carry any vehicle covered by the Motor Vehicle (Construction and Use) Regulations. ***BMS*** design for standard duty is 15 units of Highway class B (HB) loading which equates to 30 tonnes on dual tandem axles (DTA) spaced at 1.8 m. This is 50% more than the UK maximum authorised weight limit.

Although many vehicles not covered by the axle loading and spacing regulations may be carried by the weighbridge, it is important that confirmation be obtained.

Platform Height - 355 mm.

Finish
A high performance water based anti-corrosive primer with a dry film thickness of 50 microns (dft) is used. This provides excellent levels of adhesion and corrosion protection. The weighbridge is finished to a minimum thickness of 75 microns (dft), with a gloss water based, modified alkyd resin giving outstanding resistance to wear and conditions expected in a weighbridge environment. After each application the modules are cured in a full size purpose designed oven.

Corrosion within the internal box sections is prevented by fully seam welding the lower stiffening plates, forming a sealed box section with no dirt traps.

Approvals
The basic construction, Weigh Bars and mounting components are in accordance with the requirements of O.I.M.L., N.T.E.P. and EU regulations.

Environment
Consistent with conditions pertaining to a well drained outdoor installation.

The new force in weighbridge design

Resistance to Electrical Disturbances
Complies with the requirements of EN 45501.

Operating Temperature Range
-20° C to +50° C depending on Weights & Measures Regulations applicable.

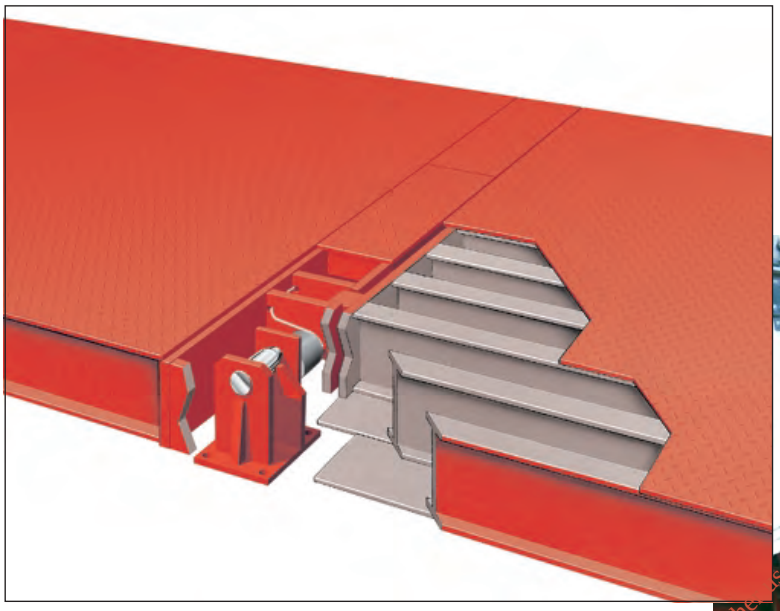
Installation and Access

Surface mounted foundations comprise a flat solid raft with concrete approach ramps. Service access to Weigh Bars and mountings is via removable covers in the top of the weighbridge. For some applications the optional steel ramps may be considered.

Options

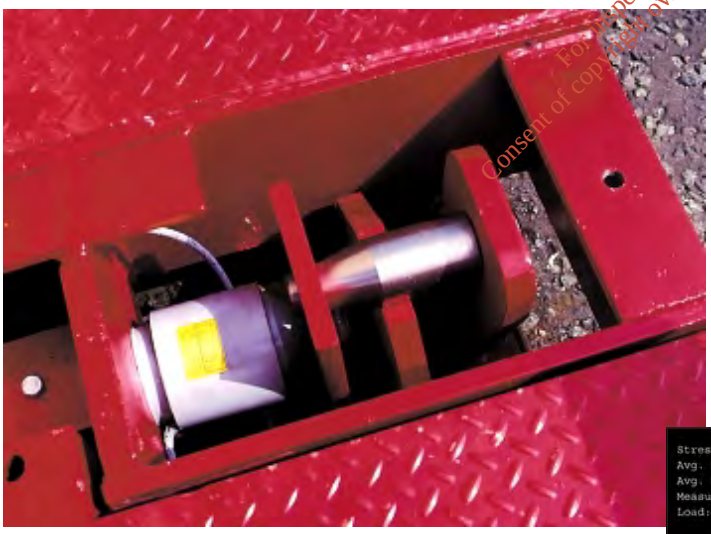
1. ***BridgeMont XT*** heavy duty range. In accordance with BS 5400, Motor Vehicle (Construction & Use) Regulations, the ***XT*** will carry 18 units of Highway class B (HB) loading which equates to 36 tonnes DTA.
2. Widths up to 3.65 m
3. No guide rails
4. Manholes, one per module
5. Steel ramps
6. Suitable for hazardous areas using Avery Weigh-Tronix ATEX T302 load cells and indicators.

The new force in weighbridge design

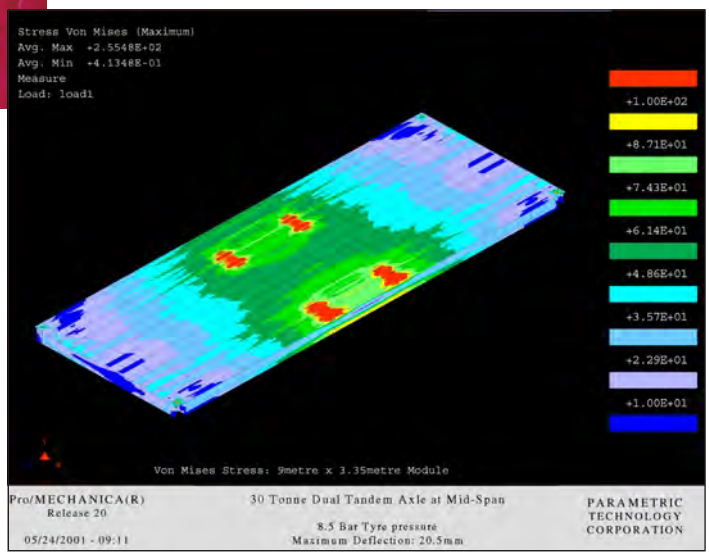


***BridgeMont**'s innovative box construction results in lighter weight deck – with no compromise on strength. The platform typically comprises one four-Weigh Bar® base module with 'adder' units to provide platforms up to 24 m long and 100 tonnes in capacity.*

*To aid safe access to the cab, the preferred standard width of the **BridgeMont BMS** is 3.35 metres with traditional three metre wide modules readily available.*



***BridgeMont**'s Weigh Bar® technology offers a host of advantages over conventional load cells and have been proven for 20 years in the field, Weigh Bars have a documented failure rate of just 0.3% - ten times the reliability of conventional load cells.*



*Computer model analysing stress loads and amount of structural deflection on a **BridgeMont BMS** weighbridge. Example shows the loading applied by a 30 tonne dual tandem axle, 8.5 bar tyre pressure, at mid span to a 9 m x 3.35 m module. The maximum deflection is 20.5 mm.*

Strength by design

Shipping Specification (Approximate)

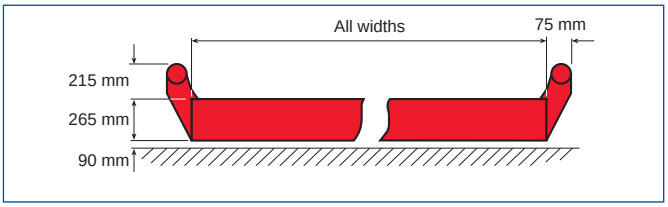
Weight of Standard Modules with Guide Rails

Platform Size	Base (Length)	Adder 1 (Length)	Adder 2 (Length)
6 m x 3 m	3230 kg		
9 m x 3 m	5050 kg		
12 m x 3 m	3230 kg (6 m)	3030 kg (6 m)	
15 m x 3 m	3940 kg (7.5 m)	3735 kg (7.5 m)	
18 m x 3 m	5050 kg (9 m)	4850 kg (9 m)	
21 m x 3 m	3715 kg (7 m)	3505 kg (7 m)	3505 kg (7 m)
22 m x 3 m	4180 kg (8 m)	3505 kg (7 m)	3505 kg (7 m)
24 m x 3 m	4180 kg (8 m)	3970 kg (8 m)	3970 kg (8 m)
6 m x 3.35 m	3660 kg		
9 m x 3.35 m	5730 kg		
12 m x 3.35 m	3660 kg (6 m)	3435 kg (6 m)	
15 m x 3.35 m	4465 kg (7.5 m)	4240 kg (7.5 m)	
18 m x 3.35 m	5730 kg (9 m)	5510 kg (9 m)	
21 m x 3.35 m	4205 kg (7 m)	3980 kg (7 m)	3980 kg (7 m)
22 m x 3.35 m	4735 kg (8 m)	3980 kg (7 m)	3980 kg (7 m)
24 m x 3.35 m	4735 kg (8 m)	4515 kg (8 m)	4516 kg (8 m)

Weighbridge Sizes & Capacities

Platform Size	Capacity	No. of Modules
6 m x 3.35 m	40 000 kg	1
9 m x 3.35 m	40 000 kg	1
12 m x 3.35 m	60 000 kg	2
15 m x 3.35 m	60 000 kg	2
18 m x 3.35 m	60 000 kg	2
21 m x 3.35 m	90 000 kg	3
22 m x 3.35 m	90 000 kg	3
24 m x 3.35 m	90 000 kg	3

Complies with requirements of EN 45501.



Foundation Drawings

Description	Width	Drawing Number
Surface Mount One Module	3.00 m	83211 – 251
	3.35 m	83211 – 252
	3.65 m	83211 – 253
Surface Mount Two Module	3.00 m	83211 – 254
	3.35 m	83211 – 255
	3.65 m	83211 – 256
Surface Mount Three Module	3.00 m	83211 – 257
	3.35 m	83211 – 258
	3.65 m	83211 – 259
Pit Mount One Module	3.00 m	83211 – 260
	3.35 m	83211 – 261
	3.65 m	83211 – 262
Pit Mount Two Module	3.00 m	83211 – 263
	3.35 m	83211 – 264
	3.65 m	83211 – 265
Pit Mount Three Module	3.00 m	83211 – 266
	3.35 m	83211 – 267
	3.65 m	83211 – 268

For further information, call 0870 90 50066

Foundry Lane, Smethwick,
West Midlands, England B66 2LP.
Tel: +44 (0)870 90 34343
Fax: +44 (0)121-224 8183

E mail: info@awtxglobal.com
Internet: http://www.averyweigh-tronix.com

Avery Weigh-Tronix

BridgeMont BMS/11.05/Issue 3

WESLEY Wheel Wash : Specification

Wheel Wash Compact FX1400
Electric Driven

Wheel Wash Compact FX1400
Diesel Driven

Wheel Wash Compact RX1400
Electric Driven

Wheel Wash Compact RX1400
Diesel Driven

General

Water Flow:
1400 litres per minute

Operating Pressure:
7 bar (14 bar EWP on the RX models)

The Wheel Wash Platform

Number of Jets:
76 stainless steel jets (42 on RX models)

Length:
10.150 metres including ramps

Width:
3.990 metres overall

Height:
1.870 metres overall

Width Between Guide Bars:
2.900 metres standard, adjustable to 3.200 metres

Vehicle Width:
2.700 metres standard, adjustable to 3.200 metres

Vehicle Length:
Any

Weight:
3916 KGS

Load Capacity:
45000 KGS

Wheel Wash Fitted With Stop/Go traffic lights, 24 volt

- Entrance sonic start sensor
- Automatic platform wash down system
- Galvanised platform structure
- Galvanised entrance and exit ramps
- Entrance and exit driver guide bars

The Wheel Wash Recycling Tank with Integrated Pump House

Water capacity:
25,000 litres

Length:
6.00 metres

Width:
2.40 metres

Height:
3.00 metres

Weight:
6500 KGS (dry)

Recycling Tank Fitted With

- 3" outlet connector for wash nozzles
- 3" outlet connector for platform wash-down nozzles
- 3" inlet connector for sump pump connection
- 3" x 6" Bauer connectors
- 3" x 6" butterfly valves
- 1" x ¾ " ball valve for fresh water supply
- High and low water sensors

The Pump House

Main wash motor:
415 volt, 3-phase, 22 KW (Star delta starter)
Requires 100 amp supply, neutral and separate earth
Kubota 26 hp water-cooled engine on diesel model

Main Wash Pump:
3 inch, centrifugal and suction

Air Compressor:
1.5 hp, 24 litres capacity with filtration unit lubricator

Pump House Fitted With

- 24 volt control circuit
- Programmed Logic Controller
- 100 amp MVB/main isolator
- System test button and system indicator lamps
- Emergency stop push button
- Hours Counter
- 2KW frost protection heater (electric model only)
- Earth rod and Clamp
- 55 litre hydraulic oil tank
- 150 litre diesel tank

The Sump Tank

Capacity:
1000 litres

Width:
1.000 metres

Length:
1.000 metres

Height:
1.500 metres

Sump Tank Fitted With

- 3” submersible pump, 4 KW (Hydraulic pump on diesel model)
- Debris collecting basket
- Security Lid

Thermally Bonded Nonwovens

Product Grades			700	900	1000	1300	1500	2000	3000	4000	4500
Mechanical Properties (Mean values)											
Tensile Strength	EN ISO 10319	kN/m	6.0	7.5	8.0	10.5	12.5	14.5	18.0	22.0	30.0
Elongation	EN ISO 10319	%	22	23	24	24	27	27	30	30	35
CBR Puncture Resistance	EN ISO 12236	N	1050	1350	1500	2000	2250	2750	3250	4300	5350
Tensile at 5% Elongation	EN ISO 10319	kN/m	2.6	3.2	3.4	4.3	4.7	5.5	6.3	7.5	9.0
Dynamic Cone Puncture	EN ISO 13433	mm	42	40	38	34	32	26	24	22	14
Hydraulic Properties (Mean values)											
Permeability (H_{50})	EN ISO 11058	$l/m^2.s$ (10^{-3} m/s)	130	105	100	80	75	65	55	45	35
Opening Size (O_{90})	EN ISO 12956	μm	180	160	150	130	125	110	100	85	75
Physical Properties (Typical values)											
Mass per Unit Area	EN ISO 9864	g/m^2	90	115	120	155	175	210	250	330	400
Thickness	EN ISO 9863-1	mm	0.6	0.7	0.75	0.85	0.9	1.1	1.2	1.4	1.6
Roll Width		m	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
Roll Length		m	150	150	100	100	100	100	100	50	50
Roll Weight		kg	65	85	60	75	85	100	120	80	95

The above listings refer to standard product weights and roll sizes. Other weights, sizes and colour maybe available on request. For further information please contact Terram Technical Support .

FM22730 CPD 0338

Terram Limited
Mamhilad, Pontypool, Gwent
NP4 0YR, United Kingdom
tel +44 (0) 1495 757722
fax +44 (0) 1495 762393
email info@terram.com
www.terram.com
A Fiberweb plc company

Notes

Composition and Environmental Behaviour

Composition

70% polypropylene / 30% polyethylene.

Durability

The products are predicted to be durable for more than 25 years for non reinforcing applications, in soils with a range of pH 2-14 and soil temperatures less than 25 degrees C.

Chemical Resistance

Alkali - Resistant to all naturally occurring soil alkalis.

Acid - Resistant to all naturally occurring soil acids, (i.e. to acids of pH 2).

Biological Resistance

Terram is unaffected by bacteria, fungi, etc. Since it is not a source of nourishment, rats and termites will not eat the product as food.

Reaction to Temperature

The tensile strength of Terram decreases with increase in temperature, but recovers fully when the geotextile is returned to normal ambient temperature.

Exposure to Sunlight

Terram is delivered in polyethylene wrappers to protect it from the harmful effects of ultra-violet rays: it is recommended that it remains wrapped until it is to be used.

The unwrapped product shall be completely covered within 14 days after installation to avoid UV radiation exposure

For projects where prolonged exposure is inevitable Terram grades with UV resistance to match the requirement are offered. In these grades the UV light resistance is enhanced by appropriate stabilisers in the polymers.

All other properties are identical to the corresponding standard series Terram presented in the data sheet. Terram products with enhanced UV resistance carry the suffix UV (e.g. Terram 1000 UV).

Notes

1. The stated properties are family mean values of the appropriate tests derived over periods of time.
2. The mean tensile values quoted are the mean values in either the length or cross directions, whichever is the lower.
3. For a full description of the test procedures quoted please refer to the specific methods of test.
4. Where widths or lengths greater than those supplied on one roll are required, jointing is normally effected by simple overlapping. However, depending upon application, substrate conditions, material loading, convenience and cost, alternative methods (pegging, sewing, stapling or gluing) may be used. Please refer to the Terram Jointing Methods leaflet for more details.
5. As part of its continual improvement process Terram Ltd reserve the right to change the properties listed on this data sheet without prior notice.

Terram Limited
Mamhilad, Pontypool, Gwent
NP4 0YR, United Kingdom
tel +44 (0) 1495 757722
fax +44 (0) 1495 762393
email info@terram.com
www.terram.com

1B1

Drainage Geocomposite

TERRAM®
Geosynthetics you can trust

Construction

Core	Extruded Polyethylene (PE) Net
Filter/Separator	Nonwoven thermally bonded geotextile (Polyethylene/Polypropylene) on each side of the core

Hydraulic Properties — Composite (Mean values)

In Plane Water Flow	EN ISO 12958	20kPa	l.m.s ($10^{-3}m^2/s$)	0.70
(Surfaces Hard/Hard, Hydraulic Gradient = 1.0)		100kPa	l.m.s ($10^{-3}m^2/s$)	0.65
		200kPa	l.m.s ($10^{-3}m^2/s$)	0.58

Hydraulic Properties — Filter (Mean Values)

Pore Size	EN ISO 12956	mm	0.15
Permeability (Velocity Index H_{50})	EN ISO 11058	l/m^2s ($10^{-3}m/s$)	100

Mechanical Properties — Composite (Mean values)

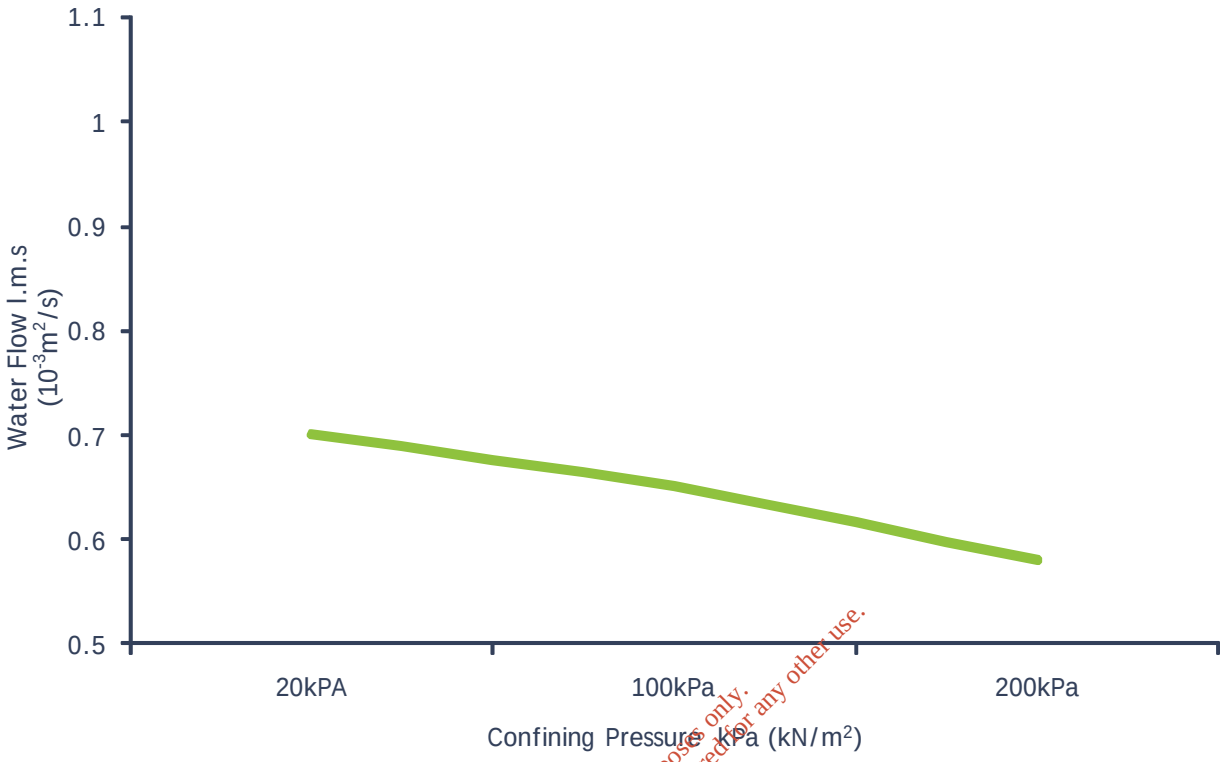
Tensile Strength	EN ISO 10319	MD	kN/m	20.0
	EN ISO 10319	CMD	kN/m	15.5
CBR Puncture Resistance	EN ISO 12236		N	3300

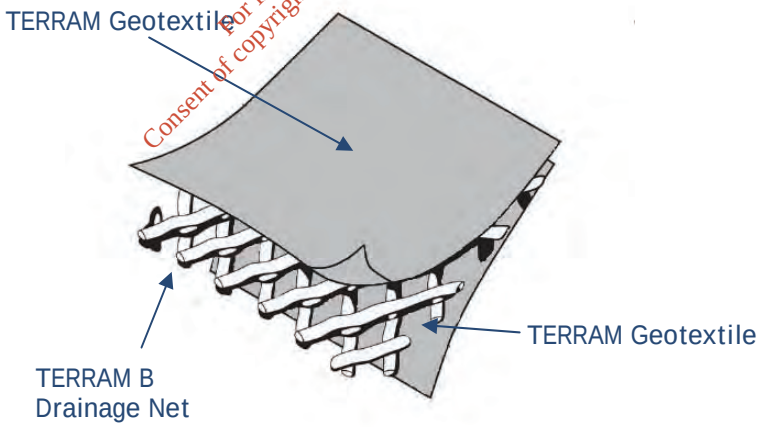
Physical Properties—Composite (Typical values)

Mass per Unit Area	EN ISO 9864	g/m^2	670
Thickness (2kPa)	EN ISO 9863-1	mm	5.0
Roll Width		m	2.0 or 4.0
Roll Length		m	25, 50 or 100
Filter Overlap (One Side)		mm	100

Notes:

1. TERRAM 1B1 comprises a polyethylene, three dimensional net structure with a layer of TERRAM geotextile bonded to each side by thermal lamination.
2. The mechanical and hydraulic results quoted are the family means of the appropriate tests derived over periods of time.
3. The in-plane water flow is measured in the length (longitudinal) direction.





FM22730 CPD 0338

Terram Limited
Mamhilad, Pontypool, Gwent
NP4 0YR, United Kingdom
tel +44 (0) 1495 757722
fax +44 (0) 1495 762393
email info@terram.com
www.terram.com
A Fiberweb plc company

The Pioneer Of Geosynthetics

S I N C E 1 9 7 2

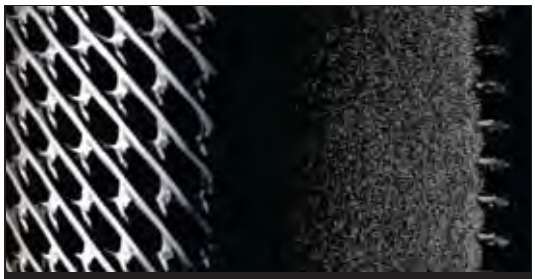
Application Sheet

Drainage Geonets & Geocomposites

ASSURED QUALITY FOR A LIFETIME

GSE drainage products have been manufactured for over 30 years. Millions of square feet of drainage products are produced every year for landfill applications.

GSE starts with the highest quality resin blended with carbon black, UV stabilizers and antioxidants to ensure the product will have a long life. The material must pass stringent testing requirements and inspection prior to shipment.



GSE geonet. GSE geocomposite.

SUPERIOR PRODUCT COMPOSITION

GSE geonets are manufactured to form a three-dimensional biplanar drainage structure that is used to replace a sand or gravel subsurface drainage system. GSE geocomposite will be needed if the drainage structure will be in contact with a soil type. This is accomplished by heat laminating a needle punched nonwoven geotextile to either one or both side to prevent soil particles from clogging the drainage core. Geotextiles are also laminated to geonet cores when there is a need to increase frictional characteristics with another geosynthetic type.

GSE developed new advantage drainage product lines, which are targeted specifically towards the high performance application range. GSE HyperNet TRx geonets and GSE FabriNet TRx geocomposites have significantly improved the hydraulic transmissivity of regular biplanar geonets under low to medium loading conditions for landfill cover drainage systems. GSE PermaNet geonets and geocomposite have a unique round-strand structure designed for providing high flow under heavy to extremely heavy loads that are expected in many landfill base liner systems and in mining projects.

In 2008, GSE was awarded a patent on the strand structure of GSE PermaNet biplanar geonets. GSE BioDrain geocomposite blanket system is another GSE patented product as a cost-effective solution to the bioreactor landfill leachate recirculation. The special woven filter design of GSE BioDrain will provide better clogging resistance and distribute liquid more uniformly.

LEACHATE COLLETION AND REMOVAL SYSTEM

The leachate collection and removal system (LCRS) is a lateral drainage system that is used to remove leachate from the lining system to maintain less than or equal to 1 ft head of liquid as required by Subtitle D. Drainage geocomposites are used in this application in place of natural soils because natural soils require extra preparation of the sub-grade and consume valuable airspace (typically 1 ft of soil). Geosynthetic drainage products are installed by simply rolling the product down the slope. Drainage geosynthetics require less sub-grade preparation and occupy far less airspace than natural drainage soils (0.20 in to 0.30 in). Drainage geocomposites provide excellent long-term hydraulic performance and creep resistance to ensure the leachate collection system will continue working over the life of the project.

LEAK DETECTION SYSTEM (LDS)

Subtitle C hazardous waste landfills regulations require a double liner system consisting of two HDPE geomembrane liners with a geonet in the middle to comprise a leak detection system. This system is used to warn of any failures in the primary liner system. The use of a biplanar drainage geonet provides high transmissivity which will continue to limit the head on the secondary liner to 1 ft as required by regulations. Biplanar geonets will also move leachate quickly through the system to leak detection locations.

Leak detection system.

The landfill gas collection system is used to collect gases such as methane (CH4) and carbon dioxide (CO2) that can build up underneath the geomembrane. Gases can be collected and used for energy production or distributed to a venting or capturing

-Continued-

Application Sheet

system to avoid air pollution. Landfill gas collection systems are used to prevent gas from accumulating underneath the liner system which could cause the liner to rupture. Instead of using a layer of sand for gas collection, a biplanar geonet or geocomposite can be utilized to accomplish the same task. The thickness of the geonet depends on the amount of gas generation expected during waste decomposition.

SUB-GRADE GAS REMOVAL

Gas pressure, due to the biodegradation of organic materials, can cause the subgrade to release gasses that will build up underneath a geomembrane and potentially cause a failure in the geomembrane liner system. In a final cover system, gas pressure, due to the release of gasses from the waste, can accumulate underneath the geomembrane causing slope instability or slope failure. In order to effectively reduce gas build-up, biplanar geocomposite strips, commonly called strip drains, can be installed to discharge gas to a gas venting system or gas collection system. Spacing between strip drains and the thickness of the geocomposite used is based on the amount of gas production released from the landfill surface and the maximum anticipated field load expected during the life of the project.

EASE OF INSTALLATION AND PRODUCT SUCCESS

GSE drainage products have been used in the above applications for many years with great success. Drainage geosynthetics require less excavation, allow for more airspace and are easy to handle. GSE drainage products are provided in roll form and can be installed with a limited amount of crew personnel and equipment.

GSE Drainage products replace natural drainage.

COMPLETE INSTALLATION SERVICES

No other company offers more experience installing geosynthetic products than GSE. GSE Installation Services is your one-stop source that offers the experience, training, expertise and complete range of geosynthetic products, fabrication and technical support on any project.

GSE installation crew.

THE GSE DRAINAGE DESIGN MANUAL

This comprehensive design manual provides the project engineer with the material properties and design procedures pertaining to drainage geonets and geocomposites for a wide range of applications. For a free copy, please contact GSE.

ADDITIONAL INFORMATION

If you have an upcoming project please give us a call. We will provide you with recommendations for material and installation.

NORTH AMERICA 800.435.2008 281.443.8564 • EUROPE & AFRICA 49.40.767420 • ASIA PACIFIC 66.2.937.0091 • SOUTH AMERICA 56.2.595.4200 • MIDDLE EAST 20.23.828.8888

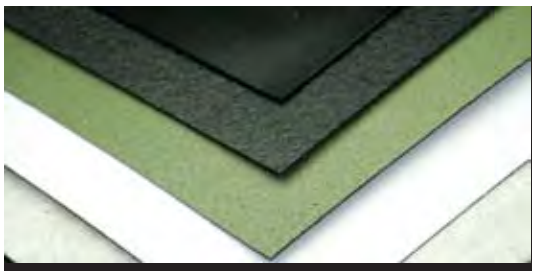
gseworld.com

The Pioneer Of Geosynthetics

S I N C E 1 9 7 2

Technical Note

Chemical Resistance for Geomembrane Products



GSE geomembranes.

GSE geomembranes are made of high quality, virgin polyethylene which demonstrates excellent chemical resistance. GSE polyethylene geomembranes are resistant to a great number and combinations of chemicals. It is this property of (HDPE) high density polyethylene geomembranes that makes it the lining material of choice.

In order to gauge the durability of a material in contact with a chemical mixture, testing is required in which the material is exposed to the chemical environment in question. Chemical resistance testing is a very large and complex topic because of two factors. First, the number of specific media is virtually endless and second, there are many criteria such as tensile strength, hardness, etc. that may be used to assess a material's resistance to degradation.

The chemical resistance of polyethylene has been investigated by many people over the past few decades. We are able to draw from that work when making statements about the chemical resistance of today's polyethylene geomembranes. In addition to that, many tests have been performed that specifically use geomembranes and certain chemical mixtures. Naturally, however, every mixture of chemicals cannot be tested for. As a result of these factors, GSE published a chemical resistance chart, demonstrating general guidelines.

Polyethylene is, for practical purposes, considered impermeable. Be aware, however, that all materials are permeable to some extent. Permeability varies with concentration, temperature, pressure and type of permeant. The rates of permeation are usually so low, however, that they are insignificant. As a point of reference, polyethylene is commonly used for packaging of several types of materials. These include gasoline, motor oil, household cleaners (i.e. bleach), muratic acid, pesticides, insecticides, fungicides, and other highly concentrated chemicals. Also, you should be aware that there are some chemicals which may be absorbed by the material but only when present at very high concentrations. These include halogenated and/or aromatic hydrocarbons at greater than 50%; their absorption results in swelling and slight changes in physical properties such as increased tensile elongations. This includes many types of fuels and oils. Recognize that this action, however, does not affect the liner's ability to act as a barrier for the material it is containing.

Since polyethylene is a petroleum product, it can absorb other petroleum products. Like a sponge, the material becomes slightly thicker and more flexible but does not produce a hole or void. However, unlike a sponge, this absorption is not immediate. It takes a much longer time for a polyethylene liner to swell than it does for a sponge. The exact time it takes for swelling to occur depends on the particular constituents and concentrations of the contained media. However, a hole would not be produced. Also, this absorption is reversible and the material will essentially return to it's original state when the chemical is no longer in contact with the liner.

With regard to typical municipal landfills in the United States, legally allowable levels of chemicals have been demonstrated to have no adverse affect on polyethylene geomembrane performance. The very low levels of salts, metals and organic compounds do not damage polyethylene. A double-lined containment with a leachate (leak detection) removal system effectively prevents any significant, continuous exposure of the secondary membrane to these materials and for practical purposes makes the total liner system even more impermeable.

NORTH AMERICA 800.435.2008 281.443.8564 • **EUROPE & AFRICA** 49.40.767420 • **ASIA PACIFIC** 66.2.937.0091 • **SOUTH AMERICA** 56.2.595.4200 • **MIDDLE EAST** 20.23.828.8888

www.gseworld.com

Application Sheet

Landfills

GEOMEMBRANE QUALITY, CONSISTENCY SERVICE

Geomembrane quality begins with base resin selection. GSE's resins are blended with premium carbon black, antioxidant additives and UV stabilizers to ensure long life—even in exposed conditions.

GSE's manufacturing facilities include state-of-the-art extrusion lines. GSE utilizes two unique geomembrane extrusion systems. With flat-cast and round-die extrusion capabilities, GSE can meet stringent tolerance requirements as well as produce patented, coextruded products.

GSE geomembrane materials must pass a battery of quality control checks before being shipped and installed. From the base resin checks to 100% on-line holiday spark-tested to laboratory quality assurance testing, all GSE geomembrane is thoroughly inspected.

Installations require extensive planning to ensure on-time delivery and coordination with the earthmoving contractors. No other company offers more experience installing geomembranes and related geosynthetic products. In addition to maintaining the largest installation workforce in the industry, GSE works with high-quality local installers around the world to ensure a global network of liner installation capability.

GSE HDPE geomembranes are the world's environmental lining material of choice.

LANDFILL CELL LINERS

Today's state-of-the-art landfill utilizes a range of geosynthetic products to maximize design efficiency, integrity and performance while minimizing overall cost. For environmental protection, the essential landfill component is the primary geomembrane liner.

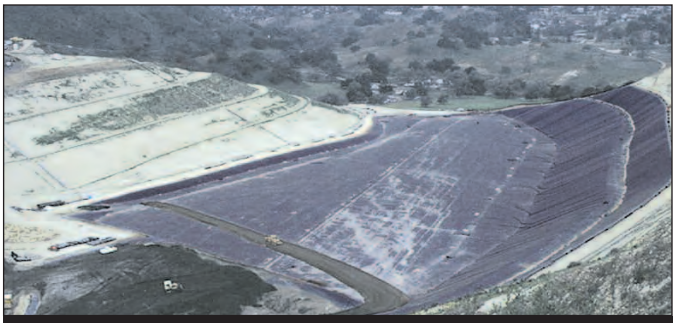
By itself, the primary liner contains hazardous leachates and protects valuable groundwater resources. However, for a landfill liner system to function optimally, it needs to incorporate more than a smooth surfaced geomembrane.

Steep side slopes have become standard in landfills as a means to increase capacity and revenue. Steep slopes present problems for smooth liners because cover soil may not stay in place and, with overburden, the liner itself can slip down the slope and increase stress on seams and the sheet itself. To solve this problem, GSE offers coextruded textured geomembranes.

The geomembrane liner provides containment for landfill leachates. For leachate collection, geocomposite nets provide high in-plane flow. The geocomposite is composed of GSE HyperNet HDPE geonet with geotextile bonded to one or both sides to keep cover soil from clogging the geonet. GSE FabriNet geocomposite is placed directly on top of the primary liner. The geotextile clings to textured geomembrane to lock the geonet in place, especially on slopes.

Many landfills require a leak detection system to ensure the integrity of the primary liner on a continuous basis. This system consists of a secondary HDPE geomembrane below the primary liner which is overlaid with either a geonet or a geocomposite net. If the leak detection system is placed directly below the primary liner, a geonet is used. If an intermediate soil layer or primary clay layer is used, then a geocomposite net is utilized.

Landfill cell liners are massive and critical projects. The geosynthetic liner system represents a small fraction of the overall cost but virtually 100% of the protection. Don't settle for mediocre quality. GSE provides everything you need for the highest quality installation and the largest selection.



8.5 million square feet (790,000 square meters) of GSE HD* used in a canyon fill in Pennsylvania.

LANDFILL COVERS

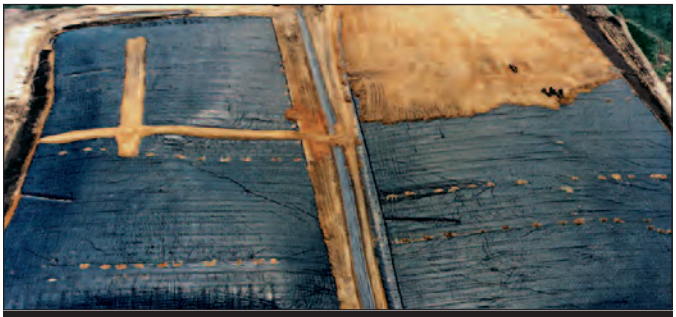
A major long-term concern when employing a landfill cover is differential settlement caused by decaying and shifting waste. The geomembrane cover must facilitate deformation caused by differential settlement without failure of the con-

- Continued -

tainment. To meet this requirement, GSE UltraFlex is made from a unique, linear low density polyethylene resin (LLDPE). Its utility and durability has been proven in over 50 million square feet (5 million square meters) of landfill cover applications.

LEACHATE PONDS

Leachate is collected from landfill cells and typically stored in lined ponds for treatment or evaporation. The liners in these ponds are generally exposed to the elements. HDPE lining systems exhibit the highest degree of durability under extreme environmental conditions including sunlight, freezing and abrasion.



Typical landfill cap using GSE HDPE geomembrane in Florida.

HIGH-END ENGINEERING

To achieve true state-of-the-art landfill design, incorporate GSE's coextruded geomembrane capabilities. GSE White is a patented, coextruded HDPE geomembrane, which provides significant benefits for the landfill owner, engineer and contractor.

The white surface has two primary functions. First, it reflects sunlight which minimizes radiant heat absorption and heat buildup to effectively minimize liner temperature. This results in less expansion of the liner. With less expansion, wrinkles are minimized. Another benefit of lower liner temperature is decreased moisture evaporation from underlaying clay layers.

The second benefit of a white surface is improved visual inspection. if the thin white surface is damaged, the black portion of the sheet shows clearly. Post-installation damage is much more likely to be observed and repaired. See the GSE White information sheet for more information.

If a post-installation leak test is required, consider the benefits of GSE's patented, spark-testable GSE Conductive. A large landfill installation can be tested for pinholes or other construction-related damage to 100% satisfaction without the added expense of flooding or the uncertainties of other leak testing methods. Specialized areas such as sumps and pipe penetrations require special products and installation techniques. To ensure complete containment protection, use GSE Conductive since it can be electrically spark-tested at any time to find even the smallest punctures resulting from pipe laying or other incidental damage.

A double lined, multi-cell landfill.

ADDITIONAL INFORMATION

If you have an upcoming project, please give us a call. We will provide you with recommendations, an estimate for material and installation, and contacts for a GSE approved installer.

North America	GSE Lining Technology, Inc.	Houston, Texas	800 435 2008	281 443 8564	Fax: 281 230 8650
South America	GSE Lining Technology Chile S.A.	Santiago, Chile		56 2 595 4200	Fax: 56 2 595 4290
Asia Pacific	GSE Lining Technology Company Limited	Bangkok, Thailand		66 2 937 0091	Fax: 66 2 937 0097
Europe & Africa	GSE Lining Technology GmbH	Hamburg, Germany		49 40 767420	Fax: 49 40 7674234
Middle East	GSE Lining Technology-Egypt	The 6th of October City, Egypt		202 2 828 8888	Fax: 202 2 828 8889

www.gseworld.com

GSE STANDARD PRODUCTS

Product Data Sheet

GSE HD

GSE HD is a high quality, high-density polyethylene (HDPE) geomembrane produced from a specially formulated, proprietary virgin polyethylene resin designed specifically for flexible geomembrane applications. GSE HD has outstanding chemical resistance, mechanical properties, environmental stress crack resistance, dimensional stability and thermal ageing characteristics. GSE HD also has excellent resistance to UV radiation and is suitable for exposed conditions.

Product Specifications

Tested Property	Test Method	Minimum Values [1]				
Thickness (mm) [2]	ASTM D 5199	0.75	1.0	1.5	2.0	2.5
Density g/cm³	ASTM D 792/1505A	0.94	0.94	0.94	0.94	0.94
Tensile Properties (each direction)	ASTM D 6693, Type IV Speed 50 mm pm					
Strength at Break (N/mm)		20	27	40	53	67
Strength at Yield (N/mm)		11	15	22	29	37
Elongation at Break, %	G.L. (50 mm)	700	700	700	700	700
Elongation at Yield, %	G.L. (33 mm)	12	12	12	12	12
Tear Resistance (N)	ASTM D 1004	93	125	187	249	311
Puncture Resistance (N)	ASTM D 4833	240	320	480	640	800
Carbon Black Content %	ASTM D 1603	2.0	2.0	2.0	2.0	2.0
Carbon Black Dispersion	ASTM D 5596	(3)	(3)	(3)	(3)	(3)
Environmental Stress Crack Resistance, hr	ASTM D 5397 Appendix	300	300	300	300	300
Reference Property	**Test Method**	**Nominal Values**				
Melt Flow Index, g/10 minutes	ASTM D 1238. Cond. 190°C/2.16 kg	<1.0	<1.0	<1.0	<1.0	<1.0
Dimensional Stability (each direction). %	ASTM D 1204, 100ºC, 1 hour	±2	±2	±2	±2	±2
Oxidative induction time, Minutes (Standard OIT)	ASTM D 3895, 200°C, pure O_2, 1atm	100	100	100	100	100
Oxidative induction time, Minutes (HP OIT)	ASTM D 5885, 150ºC, pure O_2, 500 psig	400	400	400	400	400
Oven Aging, 85ºC, 90 days/ Standard OIT, % retained	ASTM D 5721/ ASTM D 3895	55	55	55	55	55
UV exposure 1,600 hrs/ HP OIT, % retained [4]	GRI-GM 11/ ASTM D 5885	50	50	50	50	50

[1] Value at 95% confidence interval.
[2] Average value of 10 specimens taken across roll width. No value to be less than 90% of average value.
[3] Dispersion only applies to near spherical agglomerates. 9 of 10 views shall be Category 1 or 2. No more than 1 view in Category 3.
[4] Value based on % retained regardless of the HP OIT value of the unexposed sample.
Additional information on the properties of GSE geomembranes, including roll sizes, is available on request.

R03 11/01/05

GSE Lining Technology Limited • 37 Regal Drive • SOHAM, Cambridgeshire, CB7 5BE • 01353 624677 • Fax: 01353 624922 • msmith@gseworld.com
European Headquarters - GSE Lining Technology GmbH • Buxtehuder Strasse 112 • D-21073 Hamburg, Germany • +4940767420 • Fax: +49407674233

www.gseworld.com

Application Sheet

Tanks

SECURE CONTAINMENT AND LEAK DETECTION LINING SYSTEMS

For primary tank linings, secondary containment, leak detection systems, ringwalls and retrofits, GSE products meet a wide range of tank application needs. Thousands of industrial and municipal users have relied on GSE materials, technology and services in vital applications such as the secure segregation of hydrocarbons and chemical media, corrosion proofing of concrete, steel and other surfaces. With over 25 years of manufacturing and installation experience, GSE can provide you with superior quality and service. GSE offers a range of quality products to facilitate tank lining projects:

- High Density Polyethylene (HDPE) Geomembranes
- Drainage Geonets & Geocomposites
- Cast-In-Place Geomembrane Attachment Strips
- Cast-In-Place Concrete Protective Liner Systems
- Precise Factory-Controlled Prefabricated Pipe Intrusion Boots, Sumps and connections

GSE HDPE geomembranes are:

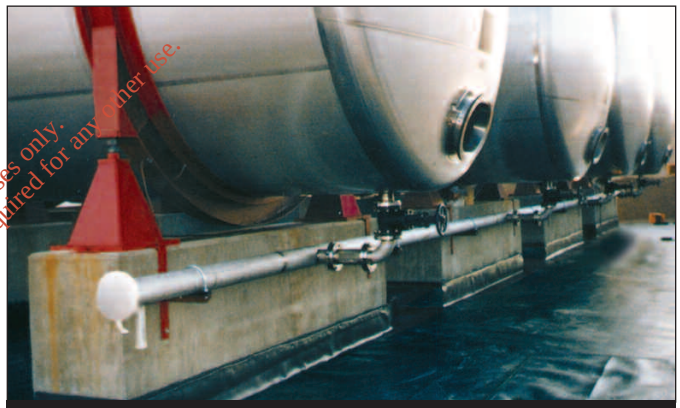
- Rugged & durable
- Resistant to most hazardous liquids
- Certified for potable water containment
- UV-resistant for exposed applications
- Cost-effective

PRIMARY TANK LINERS

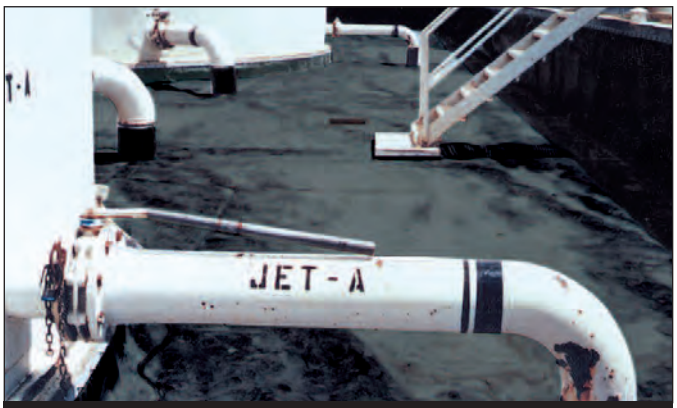
GSE geomembranes have been installed inside steel and concrete tanks of all dimensions to preserve aging tanks and to protect the tank walls from corrosion. In potable water applications, the geomembrane assures that no ground-water-based contaminants or deteriorating structural containment sediment enters the reservoir. A floating cover or fixed-roof cover can likewise keep unwanted material out of the containment or help confine vapors emitted by the contained liquid.

GSE HDPE geomembrane can be attached to steel tank walls using bolted stainless steel batten strips. Geomembrane can also be attached to concrete foundations using bolted stainless steel batten strips or more economically using GSE PolyLock HDPE concrete embedment attachment strips. The PolyLock strips are attached to the concrete forms prior to pouring. Once the poured concrete has set, the geomembrane can be securely welded to the PolyLock strip to form a continuous attachment. Refer to the GSE Tank Lining application sheet for more specific, and technical information.

Irregular surfaces and small areas are easily lined.



Industrial secondary containment application.



Secondary containment of jet fuel.

ENHANCED LININGS

GSE's patented geomembrane offers other significant benefits over traditional lining systems. A GSE Conductive liner

- Continued -

system can be thoroughly electrically spark-tested once installed. And for exposed applications, the clean conductive geomembrane can be spark-tested periodically as part of a maintenance program to ensure that no post-installation damage has occurred. GSE Conductive geo membranes offer a level of assurance not possible with other tank lining products. See the GSE Conductive application sheet for more information.

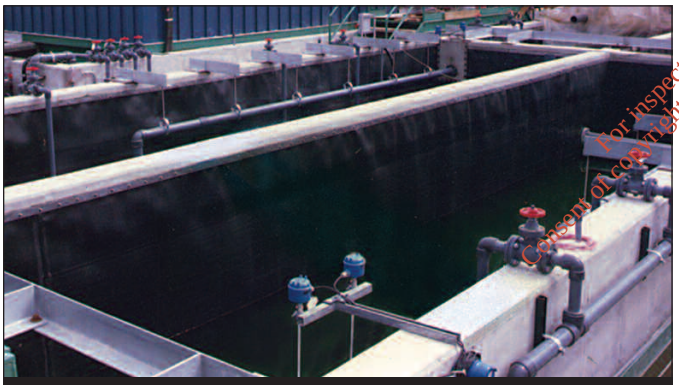
LEAK DETECTION

GSE HDPE geomembrane liners are typically utilized for leak detection systems inside the ringwall or retrofit. The liner contains and channels leaked liquids to a leak detection sump.

A GSE drainage geocomposite, placed directly on top of the geomembrane, is typically used to facilitate rapid drainage of any leaked liquid.

SECONDARY CONTAINMENT

From small tanks to entire tank farms, the secondary containment area is a critical component of tank lining protection. GSE geomembranes have been proven in hundreds of secondary containment applications. GSE's trained installation technicians have extensive experience working with pre-existing and complicated piping systems.

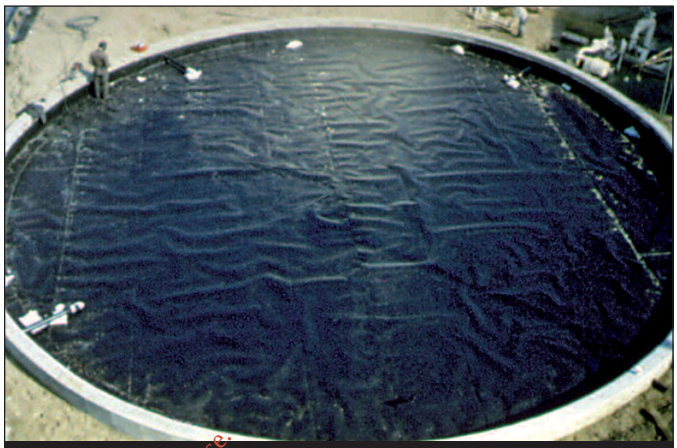


GSE HDPE geomembrane used in a process tank.

CORROSION PROTECTION

GSE HDPE geomembrane lining systems are routinely utilized to provide corrosion protection for concrete and steel surfaces. GSE offers two methods for corrosion-proofing. The first method involves attaching standard geomembrane sheeting to the concrete surface using batten strips or the PolyLock concrete embedment strip.

The second method is to use GSE StudLiner concrete protective liner systems. GSE StudLiner sheeting incorporates extruded studs on one side which are embedded into new concrete or attached using an injected mortar. The StudLiner sheet locks into the concrete and provides a tight, smooth, rigid surface. See the GSE StudLiner application sheet for more information.



GSE HDPE geomembrane in a ringwall.

ADDITIONAL INFORMATION

If you have an upcoming project, please give us a call. We will provide you with recommendations, an estimate for material and installation, and contacts for a GSE approved installer.

AP003 Tank R03/16/06

North America	GSE Lining Technology, Inc.	Houston, Texas	800 435 2008	281 443 8564	Fax: 281 230 8650
South America	GSE Lining Technology Chile S.A.	Santiago, Chile		56 2 595 4200	Fax: 56 2 595 4290
Asia Pacific	GSE Lining Technology Company Limited	Bangkok, Thailand		66 2 937 0091	Fax: 66 2 937 0097
Europe & Africa	GSE Lining Technology GmbH	Hamburg, Germany		49 40 767420	Fax: 49 40 7674234
Middle East	GSE Lining Technology-Egypt	The 6th of October City, Egypt		202 2 828 8888	Fax: 202 2 828 8889

www.gseworld.com

A well established solution to landfill engineering

WALO

WALO UK LIMITED

Contents

WALO UK LIMITED

The main benefits of using a Dense Asphaltic Concrete lining system is that it is strong and very robust, quick to lay yet extensively quality assured, flexible yet extremely impermeable and cost effective when the following points are taken into account:-

- Much less time taken for construction.
- Allowing positive target dates for completion.
- Proven consistency of all materials.
- Extensive Construction Quality Assurance.
- No protective measures required prior to laying the leachate drainage blanket.
- Reduced construction thickness on base and slopes, providing large savings in void space to be used for the waste product.
- Confidence that the surface is completely sealed.
- Environment Agency and Planning Authority approval.
- Completed areas can be left unprotected until required.
- Completed areas can be used by traffic immediately upon completion of the works.

Introduction

Dense Asphaltic Concrete Landfill lining technology at it's best

Key Points

It is generally accepted that landfills, which receive potentially hazardous wastes in locations where the release of contaminants may have environmentally unacceptable consequences, must be contained.

In selecting and designing a containment system a realistic and pragmatic approach must be adopted which accepts the limitations of current knowledge but reduces the risks to the environment to what is perceived to be an acceptable level.

Landfill operators and designers have to consider ever-changing environmental issues and policies when it comes to designing the type of liner required for a fully contained landfill area.

There are generally four classes of containment or lining systems; Single Liner, Composite Liner, Double Liner and Multiple Liner. The decision as to which system is appropriate must be made on the basis of a risk assessment which considers the nature of the waste to be disposed, the leachability ability of the contaminants within the waste, the vulnerability of ground and surface waters and the ability of the liner itself to minimise risk.

Landfills must be designed to meet the necessary conditions for preventing pollution of soil, groundwater and surface water and this is to be achieved by the combination of a geological barrier and a bottom liner during the operational/active phase. Where the geological barrier does not meet the above conditions it can be completed artificially and reinforced by other means giving equivalent protection.

A Dense Asphaltic Concrete (DAC) lining system is engineered to provide complete containment rather than controlled. Seepage the containment provided by a DAC lining system is engineered to be more effective than any other type of liner, be it Single, Composite or a Multiple System.

A well astablished solution to landfill engineering called Dense Aspualtic Concrete.

Landfill cells of any shape and size can be accommodated using DAC. The tying-in joint to an existing cell is very straight forward and made completely watertight.

FACTORS AFFECTING THE CHOICE OF LINING MATERIALS

The choice of containment system must be based on a risk assessment, one element of which is the ability of the liner itself to minimise the risk of leakage of dangerous contaminants into ground or surface water. It is however, equally important to take into account any physical or logistical constraints which may render a technically acceptable liner impractical. The principal considerations, which should be identified, are listed below:

- Minimal hydraulic conductivity possible*
- Stability on steep slopes
- Sufficient flexibility
- Robustness
- Resistance to chemical attack
- Proven longevity
- Acceptance by regulatory authorities
- Acceptable installation techniques
- Realistic cost

***Note:** The term hydraulic conductivity is used in this brochure as a measure of the rate of flow of water based liquid through substrate assuming a hydraulic head of 3 metres.*

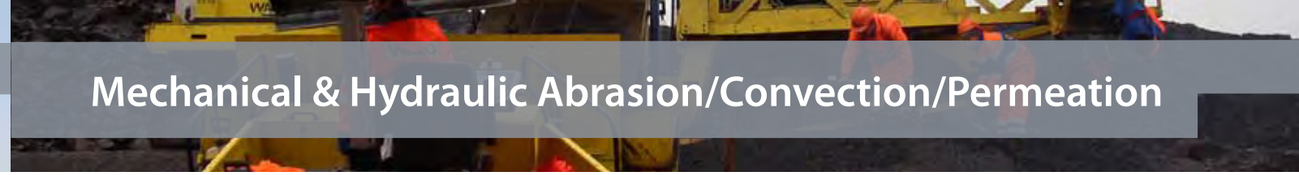
Properties of Dense Asphaltic Concrete

A dense asphaltic concrete lining system comprises of three layers, each of which fulfils specific functions to ensure the integrity of the liner system.

The stabilising/drainage layer (**SL**) is analogous to the subbase of a road. It is constructed from clean compacted, graded aggregate and serves two functions; it prevents the build up of water pressure beneath the liner caused by springs, seepage or the ingress of water around the edge of the liner whilst providing a firm, stable surface on which the equipment required for the construction of subsequent layers can be used. The (SL) is generally placed on a granular sub-grade layer or clay layer which has been compacted up to a stiffness of < 50MN/m² or a CBR of ≥20% (this deformation modulus is required to ensure satisfactory compaction of the subsequent asphaltic materials). When compacted, the stabilising layer is sprayed with a bituminous emulsion, which helps bind together the fines in the upper layers of the material whilst at the same time creating adhesion for the next layer. The asphaltic binder layer (**AB**) is an open textured asphaltic layer specifically designed to have a high permeability factor. This layer provides a strong stable base against which the dense asphaltic layer can be compacted and, by virtue of its permeability, allows any steam generated during the construction of the dense asphaltic layer to escape and so assist in preventing the formation of bubbles forming in the DAC layer. The AB layer is designed to be strong enough to support the DAC layer, the depth of the landfill, the daily cover material and any capping/restoration material without thinning and/or deforming or being forced into the voids of the underlying stabilising layer.

The dense asphaltic concrete layer (**DAC**) is not simply an artificial barrier system, it is a (**Fully Engineered, Specifically Designed Containment Lining System**) which is comprised of an asphaltic mixture with a continuously graded aggregate matrix, laboratory designed for each individual contract so that the quantity and grading of each aggregate fraction fills the gaps left in the matrix formed by larger sizes. The cementitious binding agent is bitumen, which plays an important part in the overall design and construction of the dense asphaltic concrete layer, being the agent that binds the minerals together and adds to the impermeability of the mixed material. Once laid and compacted, the material forms a completely impermeable layer that is resistant to deformation, yet retaining ample flexibility, having a bulk density of approximately 2500 kg/m².

Finally, a fine coat of mastic asphalt is applied to the top surface of the DAC layer. This mastic seal coat provides no additional strength to the liner but is an additional finish layer, providing additional protection against UV exposure and weathering during the period the DAC layer is left open to the elements.



Mechanical & Hydraulic Abrasion/Convection/Permeation

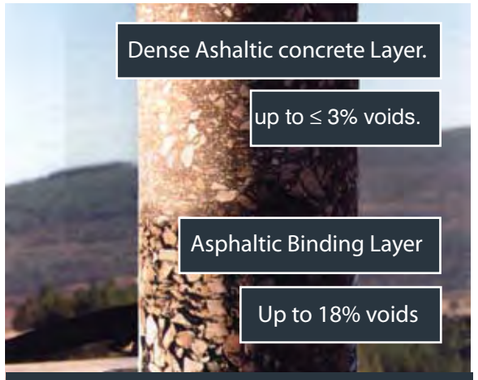
WALO have been lining landfill sites throughout continental Europe since the late 1970's, principally in Switzerland and Germany and more recently in Italy, Spain, Poland and the UK. WALO have laid DAC impermeable linings on more than 100 landfill sites to date with many having very steep side slopes. In the UK, thirteen landfill cells have been lined with DAC, two at a privately owned industrial waste landfill site and eleven at commercially owned municipal solid waste landfill sites. Many more sites are now going through the conditioning, planning and licensing stages to be engineered with DAC in the future.

Long term tests have been carried out on the hydraulic abrasion and resistance to permeability by convection and permeation using hydrocarbon solvents.

The results have proven that solvents such as trichloroethylene and a nine-component-mixture of different hydrocarbons were not able to penetrate into the mortar films of well designed dense asphaltic concrete lining systems used in the construction of landfill sites and it is proven and therefore safe to assume that DAC is durable against chemo-abrasive attacks from aggressive solvents.

Although there is no direct correlation between effective porosity and hydraulic conductivity, hundreds of tests on samples with voids of between 1.5% and 3% have regularly produced hydraulic conductivity initial inflow values of ≤K 1 x 10^{-13} m/s, tested under a 1.0 MPa, ((i.e. 10 bar - equivalent to 100m head of water) or (56lbs/inch²) or (1000kg/m²), with the outflow values showing a K factor of zero, indicating complete impermeability; (this is many orders of magnitude less than the commonly accepted k 1 x 10^{-9}m/s for landfill liners.

Laboratory tests are frequently carried out to determine the density/permeability of the DAC lining system insitu.



Picture of a core showing the difference in grading between the binding layer and the DAC layer.

The example shown in Table 1 (See page 9) are the results on four core samples taken from a DAC lining system constructed at a UK landfill site. The sample tests were undertaken by a UKAS Accredited Laboratory solely for the purposes of verifying the permeability results of the finished product and as part of the CQA requirement under the contract.

Four (DAC) cores of approximately 95mm diameter x 50mm depth were tested. Each core was given a unique laboratory sample number for identification purposes. The material testing laboratory were requested to undertake water permeability testing of the four DAC cores.

Test Method

The samples were tested in accordance with the method given in EN 12697-8; Methods of test for the determination of density and compaction.

Sample Preparation

Each core was cleaned with a dry, soft nylon brush. The test specimen was then sealed at the edges by placing in a circular stainless steel mould and filling the annular space with cold curing epoxy resin. When the resin had cured, the specimens were demoulded and conditioned at 23 ± 2°C in ambient laboratory humidity for approximately 24 hours. The water permeability determination was then commenced using the test apparatus as shown in Figure 1on page 10.

Water Permeability Coefficient Determination

A water pressure regime was applied to the test surface (top rolled surface) as outlined in Table 2. During the pressure regime, observations for water on the exposed surface were made. These observations are also shown in Table 2. Within this pressure regime, if water appeared on the exposure face, the flow was measured. If no water was observed on the exposed surface by the end of the pressure regime period each specimen was removed from the test apparatus, weighed and split longitudinally to measure the depth of water penetration.

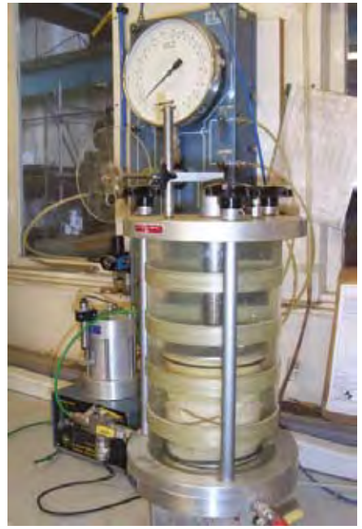
Water Permeability Results - Table 1

* Due to no flow of water recorded through the specimens, the water permeability was calculated using Valenta's modified calculation

Client Ref	Units	05-4034	05-4034	05-4034	05-4034
Lab Ref		142891	142891	142891	142891
Date Test Started		21.07.05	21.07.05	27.07.05	27.07.05
Date Test Finished		28.07.05	01.08.05	04.08.05	04.08.05
Diameter of Core	(mm)	100	100	94	94
Depth of Core	(cm)	4.98	5.00	4.83	4.83
As Received Density	(Mg/m*)	2.2382	2.382	2.387	2.387
Maximum Pressure	(Bar)	5	10	5	5
Surface Area	(cm*)	68.96	69.40	69.99	69.84
Penetration Depth	(cm)	<0.01	<0.01	<0.01	<0.01
Void Content	(%)	2.15	1.83	2.86	2.86
Test Period	(hours)	120	96	120	120
Water Permeability					
Based on penetration	Valenta's (m/s)	9.98E-18	2.65E-18	1.65E-18	1.66E-18
Based on flow *	Darcy's (m/s)	-	-	-	-

The water permeability coefficient based on the measured flow rate, (or in this testing procedure - depth of penetration), was then calculated. Due to the impermeable nature of the material, (i.e. no water was seen to flow through the samples); Darcy's method of water permeability calculation can not be used. Therefore the water permeability calculation using Valenta's modified formula method based upon water penetration, is used - (i.e. no water penetration shown indicating complete impermeability). Seepage through most types of landfill liners is normally calculated using Darcy's Law which states *"Flow rate through porous media is proportional to the head loss and inversely proportional to the length of the flow path"*. Darcy's work was however carried out in the 1850's. The structure of a DAC lining system is such that it is designed to have apparent negligible total porosity and no effective porosity. The design grading of the aggregate and filler alone, without the binding agent, can reduce effective porosity and hydraulic conductivity to very low levels (≤1 x 10^{-8} m/s), and the covering of the aggregate with bitumen (which is a material effectively impermeable) and the filling by the same material of the interstitial voids creates a very flexible and an effectively nonporous material. Total air voids are normally specified in DAC at ≤ 3%, and in practice figures well below 3% are commonly achieved.

Permeability Test Apparatus - Figure 1



Observations made during pressure regime - Table 2

Pressure (bar)	Time (hours)	05-4015 142866	05-4016 142867	05-4033 142890	05-4034 142891
1	12	No water penetration	No water penetration	No water penetration	No water penetration
2	12	No water penetration	No water penetration	No water penetration	No water penetration
3	12	No water penetration	No water penetration	No water penetration	No water penetration
4	24	No water penetration	No water penetration	No water penetration	No water penetration
5	120	No water penetration	No water penetration	No water penetration	No water penetration
10	96	N/A	No water penetration	N/A	N/A

Darcy's Law cannot apply in terms of substances as impermeable as Dense Asphaltic Concrete.

In reality, most materials contain interstitial spaces on a molecular level through which smaller molecules of certain chemical species could diffuse. The permeant migrates through the material on a molecular basis by activated diffusion and not as a liquid which can flow through the pores of soils and carry dissolved chemical species.

However the voids in a compacted DAC mix are not interconnected. This therefore makes laminar flow through the material virtually impossible and any results obtained on impervious asphaltic elements using Darcy's Law are inappropriate.

A number of conditions are required for the diffusions process to take place, the most basic of which is the "chemical potential" of the permeant and the solubility of the permeating species in the membrane. The next stage depends upon the size and shape of the molecules involved. In DAC the use of fillers inhibits diffusion rates by interfering with molecular movement, especially the polymer chains. DAC is advantageous in this respect because of its greater thickness and its asphalt and heterogeneous composition.

It should be noted that diffusion could, depending upon the circumstances (which is a landfill environment is constantly changing), operate in the reverse direction, depending upon relative concentrations on either side of the membrane. It is extremely unlikely that a condition of steady-state diffusive flow of constituents across a DAC liner will develop and thus analysis is outside the scope of Fick's first law of diffusion.

In essence therefore, the measure of escape across a DAC barrier membrane either by diffusion or by advection is virtually impossible.

Asphalt

Key Points

Chemically defined, asphalt is "a complex combination of high molecular weight organic compounds containing a relatively high proportion of hydrocarbons with high carbon-to-hydrogen ratios" whilst composed primarily of complex hydrocarbon molecules, asphalt also contains such atoms as oxygen, nitrogen and sulphur.

The principal source of asphalt used in modern construction is from the refining of crude petroleum. Crude petroleum is composed of a variety of compounds and a refinery is used to separate the crude petroleum into its various constituents. Briefly described, the refining process involves heating the crude petroleum to approximately 400°F to vaporize the lighter, more volatile fractions. These lighter fractions are removed and the petroleum is further refined into such products as naphtha, petrol, kerosene, fuel oils and lubricants.

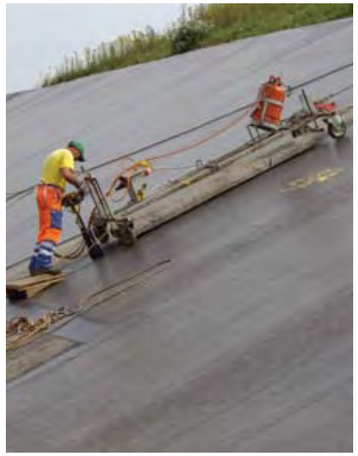
After one or more additional refining processes have removed the lighter petroleum compounds, the non-volatile portion which remains is the vacuum residuum or asphalt.

Any additional refining and manufacturing procedures are aimed at making products that meet various grades of asphalt for varying specifications.

This complexity of asphalt composition combined with the aggregate and fillers in a DAC mixture makes for an overall resistance to all forms of permeation, including gas.

The only conclusion which can be gained from the above information and from our experience of conducting many hundreds of CQA and comprehensive in-situ and laboratory tests on DAC samples over 70 years is, that providing the specification, the composition and the construction is controlled in terms of void content, DAC is vastly superior to the basic standards for lining systems required for landfills in the U.K.

Stability on Slopes



Long-term experience by WALO in the use of DAC for lining dams, reservoirs, canals and landfill sites, which have been subject to prolonged exposure to sunlight, extremes of temperature and repeated wetting and drying, indicates that these conditions do not adversely affect the performance of a DAC membrane in-situ.

The slope inclination is determined by the soil mechanics, the stability of the bituminous layers and the installation procedure employed. At present the limit of inclination for asphalt hydraulic engineering structures is 1:1.5 (34°).

Many sites throughout Mainland Europe and the UK have been lined by WALO, with slopes up to 1:1.5. WALO have extensive experience in laying DAC to steep slopes thereby providing considerable confidence in the stability of the product we provide.

Key Points

A landfill cell being lined with our impermeable DAC system, even the ramps into the cell can be completely sealed with our DAC and then trafficked.

WALO have designed the technology to be able to lay DAC at 70° - parallel to a quarry face, now making redundant quarries a viable option for landfilling.

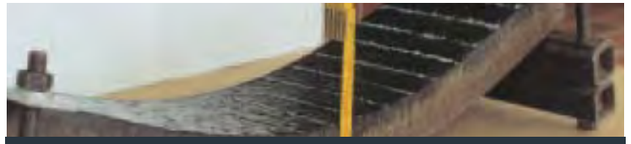
Flexiblilty

The known flexibility of asphaltic materials is reflected in its many uses at critical locations in civil engineering.

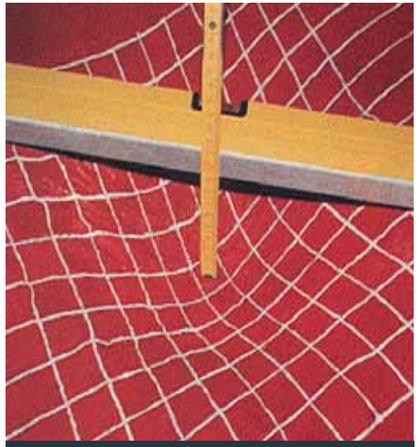
Flexibility in power station pump storage reservoirs for example, which are designed to accept extreme changes in pressure on the DAC lining system when large volumes of water is pumped from one reservoir into a lower reservoir and then back again on a daily cycle.

Another example is the use of short stretches of asphaltic surfacing on concrete surfaced highways where the road surface crosses over concrete bridge structures where flexibility is critical, (although it must be emphasised that material used for road surfacing is not designed in the same way as dense asphaltic concrete). Extensive experience and testing of dense asphaltic concrete in recent years has been more than convincing in terms of proving its ability to flex without showing signs of stress cracking. Thus accomodating any differential settlement that might be present.

Van Asbeck flexibility and bending tests performed on full thickness “beams” of asphaltic concrete cut from trial panels confirms the ability of the material to deform at ratios greater than 1:10 without stress cracking.



A laboratory test showing DAC flexing up to 50mm without showing signs of cracking and still retaining its impermeability



A laboratory sample showing DAC flexing more than 10% without cracking.

Key Points

Physiological Compatibility

The successful use of DAC in hydraulic applications such as in domestic drinking water reservoirs, fish rearing ponds and canal liners is well documented. Physiological compatibility of bitumen with drinking water has been proven many times.

DAC is durable, flexible and can be designed to be either impermeable or porous. As an inert material, it is resistant to the actions of almost all acids, alkalis and salts.
The use of Dense Asphaltic Concrete linings in reservoirs is fully compatible with all water authority drinking water hygiene regulations. The DAC material is mixed and laid at very high temperatures and during the mixing process the lighter oils contained within the bitumen are completely burnt off, leaving a material that is very stable and non-toxic.

Weathering

Whilst the stone stabilising layer and asphaltic binder layer can be laid in most climatic conditions, construction of the DAC layer is restricted during heavy rain or when the temperature and/or wind chill causes rapid cooling of the surface of the asphalt, normally at or about 5° Centigrade. Once the DAC layer has cooled however, no adverse weathering will affect its ability to function and remain completely stable.

Robustness

In terms of relative robustness, it is sufficient merely to point to the performance of dense asphaltic concrete in comparison to other lining materials. No other lining system allows traffic or waste to be placed upon it without firstly requiring extensive protective measures. DAC does not require any additional protective layers prior to placing the stone leachate drainage blanket.

Taking into account that a DAC lining system is specifically designed for each and every site, its robustness is completely assured.

Depending upon the type of lining system used, the phasing of landfill construction and its operation generally limits the extent to which additional cells are lined ahead of tipping. To ensure continuity of cell readiness, landfill cells using DAC can be lined much earlier than needed because the lining system cannot be damaged by inclement weather or by vehicles using it or by vandals.

The inherent flexibility such an approach provides allows the use of these additional cell areas for the temporary storage of solid waste for pre-treatment or for composting of green wastes which can provide additional cost benefits for the operator.

A DAC barrier is robust enough to withstand exposure to the weather for time spans running into decades and yet still give confidence that it will perform its primary function when required.

Resistance to Chemical Attack

When assessing the ability to withstand chemical attack, the significance of the DAC layer thickness (80mm) and the influence of the hardstone aggregate content and the small amount of binding agent in the DAC material should not be ignored.

When testing and evaluating chemical resistance it is necessary to take bitumen's thermoplastic characteristics into consideration, since the action of acids with a pH value of <4, (the pH of most municipal solid waste landfill leachate is usually in the range of 4.8 to 5.2) or high volumes of solvents may increase the temperature of the bitumen slightly and this could be linked to a slight softening of the bitumen's structure.

Experiments have shown however that any softening of a DAC barrier through such an attack would only affect a few millimeters in the top surface. The binder film i.e. the bitumen, between the mineral components is only a few microns in thickness and therefore the flow of fluid between these components is extremely prohibitive. In effect any loosening of the binder would increase the tightening of the aggregate interlock, thereby increasing the barriers impermeability. Once the acidity or solvent has been dissipated the bitumen reverts back to its normal state.

The DAC concept is one of using clean graded hardstone aggregates that do not swell and which are mix-designed in such a way that even without the bitumen, the composition gives a hydraulic conductivity of 1 x 10^{-8} m/s.

The hydrocarbon content in a DAC barrier comprises less than 8% of its composition of weight compared to other lining materials HDPE whose composition is nearer 100% by weight of hydrocarbon derivative.

Acceptance by Regulatory Authorities

The 'Landfill Directive 1999/31/EC' and the 'Landfill Regulatory Guidance note (RGN6)' states that the geological barrier in a landfill is to be determined by geological and hydrological conditions below and in the vicinity of a landfill site providing sufficient attenuation capacity to prevent a potential risk to groundwater. In addition, where the geological barrier does not provide sufficient environmental protection it can be artificially enhanced and reinforced by other means giving equivalent protection.

If this is not possible with the existing subgrade materials it can be made suitable with an initial capping layer of DAC placed on top of a stone drainage layer followed by the subsequent normal layers of DAC. This initial capping layer of DAC would save on the expensive cost of extraction and removal from site of any unsuitable materials and the subsequent cost of replacement, whilst providing additional attenuation and, once the normal DAC layer is placed on top of this initial capping layer, it would in effect provide a double liner system.

The Directive and Guidance also state that - *"The landfill base and sides shall consist of a mineral layer which satisfies permeability and thickness requirements. With a combined effect in terms of protection of at least equivalent to K < 1 x 10^{-9} m/s; thickness > 0.5m, for landfills taking nonhazardous waste.*

The DAC lining system is not simply another artificially established geological liner but is a *"Fully Engineered Specifically Designed Lining System"* which does not have to rely on being laid 500mm thick to make it impermeable and strong enough to withstand decades of service.

The Environment Agency: (EA) Landfill Regulatory Guidance Note 6.0 (version 2, July 2004, section 5) the guidance note is headed *"Artificial Sealing Liner"*, it states that *"the requirements for an artificial sealing liner would be met by a liner system such as a dense asphaltic concrete (DAC)".*

In Mainland Europe, where DAC has been the preferred barrier system for decades, the 'EA's' have such confidence in the material that it is the only system specified to be used in those landfill facilities which take only highly contaminated incineration fly ash.

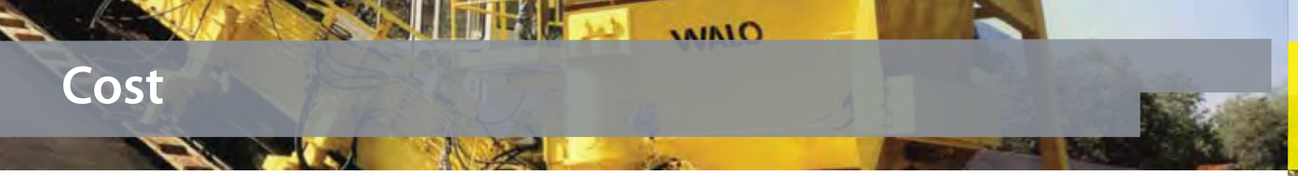
Key Points

Acceptable Installation Techniques

One of the most important elements of installation of any lining system is the supervision and construction quality assurance procedure (CQA). An intensive level of construction quality assurance testing is provided by WALO during the construction phase of its DAC lining system. In particular, the joints between adjacent lanes are rigorously tested to ensure the full effectiveness of the seal. Raw materials and mixed asphalt are thoroughly tested to ensure their compliance with the mix design, and density tests are carried out to ensure that the compacted material has a void content below 3%, thereby providing a hydraulic conductivity ≤ 1 x 10^{-13} m/s.

Whether the asphaltic material (which is mixed daily for each location) is produced on site or produced at an offsite quarry, extensive CQA procedures are carried out at every stage of the production. WALO always have a laboratory on the contract site to ensure thorough monitoring and suitability of all asphalt supplies. It is our regular practice to lay sample test areas of DAC at the beginning of a contract and subject these sample areas to intensive in-situ and core tests to ensure the design specification is achieved. Measurement of temperature and compaction is regularly carried out during all laying operations and particular attention is paid to jointed areas.

A completed landfill cell ready to recieve the stone lachate blanket. This cell of 20.000m² was completed in six weeks.



Cost

DAC has been used as an impermeable barrier system for landfills sites throughout Europe for many years. In the UK Environment Agency has approved its use for sites which have problems meeting the groundwater directive, on or near by aquifers and generally where there is a likelihood of potential settlement or where a site is close to a drinking water source.

The actual cost of a barrier system is a function of many variables in addition to the unit cost per square metre of any particular system. The overwhelming factor in deciding the cost-effectiveness of a containment system is the amount of void space the lining system itself occupies. Any additional space taken up by the containment lining system is space that cannot be occupied by waste.

There is also a difference between the real cost of installation of a barrier system and the theoretical cost. If a barrier system is susceptible to physical damage then other protection layers are necessary. Then apart from the obvious additional cost of the protection material there is also the cost involved with slower and more onerous construction practices and the inevitable delays when damage occurs which has to be repaired. Such costs can be of the order of several times the initial design cost, if the damage results in the need for extensive remedial measures.

As with all barrier systems, the cost of lining a cell with DAC depends upon its overall size, base and slope areas, the length and angle of the slope, its overall height and the general topography of the site. Prices can be readily worked out once these factors are known. Taking everything into account, such as the increased void space created by using a much thinner lining system, the speed of laying, the increased steepness of side slope and the alternative uses that a cell having a DAC lining system can be put to the price is very comparable with other lining products.

Key Points

Advantage to the Dense Asphaltic Concrete over other Lining system

The following is a summary of the benefits of using Dense Asphaltic Concrete as the impermeable lining system for landfill sites.

It is much quicker to construct, taking weeks instead of months to complete. It is not affected by inclement weather whilst being laid or afterwards, giving the landfill operator a quicker response time for starting his landfill operations.

It is a much thinner lining system to construct, with the total thickness generally averaging approximately 340cm. (including drainage layer, binder layer, and the DAC layer) a saving of a metre or more of void space against most other lining systems.

It is strong and constructed to provide hydraulic permeability results of $\leq 1 \times 10^{-13}$ m/s, tested up to 10 bar (100m) head of water pressure.

It is constructed using an extensive construction quality assurance procedure, and all results can be re-tested throughout the construction period and afterwards without destroying the integrity of the lining material.

It is extremely flexible, allowing sufficient flexibility to accommodate a differential settlement of the underlying formation amounting up to 1 in 10 without showing any signs of stress fracture or cracking.

It does not contain mobile toxic compounds that may pollute the ground or surface water.

It has complete stability when placed on slopes of up to 1:1:5 (34°) under all conditions of waste and leachate cover. The increased steepness of slopes provides extra void space for the waste product.

It can be laid parallel to a quarry face of 70°

It is unaffected by vandalism, frost action and all natural weather conditions that may be experienced before covering with waste. Rubber tyred construction plant and vehicles may run on the surface without fear of damaging the lining system.

It is strong enough to support landfill material, daily cover material and capping material without thinning or deforming.

It cannot be punctured and is resistant to mechanical forces resulting from the impact of drainage materials and landfill materials.

It is unaffected by leachate and gases normally found in MSW landfills.

Conclusion and Summary

Lining systems have developed from simple layers of compacted clay to complex composite and multi layer systems of engineered clay, plastic membranes (usually HDPE) and/or Bentonite treated soils or Bentonite geocomposites.

The cost of lining any reasonable size waste cell is now significant and must of course be borne by the operator well before any payback in the form of waste through the gate can be achieved.

The true cost of many barrier systems is seldom calculated, because many of the aforementioned lining materials have specific installation problems that lead to delays (often due to poor weather conditions or construction methods).

There are often difficulties in supply, damage and deterioration over time, sometimes requiring repair and/ or replacement. In addition, there is a general acknowledgement that it is difficult to install some lining materials without causing punctures and tears and this is leading to the specification of ever more complex multilayer systems. The cost effectiveness of laying varying thickness of lining materials with their subsequent protective layers is also open to question and, by taking up evermore valuable void space, does not lend itself to the overall concept of sustainable waste management.

The Dense Asphaltic Concrete impermeable lining system has been used for sealing landfill sites and waste treatment facilities throughout Continental Europe since the late 1970's, longer than some of the materials commonly accepted here in the UK as being tried and tested.

Walo UK Limited was the specialist company involved in the construction of the UK's first DAC lining system at a commercial municipal solid waste landfill site in Derbyshire. Since then eleven more cells have been constructed in the UK using DAC as the lining system and many more sites are already being programmed for lining with DAC in the foreseeable future.

Walo lined a 40,000m² landfill cell in the UK in less than nine weeks and have gone on to complete additional cells for the same client, with several new sites now coming on stream.

Due to its flexible nature, its superior impermeable properties and its much reduced overall thickness compared to alternative systems, DAC is also suitable for capping completed landfill sites and brownfield sites.

A DAC installation generally consists of three main layers; a granular stabilising layer, an asphaltic binder layer and a dense asphaltic layer. Finally a seal coat of hot mastic is applied to the top coat to give additional protection from exposure to ultra violet-rays.

Slopes up to a gradient of 1 in 1.5 and heights up to 150m can be constructed using our specially designed slope laying equipment. This method of construction, using established engineering techniques combined with our unique laying and testing methodology, provides proven confidence in the quality of the final product we produce.

The Dense Asphaltic Concrete lining system is engineered using a very thorough CQA procedure throughout the whole construction period in which temperature; thicknesses and density are regularly measured. External laboratory tests are carried out on cores taken from the compacted materials to examine porosity and hydraulic conductivity.

Detailed written and computerised information is made available to the client, the Environment Agency and associated regulatory authority risk assessment programmes. The speed of completion of the works is a significant element in the saving of costs.

The capacity to lay a considerable area of high quality lining system in a short time period, even during inclement weather conditions, and to know that it will not be subject to subsequent deterioration or loss in performance is seen by most clients as being extremely advantageous.

The indirect and practical advantages of a DAC lining system go towards making the overall installation of the lining system very comparable when compared to other lining materials. Other benefits include the fact that our DAC system is relatively thin, yet strong enough to be robust under all conditions, so void space is maximised without compromising containment standards.

The strength of the lining system is such that it can be trafficked by rubber tyred equipment almost immediately after completion without fear of damage or puncture. The final surface is one on which surface water run-off can be easily controlled, even on steep slopes, thus preventing excessive leachate generation. As an engineering material, DAC certainly adds to the range of engineered options that are available in the quest to minimise risk associated with landfill operations.

Rain water divert channels stuck onto the barrier. These channels prevent excessive rainwater entering the cell. They can be removed or simply left in place without fear of damaging the barrier

Key Points

Walo UK Limited is a division of the Walo Bertschinger Group of companies whose headquarters are situated in Zurich, Switzerland.

The Walo Bertschinger Group was established in 1917 as a civil engineering company and over the past 91 years has expanded its activities in the civil engineering and construction industry to include rail construction, general building construction, tunnelling, road surfacing for indoor and outdoor sports grounds and hydraulic engineering.

Hydraulic engineering has become a very important aspect in the companies' development whereby WALO are now regarded as one of the leading specialists in the world in the construction of hydraulic asphaltic linings for dams, reservoirs, canals, pump storage basins and for the past 29 years, for waste disposal sites and waste treatment facilities.

The Bertschinger Family wholly owns the Group which has over 2,200 employees in departments operating throughout Europe. In 1955 the Walo Group engineered the first of many reservoirs with dense asphaltic concrete and in 1979 successfully completed the first Dense Asphaltic Concrete landfill lining contract in Switzerland. Since then the company has lined more than 100 separate landfill sites throughout Continental-Europe and the United Kingdom.

In 1999 the Walo Group established an operating division in the UK, which is now based in Stafford (Walo UK Limited), to provide a local service of construction of dense asphaltic concrete lining systems throughout the United Kingdom and Ireland. From our base at Stafford we can quickly respond to any request for information on our system and are able to organise and carry out projects with minimal notice.

We have at our disposal the technical support of our ISO/IEC accredited independent laboratory, together with our own operational expertise and specialist equipment necessary to carry out landfill lining systems of any size and anywhere.

If you would like to receive more information on our DAC lining system, or would like to discuss a project, then please contact: David Wilson – Managing Director at Walo UK Ltd. Or visit us at:
www.walo.co.uk

Dense Asphaltic Concrete

Landfill lining technology at its' best

The Dense Asphaltic Concrete (DAC) lining system is a well proven solution to landfill engineering technology. Its strengths and remarkable impermeable properties provide the Landfill Engineer with a lining system which gives confidence that it will withstand many decades of use without risk of leakage or degradation.

The DAC system can also be adapted to increase the attenuation of the existing geological sub-grade if required and all with the benefit of saving valuable void space for the waste product, whilst ensuring the complete protection to the environment.

WALO UK LIMITED

WALO UK LIMITED

Walo UK Limited

16 Parker Court - Staffordshire Technology Park - Dyson Way - Stafford - ST18 0WP
TEL: +44 (0) 1785 330618 **FAX:** +44 (0) 1785 221781 **WEB:** www.walo.co.uk

Appendix D.1.2

Surface Water Management Calculations and Datasheets

SURFACE WATER MANAGEMENT CALCULATIONS AND DATASHEETS

SuDS Site Evaluation

Site Name: MEHL Hollywood Great Naul

Reference: 1285691631133
Date: 28/9/2010

1. Introduction

This is a site specific report to provide outline guidance on drainage and the use of SuDS. Neither HR Wallingford nor any Irish Local Authority is liable for the performance of any drainage scheme which is based upon these results. It is recommended that detailed design of any scheme is carried out before construction takes place.

The following site characteristics were entered.
Site Development Includes: Industrial;
Drainage Ownership: Private;
Site Size: Between 3 ha and 50 ha.
Soil Type: 1 and 2.
Land Use: Greenfield Development.
Location: Uplands.
Other Characteristics:
Ground Water: More than 2m below surface.

General

The general principle behind the use of SuDS for any site is to comply with the following:

- achieve adequate water quality treatment
- runoff volumes should be minimised
- runoff rates should be minimised
- the stormwater effluent is treated appropriately before discharge from the site bearing in mind the requirements of the receiving watercourse
- groundwater must be protected

in addition it is desirable to maximise the amenity potential and ecological benefits where there is an opportunity to provide this.

The various suds components should not be treated as individual options, but should be seen as providing a set of drainage features (a **treatment train**) which are appropriate at various scales. It is always desirable to have a mix of suds components across the site to take opportunity of their respective benefits.

SuDS Ownership

Due to institutional and legislative constraints it is possible that the most technically appropriate solution may not be appropriate due to ownership and maintenance issues. It is essential that any drainage proposal will receive appropriate long-term maintenance.

Private owners have no constraints on the use of any SuDS component. Careful assessment should be made of the risk of a change to the SuDS component occurring in the property and the impact this might have on the whole system performance.

The following table summarises the current position on vesting of SuDS systems in Ireland (LA = Local Authority).

Ownership/Maintenance by Drainage Organisation				
SuDS Component	**LA Drainage**	**LA Roads**	**LA Parks**	**Private**
Ponds	No	No	Yes	Yes
Basins	No	No	Yes	Yes
Pervious Pavements	No	No	No	Yes
Swales	No	Yes	No	Yes
Infiltration Trenches	No	No	No	Yes
Soakaways	No	No	No	Yes
Green Roofs	No	No	No	Yes
Rainwater Harvesting	No	No	No	Yes
Bio-retention	No	No	No	Yes

Design of SuDS

It is important to be aware of both the opportunities and constraints of using SuDS for providing the most appropriate drainage system for a development. For more in-depth guidance the most appropriate document (other than GDSDS policy guidance) is the SUDS manual by CIRIA and SuDS for High Density Developments by HR Wallingford. Other SuDS reference documents and manuals are to be found in the references section of this web site.

Design of SuDS with access to temporary or permanent water should consider public health and safety as well as issues associated with construction and operational management of the structures.

Where SuDS are being used in rolling or steep terrain careful consideration of site layout planning and SuDS alignment is needed to minimise gradients of swales and construction of large embankments.

Construction of SuDS

SuDS are a combination of civil engineering structures and landscaping practice. Due to the limited experience of building SuDS in the water industry, there are a number of key issues which need to be particularly considered as their construction requires a change in approach to some standard construction practices. Detailed guidance on the construction related issues for SuDS is available in the SUDS Manual and the associated Construction Site handbook (CIRIA, 2007).

SuDS Components for Your Site

The following table summarises the SuDS components that might be used at your site, based on the input you have given:

SuDS Component	Applicability
Ponds	yes
Basins	yes
Pervious Pavements	yes
Swales	yes
Infiltration Trenches	yes
Soakaways	yes
Green Roofs	yes
Rainwater Harvesting	yes
Bio-retention	yes

The Use of SuDS for Infiltration

The use of infiltration in industrial areas should normally be avoided unless the risks of serious pollution are assessed as being low.

There is a risk with steep sites that excessive use of infiltration might result in groundwater reappearing at lower locations. Careful consideration of the soil characteristics and groundwater depths is needed.

Treatment Train

In principle, the more SuDS used in a treatment train the better. Ponds should preferably not be used as the first SuDS component for any paved runoff. Treatment will be more effective and hydraulic benefits will also be gained.

Where commercial or industrial development is proposed, greater emphasis on the treatment train will be required. It would generally be desirable to separate the systems serving these areas from systems serving residential developments.

Where sites are very large, greater emphasis on treatment trains is needed to address the increased risk of accidental pollution incidents.

Where developments drain to small streams, the impact of the development will be significant on the watercourse and greater emphasis on treatment is needed.

2. Suitable SuDS Components

The following SuDS might be suitable components of the drainage system for the reasons given:

- **Ponds**

Ponds are suitable for this site.

Where industrial areas are served by ponds it is important to maximise the treatment process and minimise the transmission of an accidental spillage. Ponds should therefore be designed as multiple units if possible.

Ponds built in permeable soils may require liners to ensure the existence of the permanent pool. The liner may be finished 100 or 200 mm lower than the outlet invert to encourage some infiltration to take place. Design of this perimeter zone should maximise infiltration.

- **Basins**

Basins are suitable for this site.

Where industrial areas are served by a basin it is important to maximise the treatment process and minimise the transmission of an accidental spillage. Basins should therefore be designed as multiple units if possible and have control structures to prevent transmission of polluted flows downstream.

- **Pervious Pavements**

Pervious pavements are suitable for this site.

Pervious pavements used in industrial areas need to consider the risk of pollutants. In most situations it is likely that the permeable pavement will be lined to avoid the risk of infiltrating pollutants. Experience has shown that great care is needed in making linings watertight due to the practical difficulties of working on a site. Concrete block permeable pavements have been used in industrial situations with heavy goods vehicles. However it is important to specifically address the additional forces to avoid deformation of the pavement.

- **Swales**

Swales are suitable for this site.

The land take of swales is significant except for mini-swales. Although these SuDS components are very effective, their use in high density developments may be precluded due to lack of

space. In spite of this issue of land take and adoption difficulties, the use of these SuDS units is very desirable due to their effectiveness in addressing both hydraulic and water quality issues.
Swales built to serve industrial areas should use soils which are relatively impervious to minimise the risk of infiltrating pollutants.

- **Infiltration Trenches**

Infiltration trenches are suitable for this site.
Warning: The use of infiltration in industrial areas may be possible, but only after careful consideration of the risks to groundwater have been assessed in detail.

- **Soakaways**

Soakaways are suitable for this site.
Warning: The use of infiltration in commercial or industrial areas may be possible, but only after careful consideration of the risks to groundwater have been assessed in detail.

- **Green Roofs**

Green roofs are suitable for this site.
The use of green roofs provides a number of benefits including reducing runoff volumes for ordinary rainfall events. However they do not have a significant impact on the sizing of main drainage components unless the rainwater is harvested and used.

- **Rainwater Harvesting**

Rainwater harvesting is suitable for this site.
Warning: Rainwater harvesting for large roof areas may have a higher yield than the demand for the collect water. In this situation stormwater management benefits assumed for extreme storm event management will be limited and require careful analysis.
Rainwater harvesting has benefits in reducing potable water demand and also can have a significant impact in reducing the size of some main drainage components if rainfall storage tanks are large enough. Where water resources are particularly scarce, rainwater harvesting should be positively considered. Depending on proposed usage and yield, guidelines suggest that the volume of storage provided should be around 350 litres per person to ensure reasonable continuity of supply. However where rainwater harvesting is used to obtain stormwater management benefits this figure should be multiplied by around 3 (1000 l/person). Detailed evaluation of the rainwater harvesting benefits requires the use of time series rainfall data.

- **Bio-retention**

Bio-retention is suitable for this site.
Warning: The risk of pollutants affecting the groundwater may be significant if bio-retention is used in industrial areas.

3. Unsuitable SuDS Components

The following SuDS have been excluded as suitable components of the drainage system for the reasons given:

PRELIMINARY - SURFACE WATER STORAGE CALCULATIONS FOR

Proposed Landfill Development Filter Drain for Access Road - Naul

Storm Return Period =	**100 Year incl. 10%CC**	
Maximum Storage Required =	**81 m³**	
Filter Drain providing Storage of=	**72 m³**	
Rainfall Data as Recorded by Met Eireann in	**FSU - OPW**	
Allowable Discharge =	**2.64 l/s/ha**	**0.32 l/s**

Proposed Impermeable Areas	Gross	Unit	Impermeability		Nett
Roads	0.150	ha	@	100%	0.150
Total					**0.150**

Duration (min)	Rainfall (mm)	Intensity (mm/hr)	Rainfall (m³/ha)	Proposed Imperm. Area (ha)	Proposed Run-off (m³)	Outflow (m³)	Storage Required (m³)
15	19.6	784.00	196	0.15	29	0.3564	29.0
30	24.1	482.00	241	0.15	36	0.7128	35.4
60	29.6	296.00	296	0.15	44	1.4256	43.0
120	36.4	182.00	364	0.15	55	2.8512	51.7
180	41.1	137.00	411	0.15	62	4.2768	57.4
240	44.8	112.00	448	0.15	67	5.7024	61.5
360	50.5	84.17	505	0.15	76	8.5536	67.2
540	57.1	63.44	571	0.15	86	12.8304	72.8
720	62.2	51.83	622	0.15	93	17.1072	76.2
1080	70.2	39.00	702	0.15	105	25.6608	79.6
1440	76.8	32.00	768	0.15	115	34.2144	81.0
2880	90.2	18.79	902	0.15	135	68.4288	66.9
4320	101.3	14.07	1013	0.15	152	102.6432	49.3
5760	111	11.56	1110	0.15	167	136.8576	29.6
8640	127.9	8.88	1279	0.15	192	205.2864	-13.4
11520	142.8	7.44	1428	0.15	214	273.7152	-59.5
14400	156.4	6.52	1564	0.15	235	342.144	-107.5
17280	169	5.87	1690	0.15	254	410.5728	-157.1
23040	192.3	5.01	1923	0.15	288	547.4304	-259.0
28800	213.6	4.45	2136	0.15	320	684.288	-363.9
36000	238.4	3.97	2384	0.15	358	855.36	-497.8

Storage Required = 81 m³

PRELIMINARY - SURFACE WATER STORAGE CALCULATIONS FOR

Proposed Landfill Development Control Area- Naul - 100 Year Throttle

Storm Return Period = 100 Year incl. 10%CC

Maximum Storage Required = 771 m³

Rainfall Data as Recorded by Met Eireann in FSU - OPW

Allowable Discharge = 2.64 l/s/ha | 3 l/s

Proposed Impermeable Areas	Gross	Unit	Impermeability		Nett
Roof Area	0.166	ha	@	100%	0.166
Roads, Paths Paving	0.666	ha	@	100%	0.666
Grassed Area	1.20	ha	@	30%	0.360
Total					**1.192**

Duration (min)	Rainfall (mm)	Intensity (mm/hr)	Rainfall (m³/ha)	Proposed imperm. Area (ha)	Proposed Run-off (m³)	Outflow (m³)	Storage Required (m³)
15	19.6	784.0	196	1.19	234	1.6	232.0
30	24.1	482.0	241	1.19	287	3.2	284.1
60	29.6	296.0	296	1.19	353	6.3	346.5
120	36.4	182.0	364	1.19	434	12.7	421.2
180	41.1	137.0	411	1.19	490	19.0	470.9
240	44.8	112.0	448	1.19	534	25.3	508.7
360	50.5	84.2	505	1.19	602	38.0	564.0
540	57.1	63.4	571	1.19	681	57.0	623.7
720	62.2	51.8	622	1.19	741	76.0	665.5
1080	70.2	39.0	702	1.19	837	113.9	722.9
1440	76.8	32.0	768	1.19	915	151.9	763.5
2880	90.2	18.8	902	1.19	1075	303.8	771.4
4320	101.3	14.1	1013	1.19	1207	455.7	751.8
5760	111	11.6	1110	1.19	1323	607.6	715.5
8640	127.9	8.9	1279	1.19	1525	911.5	613.1
11520	142.8	7.4	1428	1.19	1702	1215.3	486.9
14400	156.4	6.5	1564	1.19	1864	1519.1	345.2
17280	169	5.9	1690	1.19	2014	1822.9	191.5
23040	192.3	5.0	1923	1.19	2292	2430.6	-138.4
28800	213.6	4.5	2136	1.19	2546	3038.2	-492.1
36000	238.4	4.0	2384	1.19	2842	3797.8	-956.1

Storage Required = 771 m³

PRELIMINARY - SURFACE WATER STORAGE CALCULATIONS FOR

Proposed Landfill Development Capped Cells - Naul - Qbar Throttle

Storm Return Period =	**Qbar (2.3 Year)**	
Maximum Storage Required =	**3,786 m³**	
Rainfall Data as Recorded by Met Eireann in	**FSU - OPW**	
Allowable Discharge =	**2.64 l/s/ha**	**61 l/s**

Proposed Impermeable Areas	**Gross**	**Unit**	**Impermeability**		**Nett**
Capping Area	25.500	ha	@	90%	22.950
Total					**22.950**

Duration (min)	Rainfall (mm)	Intensity (mm/hr)	Rainfall (m³/ha)	Proposed Imperm. Area (ha)	Proposed Run-off (m³)	Outflow (m³)	Storage Required (m³)
15	6.5	26.00	65	22.95	1492	54.5	1437.2
30	8.5	17.00	85	22.95	1951	109.1	1841.7
60	11	11.00	110	22.95	2525	218.1	2306.4
120	14.2	7.10	142	22.95	3259	436.2	2822.7
180	16.6	5.53	166	22.95	3810	654.4	3155.3
240	18.5	4.63	185	22.95	4246	872.5	3373.3
360	21.5	3.58	215	22.95	4934	1308.7	3625.5
540	25	2.78	250	22.95	5738	1963.1	3774.4
720	27.9	2.33	279	22.95	6403	2617.4	3785.6
1080	32.5	1.81	325	22.95	7459	3926.1	3532.6
1440	36.3	1.51	363	22.95	8331	5234.8	3096.0
2880	43.8	0.91	438	22.95	10052	10469.6	-417.5
4320	49.8	0.69	498	22.95	11429	15704.4	-4275.3
5760	55.2	0.58	552	22.95	12668	20939.2	-8270.8
8640	64.5	0.45	645	22.95	14803	31408.8	-16606.1
11520	72.8	0.38	728	22.95	16708	41878.4	-25170.8
14400	80.3	0.33	803	22.95	18429	52348.0	-33919.2
17280	87.4	0.30	874	22.95	20058	62817.6	-42759.3
23040	100.4	0.26	1004	22.95	23042	83756.9	-60715.1
28800	112.5	0.23	1125	22.95	25819	104696.1	-78877.3
36000	126.6	0.21	1266	22.95	29055	130870.1	-101815.4

Storage Required = 3,786 m³

PRELIMINARY - SURFACE WATER STORAGE CALCULATIONS FOR

Proposed Landfill Development Capped Cells - Naul - 30 Year Throttle

Storm Return Period = 30 Year

Maximum Storage Required = 7,409 m³

Rainfall Data as Recorded by Met Eireann in FSU - OPW

Allowable Discharge = 4.17 l/s/ha | 96 l/s

Proposed Impermeable Areas	Gross	Unit	Impermeability		Nett
Capping Area	25.500	ha	@	90%	22.950
Total					**22.950**

Duration (min)	Rainfall (mm)	Intensity (mm/hr)	Rainfall (m³/ha)	Proposed Imperm. Area (ha)	Proposed Run-off (m³)	Outflow (m³)	Storage Required (m³)
15	14.6	58.40	146	22.95	3351	86.156136	3264.5
30	18.2	36.40	182	22.95	4177	172.312272	4004.6
60	22.7	22.70	227	22.95	5210	344.624544	4865.0
120	28.3	14.15	283	22.95	6495	689.249088	5805.6
180	32.2	10.73	322	22.95	7390	1033.87363	6356.0
240	35.3	8.83	353	22.95	8101	1378.49818	6722.9
360	40.2	6.70	402	22.95	9226	2067.74726	7158.2
540	45.8	5.09	458	22.95	10511	3101.6209	7409.5
720	50.2	4.18	502	22.95	11521	4135.49453	7385.4
1080	57.1	3.17	571	22.95	13104	6203.24179	6901.2
1440	62.8	2.62	628	22.95	14413	8270.98906	6141.6
2880	74.4	1.55	744	22.95	17075	16541.9781	532.8
4320	83.8	1.16	838	22.95	19232	24812.9672	-5580.9
5760	92.1	0.96	921	22.95	21137	33083.9562	-11947.0
8640	106.6	0.74	1066	22.95	24465	49625.9343	-25161.2
11520	119.3	0.62	1193	22.95	27379	66167.9124	-38788.6
14400	130.9	0.55	1309	22.95	30042	82709.8906	-52668.3
17280	141.7	0.49	1417	22.95	32520	99251.8687	-66731.7
23040	161.6	0.42	1616	22.95	37087	132335.825	-95248.6
28800	180	0.38	1800	22.95	41310	165419.781	-124109.8
36000	201.3	0.34	2013	22.95	46198	206774.726	-160576.4

Storage Required = 7,409 m³

PRELIMINARY - SURFACE WATER STORAGE CALCULATIONS FOR

Proposed Landfill Development Capped Cells - Naul - 100 Year Throttle

Storm Return Period = 100 Year incl. 10%CC

Maximum Storage Required = 9,131 m³

Rainfall Data as Recorded by Met Eireann in FSU - OPW

Allowable Discharge = 5.34 l/s/ha | 123 l/s

Proposed Impermeable Areas	Gross	Unit	Estimated Runoff		Nett
Capping Area	25.500	ha	@	90%	22.950
Total					**22.950**

Duration (min)	Rainfall (mm)	Intensity (mm/hr)	Rainfall (m³/ha)	Proposed Imperm. Area (ha)	Proposed Run-off (m³)	Outflow (m³)	Storage Required (m³)
15	19.6	784.00	196	22.95	4498	110.367101	4387.8
30	24.1	482.00	241	22.95	5531	220.734202	5310.2
60	29.6	296.00	296	22.95	6793	441.468403	6351.7
120	36.4	182.00	364	22.95	8354	882.936806	7470.9
180	41.1	137.00	411	22.95	9432	1324.40521	8108.0
240	44.8	112.00	448	22.95	10282	1765.87361	8515.7
360	50.5	84.17	505	22.95	11590	2648.81042	8940.9
540	57.1	63.44	571	22.95	13104	3973.21563	9131.2
720	62.2	51.83	622	22.95	14275	5297.62084	8977.3
1080	70.2	39.00	702	22.95	16111	7946.43126	8164.5
1440	76.8	32.00	768	22.95	17626	10595.2417	7030.4
2880	90.2	18.79	902	22.95	20701	21190.4834	-489.6
4320	101.3	14.07	1013	22.95	23248	31785.725	-8537.4
5760	111	11.56	1110	22.95	25475	42380.9667	-16906.5
8640	127.9	8.88	1279	22.95	29353	63571.4501	-34218.4
11520	142.8	7.44	1428	22.95	32773	84761.9334	-51989.3
14400	156.4	6.52	1564	22.95	35894	105952.417	-70058.6
17280	169	5.87	1690	22.95	38786	127142.9	-88357.4
23040	192.3	5.01	1923	22.95	44133	169523.867	-125391.0
28800	213.6	4.45	2136	22.95	49021	211904.834	-162883.6
36000	238.4	3.97	2384	22.95	54713	264881.042	-210168.2

Storage Required = 9,131 m³

Pipe Run Ref.	Area m^2	Imperm. %	Imperm. Area m^2	Rainfall Intensity mm/hr	Less Cell Storage Litres	Discharge l/s	Pipe Size mm	Gradient 1 in …	k_s mm	Velocity m/s	(Full-flow) l/s
Landfill Cell	18,000	100%	18,000	31	539000	3					
LE11 - LE1			18,000			3	225	200	0.06	1.11	44

30 year 1 hour duration casement = 30.6

Codes Of Practice: B.S. 8301:1985 Building Drainage
B.S. 8301:1985 Drainage of Roof and Paved areas.

Pipe Run Ref.	Area m^2	Imperm. %	Imperm. Area m^2	Rainfall Intensity mm/hr	Discharge l/s	Pipe Size mm	Gradient 1 in …	k_s mm	Velocity m/s	(Full-flow) l/s
Road/Footpath	423	100%	423	50	6					
MH 2A - 1A			423		6	150	20	0.06	2.89	51
Road/Footpath	910	100%	910	50	13					
MH1A/2 - 1A/1			910		13	150	150	0.06	1.00	18
Road/Footpath	0	100%	0	50	0					
MH1A/2 - 1A/1					13					
MH1A/1 - 1A			0		13	150	150	0.06	1.00	18
Road/Footpath	0	100%	0	50	0					
MH1A/1 - 1A					13					
MH 2A - 1A					6					
MH 1A - 3			0		19	225	200	0.06	1.11	44
Road/Footpath	502	100%	502	50	7					
MH 3/1/1 - 3/1			502		7	150	150	0.06	1.00	18
Road/Footpath	290	100%	290	50	4					
MH 3/2-3/1			290		4	150	150	0.06	1.00	18
MH 3/1/1 - 3/1			502		7					
MH 3/2-3/1					4					
MH 3/1 - 3			502		11	150	150	0.06	1.00	18
Road/Footpath	373	100%	373	50	5					
Pumped MH 1 B					70					
MH5-MH4			373		75	450	400	0.6	1.01	160
Road/Footpath	805	100%	805	50	11					
MH5-MH4					75					
MH4-MH3			805		86	450	400	0.6	1.01	160
Road/Footpath	253	100%	253	50	4					
MH 7B-MH 6B			253		4	150	20	0.06	2.89	51
Road/Footpath	328	100%	328	50	5					
MH 7B-MH 6B					4					
MH 6B-MH 5B			328		8	150	20	0.06	2.89	51
Road/Footpath	273	100%	273	50	4					
MH 6B-MH 5B					8					
MH 5B-MH 4B			273		12	150	20	0.06	2.89	51
Road/Footpath	695	100%	695	50	10					
MH 5B-MH 4B					12					
MH 4B-MH 3B			695		22	150	20	0.06	2.89	51
Road/Footpath	0	100%	0	50	0					
MH 4B-MH 3B					22					
MH 3B-MH 2B			0		22	150	80	0.06	1.39	25
Road/Footpath	379	100%	379	50	5					
MH 3B-MH 2B					22					
MH 2B-MH 1B			379		27	225	80	0.06	1.81	72
Slope -MH1B	10,365	30%	3,110	50	43	300	300	0.06	1.08	76
Grass Area	593	30%	178	50	2					
MH4-MH3					86					
MH 3/1 - 3					11					
MH 1A - 3					19					
MH 3-MH 2			178		118	450	400	0.6	1.01	160
Atten- Outlet					11.5	100	50	0.06	1.37	11

Ks Conc = 0.6

Ks Plastic= 0.06

Codes Of Practice: B.S. 8301:1985 Building Drainage
B.S. 8301:1985 Drainage of Roof and Paved areas.

FILTER DRAINS

SOURCE CONTROL

Filter Drain

PRIMARY CONSIDERATIONS	
Construction Cost	LOW
Maintenance Requirements	HIGH
Land Take	LOW

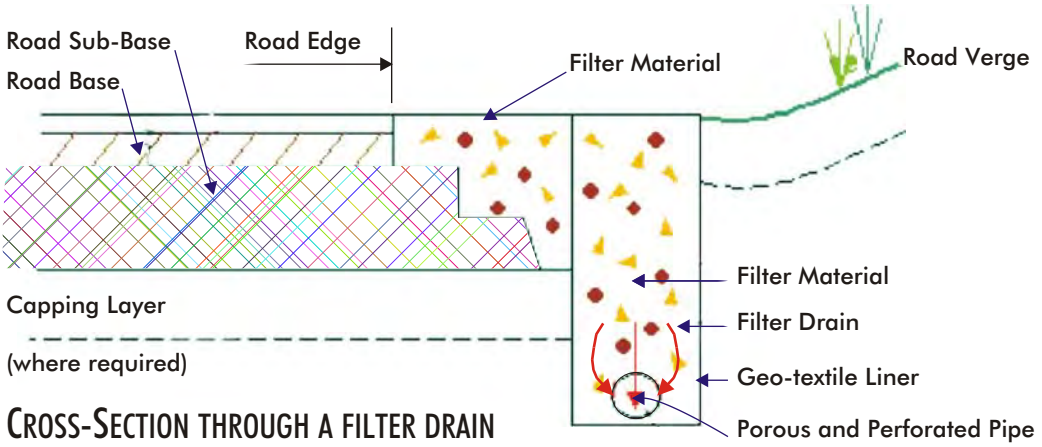
BENEFITS	
☑Water Quality Control	YES
☑Water Quantity Control	YES
☒Amenity Value	NO
☒Habitat Creation Value	NO
☒Biological Treatment	NO

DESCRIPTION

A filter drain is a gravel filled trench, generally with a perforated pipe at the base. Run-off flows slowly through the granular material, trapping sediments and providing attenuation. Flow is then directed to a perforated pipe, which conveys run-off either back into the sewerage network or into a waterbody. Filter drains are mainly used to drain road and carpark surfaces. Ideally these systems are used as a component of a treatment train.

DESIGN

- Filter drains are normally situated on the roadside verge or median strip. The perforated pipe is not required along the entire length of the trench, only near the end of the device.
- The trench is usually lined with geotextile to prevent ingress of soil and other material into the structure (CIRIA,2000).
- Inspection manholes should be located at regular intervals along the length of the device.
- Excess flows during extreme rainfall events may be dealt with by overland flooding passing to swales or by an overflow pipe which connects to swales or other parts of the drainage system.
- The dimensions of the trench should be selected to meet the level of reduction and attenuation of flows required, the assessment of hydraulic design performance being site specific.
- Should only be used to drain areas less than 5 hectares.
- Ideally a pre-treatment device (such as a filter strip or grassed area) should be incorporated to increase the longevity of the system.
- Construct at least 1.5m above the maximum groundwater level and only where the groundwater classification allows.
- Design to avoid flooding for 1:30 year storm event. For 100 year events, property flooding should not take place and overland flows should not pass from the site to cause flooding to other areas.
- Filter drains should not be located on common boundaries as construction of fences and hedges will destroy them.
- The minimum distance from a property should be at least three times the depth of the trench.
- Consideration of topography is important to ensure sub-surface and overland flows are directed away from properties.
- When filter drains are used to drain road surfaces, there is a possibility of the stones being scattered when vehicles leave the carriageway. This can be minimised by using crushed rock on the surface layer of the fill material (CIRIA, 2000).
- Filter drains can be used in the base of swales to provide additional attenuation and treatment.
- When using filter drains, the use of gullypots is not required and should be avoided.
- Do not construct near drinking water wells, septic tanks or drain fields, unless fully lined.



CROSS-SECTION THROUGH A FILTER DRAIN

MORE OVERLEAF - 1 of 2

FILTER DRAINS

SOURCE CONTROL

POLLUTANT REMOVAL

Ideally sediment should be removed in a pre-treatment device, rather than in the filter drain itself.

Pollutant	Removal (%)
TSS	85
Total Lead	83
Total Zinc	81
Oil	70
Nutrients (N & P)	Limited

MAINTENANCE CONSIDERATIONS

Regular inspections are required to monitor sediment build-up.
This can involve:
- digging up sections of the trench to check for clogging;
- use of inspection manholes;
- CCTV surveys within the perforated pipe.

Remedial work will also be required at intervals to remove sediment from the device. This can be done by replacing the filter material or through cleaning and replacement.

IRISH EXPERIENCE

These drains are used on the National Road Project serving a dual purpose of groundwater control and run-off drainage. The pipe is conservatively sized for the run-off flow assuming negligible attenuation in the media or loss to infiltration.

INTERNATIONAL EXPERIENCE

Scotland

Many of the first filter drains used extensively in Scotland were inappropriately designed as end of pipe features and became clogged at the inlet. Filter drains are meant to be linear features designed to run parallel to the surface they are draining.
Filter drains serving trunk roads and motorways have also occasionally been problematic. Following an accident on the M74 motorway in Scotland, a quantity of fuel oil was spilled onto the road when tanks ruptured on a heavy goods vehicle and this was subsequently discharged into a nearby watercourse through filter drains. The use of above ground structures such as swales and ponds would have minimised the effects of the incident, as measures could have been taken to contain the pollutants within the structures.

Preliminary monitoring results suggest that filter drains have a finite lifespan. Many are prone to clogging due to the absence of some form of pre-treatment device. Rumble strips or other measures can be incorporated to minimise stone scattering by vehicles. They have perfomed well on major roads, but may receive higher solids in urban use areas.

A Filter Drain under Construction

ADVANTAGES

- ☑ Provides attenuation.
- ☑ Provides limited treatment.
- ☑ Relatively inexpensive.
- ☑ Relatively low land take.
- ☑ Can be used in most soil conditions provided run-off discharges into a perforated pipe rather than to soil.
- ☑ Minimal safety risk.

LIMITATIONS

- ☒ No habitat or amenity value provided.
- ☒ Does not provide biological treatment.
- ☒ Below ground structure therefore operational problems not always visible at surface. Similarly significant pollution events are routed below ground and are difficult to identify.
- ☒ Not suitable where groundwater levels are high, i.e. likely to come within 1.5m of the base of the device.
- ☒ Not suitable for industrial areas unless treatment is provided upstream of the device and operates as part of a treatment train.
- ☒ Regular maintenance required.

FROM PREVIOUS - 2 of 2

INFILTRATION TRENCHES & SOAK-AWAYS

SOURCE CONTROL

Side-entry pits drain to infiltration trench in car-park

PRIMARY CONSIDERATIONS	
Construction Cost	LOW
Maintenance Requirements	HIGH
Land Take	LOW

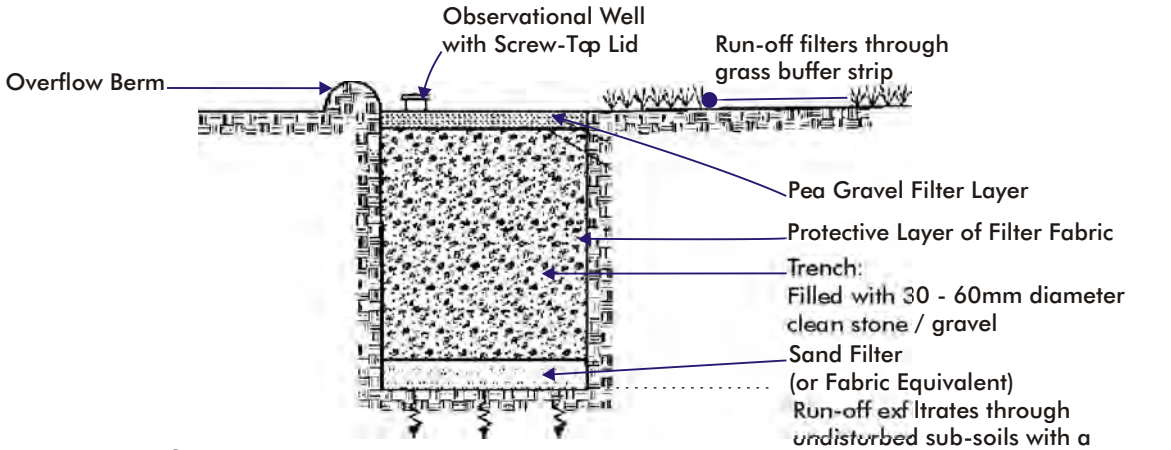
BENEFITS	
☑ Water Quality Control	YES
☑ Water Quantity Control	YES
☒ Amenity Value	NO
☒ Habitat Creation Value	NO
☒ Biological Treatment	NO

DESCRIPTION

An infiltration trench is a gravel / rock-filled trench designed to infiltrate run-off to the ground. Infiltration trenches are essentially long thin soakaways (rock filled pits or large tanks structures). Run-off is stored in the voids allowing it to slowly infiltrate through the bottom into the soil matrix. This reduces the volume of water that is discharged into receiving watercourses thereby reducing some of the impacts caused by excess flows and pollutants.

DESIGN

- Soils underlying the site should be permeable, i.e. have a clay content of less than 20% and a silt/clay content of less than 40%. (Refer BRE,1991 and CIRIA, 1996). Infiltration controls can be used on soil types 1 or 2* and where it can be demonstrated that the trench will infiltrate the design treatment volume within 12 hours under average winter rainfall (Campbell, 2000).
- A pre-treatment device such as a swale or filter strip is recommended upstream of the trench to reduce incoming velocities and coarser sediments.
- The device should be constructed at least 1.5m above the maximum groundwater level or bedrock layer and only where the groundwater classification allows.
- The trench should be filled with clean stones that can retain the required volume of water to be treated in their void space.
- The stone should be wrapped in a geo-textile. This fabric should be selected on the basis of durability with adequate opening size to resist clogging.
- The treatment volume should completely infiltrate through the trench bottom in 24 hours.
- Trenches should be under-drained, so that in the event of clogging it can act as an overflow.
- With long infiltration trenches it is advisable to provide inspection tubes at regular intervals along the trench (CIRIA, 2000).
- The maximum contributing area to infiltration trenches should be less than 5 hectares.
- The infiltration device should not be constructed within 5m of the foundations of buildings or under a road.
- Do not construct near drinking water wells, septic tanks or drainfields .
- During construction, measures to minimise sediment erosion and soil compaction should be used.
- The facility should not come into use until construction and landscaping of the site that drains to it is completed.
- Areas upstream of the trench should be stabilised.



SECTION

* Flood Studies Report, WRAP Classification

MORE OVERLEAF - 1 of 2

Dublin City Council
Comhairle Cathrach Bhaile Átha Cliath

Dublin Drainage
A Strategic Study for Greater Dublin

INFILTRATION TRENCHES & SOAK-AWAYS

SOURCE CONTROL

POLLUTANT REMOVAL

- Failure rates are discussed in an article published by the Centre for Watershed Protection.
- Details of other studies are available from the (US) National Stormwater Best Management Practices Database. (www.bmpdatabase.org)

Pollutant	Removal (%)
TSS	NA
TP	100
TN	42
NOx	82

MAINTENANCE CONSIDERATIONS

- The possibility of replacing an infiltration trench once every 5 years should be considered, due to clogging.
- Minimise clogging by regularly sweeping the draining area to the infiltration device.
- Inspect and observe the infiltration system several times during the first year, particularly after heavy rainfall, and annually thereafter. Regular inspection can substantially help to lengthen the time interval between major rehabilitations.

INTERNATIONAL EXPERIENCE

Scotland

Infiltration trenches have been used extensively in Scotland. A SuDS database compiled by the Scottish Environment Protection Agency (SEPA) suggests that there were around 230 such systems in operation in Scotland by Jan. 2003. This has raised concerns, as much of Scotland is covered in clay soils which do not allow good infiltration.

Soakaways have been in existence for many years. They have been applied to highway drainage, however their use for anything other than roof water is not advised as the high sediment loads from road run-off usually causes blockage problems within 20 years. This can be avoided by routine removal and replacement of sand layers on an annual basis. However, this philosophy of high maintenance is not practiced in the UK.

Sweden

The city of Malmo, Sweden has successfully used infiltration trenches to control run-off from the residential lots by covering the top with a grass layer. The grass layer filters the water as it passes through the soil; the trench keeps the overlying soil filter from becoming saturated.

Germany

In Essen, Germany, a similar application has been successful. In this case an overflow for the trench is provided to carry away the excess flow generated by large storms.

U.S.A

A study conducted in Maryland, USA (Galli, 1992), revealed that less than half of the infiltration trenches investigated were still functioning properly, and less than 1/3 still functioned properly after 5 years. Many of these practices, however, did not incorporate advanced pre-treatment (e.g., swales upstream). (Refer to USEPA Factsheets at www.epa.gov).

ADVANTAGES

- ☑ Provides treatment of run-off through filtration, absorption & microbial decomposition.
- ☑ Reduce the volume of run-off from a drainage area.
- ☑ Can be used where space is limited
- ☑ Relatively cheap option to install due to the limited land requirements (2%-3%).
- ☑ Minimum safety concerns.

LIMITATIONS

- ☒ Provides no aesthetic benefits.
- ☒ Potential for underground contamination.
- ☒ Can fail, if receives high sediment loads.
- ☒ Requires frequent inspection and maintenance.
- ☒ Maintenance and replacement costsmaybehigh.
- ☒ Not suitable in areas with natural slopes greater than 15%.
- ☒ Not appropriate for areas with a lot of underground infrastructure.
- ☒ Not suitable to treat run-off from pollution hotspots such as industrial estates, unless the run-off has been treated upstream.
- ☒ Soil, geological and groundwater conditions must be such that the device does not cause pollution.
- ☒ May be inneffective for soluble pollutants such as hydrocarbons, nitrates, salts or organic compounds.
- ☒ Operational problems not always visible at the surface.

FROM PREVIOUS - 2 of 2

DETENTION BASINS

SITE CONTROL

Grassed Detention Basin, South Dublin

PRIMARY CONSIDERATIONS	
Construction Cost	LOW
Maintenance Requirements	HIGH
Land Take	MEDIUM

BENEFITS	
☑ Water Quality Control	YES
☑ Water Quantity Control	YES
+/- Amenity Value	SOMETIMES
☒ Habitat Creation Value	NO
☒ Biological Treatment	NO

DESCRIPTION

Detention basins are vegetated depressions designed to impound run-off in basins during large storms and gradually release it. Detention basins mainly provide runoff rate control as opposed to water quality control and are therefore best used as part of an overall treatment train approach. However, a limited amount of treatment is provided through settlement of suspended solids.

Detention Basin, Residential Area, Scotland

DESIGN

Basic Design Features:

- Basins should be designed to empty within 24 hours of a storm thus not have a permanent pool of water.
- The treatment volume required for water quality control is 1 x Vt (Wallingford Pocedure).
- The maximum water depth in the basin should not exceed 3 m.
- The side slopes of the basin should ideally be terraced with an average 3:1 slope or flatter, which will minimise the potential for erosion and will allow easy access for maintenance and for safety purposes. Slope protection may be required during the construction of the basin.
- The side slopes and base should be planted with dense native vegetation which can tolerate periodic inundation and water flow. This will provide slope protection and assist sediment removal.
- The basin should have a length to width ratio greater than 3:1 to increase basin performance.

The inlet structures should be designed to incorporate energy dissipaters (such as micropools or flow spreaders) to reduce the inflow velocity and turbulence.

- The outlet device should be designed so that the facility temporarily impounds runoff in the basin during large storms, to reduce the peak rate of discharge for a given design storm to pre-development levels (e.g., 2-, 5-, 10- or 100-year storm). (Texas Nonpoint Sourcebook).
- An overflow or spillway should also be included in the basin design, to prevent the water levels from over topping the embankment.
- Design can be adjusted to suit areas of limestone topography or rapidly percolating soils such as sands.
- Impermeable liners should be incorporated where there is significant potential for seepage of pollutants to groundwater.

Design Enhacement Options:

- Sediment forebay to assist sediment removal.
- Extended detention can provide the required treatment for certain industrial premises.
- Micro-pool (typically shallow and undrained) at the outlet to concentrate finer sediment and reduce re-suspension. Can be planted with wetland species.
- Low flow channels to prevent erosion at the inlet and to route the last remaining run-off to the outlet after the event, ensuring the basin dries completely. For Design and Operation Details, refer to the Minnesota Urban Small Sites Manual

Dry Detention Basin, South Dublin

MORE OVERLEAF - 1 of 2

DETENTION BASINS

SITE CONTROL

Volumetric Design Criteria

Defined by a matrix of parameters:

1) Depth / Area Storage Relationship:

- Largely dictated by topography and outfall levels. Volumetric allowances for vegetation of up to 25% should be provided.

2) Head / Discharge Relationship:

- The pond/basin should be designed to a maximum discharge rate achieved, when the structure is full but consideration must be given to outfall conditions, e.g. receiving water levels.

3) Throttle Rate:

- Throttle sizes are generally a minimum of 150mm. In smaller developments, the volumetric element of storage is likely to be achieved by other drainage components such as lined or unlined permeable pavement car parks or soak-aways.

4) Effective Contributing Area:

- The paved and pervious catchment surfaces which contribute run-off after various losses. The relationship between contributing area and throttle rate will define the critical duration of the design rainfall events. Events will be longer for tighter throttle rates and storage volumes larger.

5) Rainfall Characteristics of the Area:

- Ireland has been analysed for hydrological characteristics. These have been processed to enable appropriate design storm events to be produced for any location, duration and return period. This is based on the Flood Studies Report undertaken in the 1970s.

6) Level of Service:

- Design should be for a range of return periods (up to 100 years). It is unlikely that one structure will serve the needs of the various criteria. Temporary flooding of car parks and public space areas are likely to be acceptable on occasions. The hydraulic implications for loss of volume due to sediment or vegetation should also be considered.

7.) Safety:

- Should be considered for all stages of construction, operation, maintenance and decommissioning.
- Appropriate design criteria should be applied to protect against overtopping in extreme events.
- Large storage areas may have to consider not only the freeboard and wave development. The return period for such design is likely to relate to dam legislation and the downstream risk with the occurrence of a failure.
- Blockage of the pass forward structure must be catered for and an alternative method of drawing down the storage system must be provided.

Pollutant Removal

- Detention basins provide moderate pollutant removal.
- Removal efficiency is limited for soluble pollutants due to the absence of a permanent pool of run-off, although they can be effective at removing some pollutants through settling.
- Typical removal rates, as reported by Winer (2000) are:

Pollutant	Removal (%)
TSS	61 ± 32[1]
TP	20 ± 13
TN	31 ± 16
NOx	-2 ± 23
Metals	29 - 54
Bacteria	78[2]

1: ± values represent one standard deviation
2: Data based on less than five data points

For details of other studies refer to the National Stormwater Best Management Practices Database. (www.bmpdatabase.org)

Maintenace Considerations

- The basin should be inspected after severe events to check bank stability and vegetation growth.
- Twice yearly inspections will be required to check for subsidence, erosion and sediment accumulation.
- Inlet and outlet structures should be inspected for debris and erosion at least twice a year or after large storms (CIRIA , 2000). Any problems should be addressed immediately.
- Debris and litter should be removed, as required.
- Sediment should be removed from the basin, as necessary. CIRIA (2000) suggest sediment removal will be required every 7 to 10 years (up to 25 years depending upon the design and inclusion of a sediment forebay).

International Experience

Detention Basins have been used for several years in Scotland. They were first used as part of the drainage masterplan for a development called the Dunfermline Eastern Expansion Area. This masterplan was developed using the treatment train concept, where the basins were located upstream of regional control facilities. Monitoring work carried out in Scotland, has highlighted the habitat value of such basins, when grass cutting is kept to a minimum. This research has also reinforced the importance of providing adequate vegetation cover. In several basins, planting took place at the wrong time of year leading to erosion and operational difficulties.

Vegetated Detention Basin

Advantages

- ☑Provides for flow control.
- ☑Can limit downstream scour by reducing peak flow rate and dissipating the energy of the run-off.
- ☑Can be used as recreational areas such as football pitches.
- ☑Could be integrated into green space areas, typically found in Irish housing estates.
- ☑Limited safety concerns.
- ☑Can be used in almost all soils and geology, with minor design adjustments for regions of limestone topography or rapidly percolating soils such as sand.
- ☑Can accept run-off from stormwater hotspot such as industrial sites.
- ☑Can be used to trap construction run-off, as long as all deposited sediment is removed before normal operation begins.
- ☑Detention basins are relatively long lived facilities.
- ☑When appropriate wetland species are planted on the base, basins can provide important micro-habitats.

Limitations

- ☒Limited pollutant removal capabilities.
- ☒Potential for clogging of outlets.
- ☒Needs a relatively large land area therefore may be limited to greenfield sites.

FROM PREVIOUS - 2 of 2

STORMWATER WETLANDS *REGIONAL CONTROL*

Stormwater Wetlands

PRIMARY CONSIDERATIONS	
Construction Cost	HIGH
Maintenance Requirements	MEDIUM
Land Take	HIGH

BENEFITS	
☑Water Quality Control	YES
☑Water Quantity Control	YES
☑Amenity Value	YES
☑Habitat Creation Value	YES
☑Biological Treatment	YES

DESCRIPTION

Stormwater wetlands are similar to retention ponds but with more emergent aquatic vegetation and a smaller open water area (less than 25% of the water surface area).

Stormwater Wetlands are shallow pools that create growing conditions suitable for the growth of marsh plants. They typically have less bio-diversity than natural wetlands. Because wetlands are heavily vegetated, they serve as a natural filter for urban run-off.

Stormwater wetlands detain urban run-off, remove pollutants through biological treatment and settlement and provide habitat and aesthetic benefits. Wetlands can be integrated into developments as a community water feature.

A Stormwater Wetland in Scotland

DESIGN

General Design Criteria / Features

- Design to retain water for 14 days during the wettest months to allow for biological treatment and for settlement of solids.
- Design to have a minimum permanent pool of 3 x Vt (Wallingford Procedure).
- The simplest form of a constructed wetland comprises of a basin with a forebay and wetland vegetation area.
- An adequate water flow is required to ensure a permanent pool of water.
- Wetlands should have a length-to-width ratio of at least 5:1, which helps prevent short-circuiting (US EPA Factsheets).
- The distance between inlet and outlet should be maximised. The use of islands and peninsulas will ensure this.
- The drainage area should be greater than 5 hectares.
- Sediment forebays are recommended to decrease the velocity and sediment loading. Forebays should be a separate cell. It is suggested that they should be 2 to 3m deep and contain at least 10% of the wetland's treatment volume. Coarse particles remain trapped in the forebay and maintenance is performed in this smaller pool, eliminating the need to dredge the entire wetland. Alternatively a detention basin may be placed before the wetland, to remove settleable solids and protect the wetland from extreme fluctuations in water levels during large storms.
- Effective wetland design displays "complex microtopography"; wetlands should have zones of both very shallow and moderately shallow wetlands using underwater earth berms to create the zones. This design will provide a longer flow path through the wetland to encourage settling and plant diversity and to discourage undesirable plant monocultures.
- The average depth of the wetland should be 0.5 to 0.75m. The depth of open water should not exceed 2 metres. Water deeper than 2m inhibits rooted plant growth, thus providing areas of open water. However, wetlands can be designed for flood control by providing flood storage of up to 2m, above the level of the permanent pool.
- The open water area should be less than 25% of the water surface area.
- Shallow side slopes should be gradual (e.g. 1 in 4), as in natural wetlands and should not exceed 3:1 (Horner et al, 1994) to reduce safety hazards and enable maintenance.
- Wetlands should be constructed to have no lateral slope perpendicular to the flow path to avoid concentrating the flow in preferred channels.

Habitat Enhancement

- A wetlands ecologist should be consulted about planting so that plants are selected which are capable of pollutant removal, adapted to saturated soil conditions, tolerant of periodic inundation by run-off and which can withstand the dry periods that naturally occur in the local area. A diverse native selection should be planted shortly after constructing the wetland. Mostly perennial species should be selected with priority to those that establish rapidly. Vegetation reduces the effect of wind which can cause short circuiting of the wetland.
- If possible, stormwater wetlands should be located close to natural waterbodies, to enhance colonisation. However, existing important habitat areas should be avoided.

MORE OVERLEAF - 1 of 3

STORMWATER WETLANDS *REGIONAL CONTROL*

DESIGN

Volumetric Design Criteria

The volume required is defined by a matrix of parameters, which are summarised as:

1) Depth / Area Storage Relationship:

- This is largely dictated by topography and outfall levels. Volumetric allowances for vegetation of up to 25 percent should be provided.

2) Head / Discharge Relationship:

- The pond/basin should be designed to a maximum discharge rate, achieved when the structure is full. Consideration must be given to outfall conditions, e.g. receiving water levels.

3) Throttle Rate:

- Throttle sizes are generally a minimum of 150mm. For smaller developments, the volumetric requirement is likely to be achieved by other drainage components such as lined or unlined permeable pavement car parks or soak-aways.

4) Effective Contributing Area:

- This is the paved and pervious catchment surfaces, which contribute run-off after various losses.
- The relationship between contributing area and throttle rate will define the critical duration of the design rainfall events. Events will be longer for tighter throttle rates and storage volumes larger.

5) Rainfall Characteristics of the Area:

- Ireland has been analysed for hydrological characteristics. These have been processed to enable appropriate design storm events to be produced for any location, duration and return period. This is based on the Flood Studies Report work carried out in the 1970's.

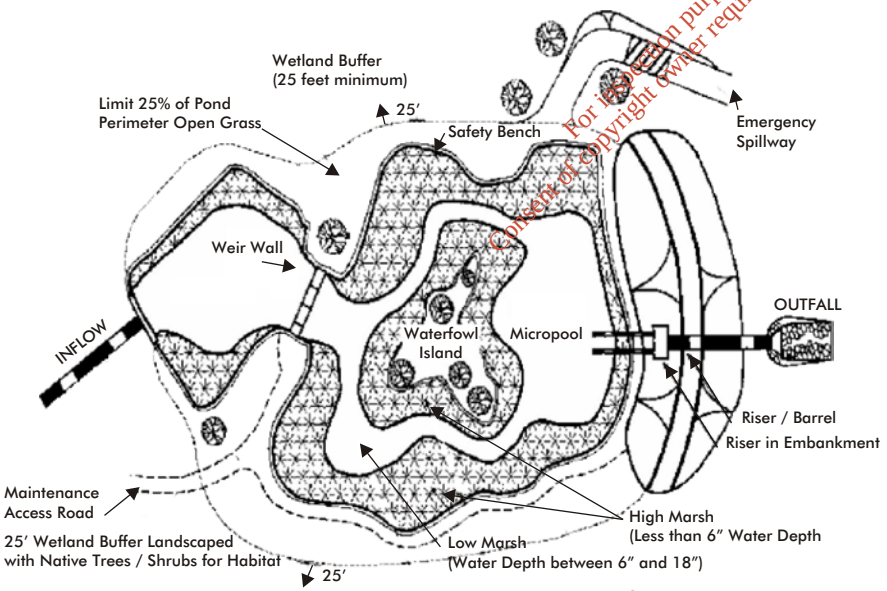
6) Level of Service:

- Design should be for a range of return periods (1 to 100 years). It is unlikely that one structure will serve the needs of the various criteria. Temporary flooding of car parks and public space areas are likely to be acceptable on occasions. The hydraulic implications for loss of volume due to sediment or vegetation should also be considered.

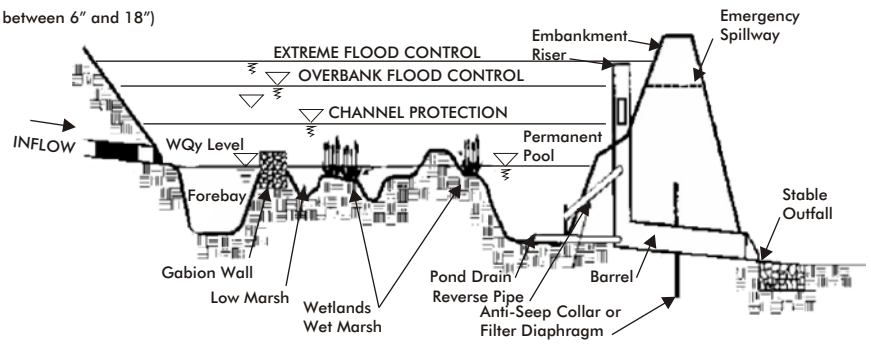
DESIGN

Other Design Issues

- Stormwater wetlands can accept run-off from stormwater hotspots, but need significant separation from groundwater if they will be used for this purpose. Where the potential for groundwater contamination is high, such as in industrial estates, the use of liners is required.
- Wetlands can be used in almost all soils and geology. At sites where infiltration occurs, it may be necessary to incorporate an impermeable liner into the design in order to maintain a permanent pool.
- Warning signs may be posted during cold periods, to warn of the dangers of ice.
- Stormwater wetlands are generally safer than retention ponds but deep zones may still be a hazard. Fencing of wetlands is generally not desirable but may be required in some situations. A preferred method is to manage the contours of the pond to eliminate drop-offs and other safety hazards. Barrier planting around the margins will restrict access.
- Groundwater inflows and outflows can have a significant effect on a constructed wetland system. Groundwater chemistry can affect water quality and processes such as sedimentation and vegetation growth.
- Construction run-off should be prevented from entering the constructed wetlands as the resulting sediment loading can severely degrade the performance of the system.



PLAN VIEW



PROFILE

FROM PREVIOUS & CONTINUES - 2 of 3

Dublin City Council
Comhairle Cathrach Bhaile Átha Cliath

Dublin Drainage
A Strategic Study for Greater Dublin

STORMWATER WETLANDS *REGIONAL CONTROL*

Pollutant Removal

Wetlands are the most effective type of SUDS in terms of pollutant removal. As storm run-off flows through the wetland, pollutant removal is achieved through settling and biological uptake within the facility. Stormwater wetlands can provide significant reductions in sediment, nutrient, heavy metals, toxic materials, floatable materials, oxygen demanding substances, oil and grease as well as a partial reduction in bacteria and viruses.

Pollutant	*Removal (%)
Total Suspended Solids	60-80
Oil & Grease	Detail Unknown
Total Phosphorous	20-40
Total Nitrogen	20-40
Bacteria	60-80
Copper	60-80

*Typical Removal Rates based on National US Data Range

Details of other studies which have been carried out world-wide, are available from the National Stormwater Best Management Practices Database.

Maintenance Considerations

Maintenance requirements for wetlands are similar to those of retention ponds:

- Inlets and outlets should be inspected quarterly or after large storms for evidence of clogging or accumulation of debris.
- During the first two years, it is extremely important that the facilities be inspected quarterly for nuisance vegetation and that these be removed; this will insure a healthy and aesthetically pleasing facility.
- Other potential problems that should be checked include subsidence, erosion and litter accumulation. Remedial work should be carried out when required.
- Sediment may have to be removed from the forebay once every 5 to 7 years or when half of the forebay depth is filled with sediment.
- The wetlands themselves may have to be dredged once every 25 years or less.
- Stormwater wetlands require frequent maintenance in the first 3 years to establish the marsh.

Thereafter, maintenance will be that carried out as in other pond systems.

- Aquatic vegetation within the wetland should be cut back after flowering, and thinned when necessary, typically every 7 to 10 years.

Cost Considerations

- Wetlands have a long life span, compared to many other types of SuDS. In the US the annual cost of routine maintenance is typically estimated at about 3% to 10% of the capital cost.
- Maintenance costs may be higher in the first few years after construction, until the vegetation becomes established.
- It is anticipated that well designed wetlands, which incorporate additional aesthetic features may provide an economic benefit by increasing property values.

International Experience

Stormwater wetlands have been used extensively in the US. Further details are available from the National Stormwater Best Management Practices Database. (www.bmpdadabase.org)

Advantages

- ☑ Provide high pollutant removal efficiencies.
- ☑ Require relatively low maintenance.
- ☑ Can be used in almost all soils and geology.
- ☑ Creates habitat.
- ☑ Can enhance the aesthetics of an area and provide recreational benefits.
- ☑ Can provide an economic benefit by increasing property values.

Limitations

- ☒ Large land requirements.
- ☒ Seasonal variations in treatment and pollutant removal efficiencies.
- ☒ Wetlands require careful design and planning to ensure that wetland plants are sustained after the practice is in place.
- ☒ Delayed efficiency until plants are well established.
- ☒ Requires reliable water supply.
- ☒ Acceptance influenced by public opinion.
- ☒ Topography of the site.

FROM PREVIOUS - 3 of 3

OIL INTERCEPTORS

SOURCE CONTROL

Example of an Oil Interceptor

PRIMARY CONSIDERATIONS	
Construction Cost	MEDIUM
Maintenance Requirements	HIGH
Land Take	LOW

BENEFITS	
☑Water Quality Control	YES
☑Water Quantity Control	YES
☒Amenity Value	NO
☒Habitat Creation Value	NO
☒Biological Treatment	NO

DESCRIPTION

Oil interceptors generally comprise three underground retention chambers designed to remove coarse sediments and retain oils. The first chamber is used for sedimentation and removal of large debris. This chamber contains a permanent pool of water and a well screened orifice which allows regulated flow into the second chamber. The second chamber is used for oil retention and also contains a permanent pool of water. An inverted elbow pipe permits regulated flow from this chamber into the third chamber. The inverted pipe collects water from deep in the permanent pool leaving oil contaminants floating on the surface until it is removed or absorbed by sediment particles when they settle. The third chamber is used to collect and disperse flow into the stormwater drain network or an infiltration basin. This chamber contains an orifice outlet which is often raised to create a third settling pool and regulate outflow.

DESIGN

1) Run-off segregation:

Only run-off from areas which are likely to have oil contamination (e.g. filling areas for service stations) should be directed to the separator. This will reduce the size of the separator required. Appropriate use of bunding may help segregate oil contamination from 'clean' run-off.

2) High flow bypass:

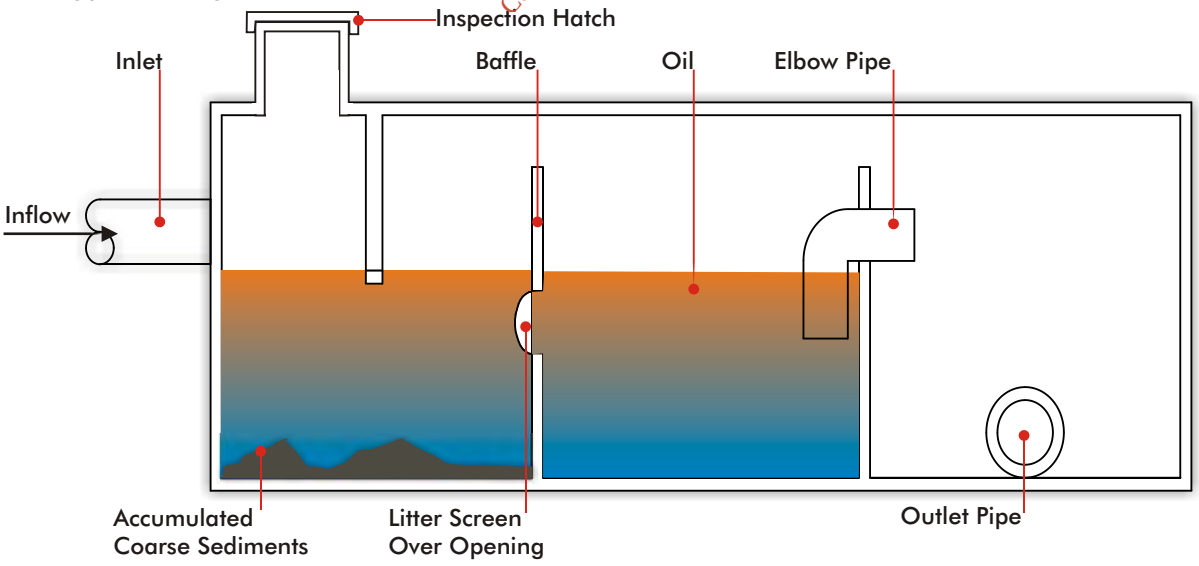
The separator should be designed to accept low flow only, with a high flow bypass installed to provide for the residual flow up to the capacity of the pipe system.

3) Interceptor chamber screening:

Ensure that the orifice between the primary and secondary chambers is effectively screened. This should generally not allow debris greater than 5 millimetres in diameter to enter the second chamber. It should be easily accessible and easily removed for cleaning.

4) Maintenance access:

Easy access is required for inspection and cleaning. Each chamber could have its own inspection entrance, with step rings leading to the bottom of the chamber.



TRIPLE INTERCEPTOR DEVICE

MORE OVERLEAF - 1 of 2

OIL INTERCEPTORS

SOURCE CONTROL

POLLUTANT REMOVAL / MAINTENANCE

Triple oil interceptors have been reported to have relatively poor pollutant removal capability. This has been attributed to poor maintenance and the passage of high flows though the device (Galli, 1992). They have also been found to be expensive to operate due to their high maintenance requirements (Ontario Ministry of Environment & Energy, 1994).

Pollutant	Removal
Gross Pollutants	Low to Medium
Fine Sediment	Low
Medium Sediment	Low to Medium
Coarse Sediment	Medium
Attached Pollutants	Low
Dissolved Pollutants	None
Oil & Grease	Medium to High
Floatable Material	Medium to High

MAINTENANCE CONSIDERATIONS

Clean once a month to keep accumulated oil and grit from escaping. A vacuum pump tanker can be used to pump out the contents of each chamber.

Without regular maintenance, the system quickly reaches capacity. Oil and solid pollutants are re-entrained into the flow, rendering the device ineffective. Regular inspections should be made to assess sediment and oil levels along with outflow oil concentrations.

INTERNATIONAL EXPERIENCE

Oil interceptors are widely used to protect receiving waters from pollution by oil.

See Pollutant removal capacity included for documented experience of their performance.

ADVANTAGES

☑Suitable for treating stormwater from areas with significant vehicular pollution (e.g. car parks).

☑Can also trap litter.

☑Can treat stormwater from areas storing or handling petroleum products (e.g. service station and petroleum depots).

☑Can be retrofitted into existing drainage systems.

☑Minimum visual impact.

LIMITATIONS

☒Limited removal of fine sediments or soluble pollutants.

☒Turbulent conditions may re-suspend particles or entrain floating oil. (A high flow by-pass can overcome this problem).

☒Trapped debris is likely to have a high concentration of pollutants, possibly toxic.

☒Requires regular cleaning to achieve design objectives.

☒Can pose a potential safety hazard for maintenance personnel.

TRIPLE CHAMBER OIL INTERCEPTOR

FROM PREVIOUS - 2 of 2

CARLOW PRECAST
Concrete Engineering

Separators

Oil/Fuel Range

(Certified to EN 858 Part 1)

www.carlowprecast.com

Collateral Warranty & Professional Indemnity Insurance

Email: separators@carlowprecast.com
Direct Line: R.O.I. 059 915 9550 / U.K. 0870 493 1408

Separator Range

The use of an oil/water separator is required wherever there is the risk of hydrocarbon pollutants causing contamination at the point of discharge, i.e. an open ditch, river/stream, stormwater or foul sewer. Normally the interceptors are made of GRP or PVC, which need to be installed on a reinforced concrete base, filled with water and then encased in concrete. This can be a slow and expensive method of installation.

Our interceptors are manufactured from precast concrete, and are normally installed on a bed of cl804 stone and backfilled with the excavated material. This results in considerable savings on time and materials. Our service also includes delivery to site and off-loading into position.

Design
In principle, we design to four basic classifications; Full Retention, Bypass, Class I and Class II. Classes I and II pertain to the Eurocode ISEN858 (Separator Systems for Light Liquids Pt. 1)

Our designs comply with the requirements of the EPA Wastewater Treatment Manuals:-
- Preliminary Treatment: Part 5: Oils, Grease and Fats
- Primary Secondary and Tertiary Treatment: Part II
- IS EN858 Part1

All of our products are engineered to the customer's requirements, using established design parameters. The designs are based on flow speeds, retention times, temperature and the settlement characteristics of the target materials. The tank structures are designed to BS8110, BS8007 and the Dramix Design Guidelines for Steel Fibre Reinforced Concrete Structures.

Description of basic type - Class I & II
The European Standard EN 858-1 refers to two classes of separator and the performance results achieved under standard test conditions.

Class 1 Separator
This type of unit is required where the hydrocarbon pollutant concentration in the liquid discharging from the separator must be 5 mg/l or less, or where discharge is to sensitive waters.

Class I units contain a coalescing filter which prevents passage of oil droplets, found in suspension in the liquid, through the system. Class I units also contain an emergency closure device. In the event of a major spillage, exceeding the max. oil storage capacity of the separator, the closure device will shut-off the outlet flow. The pollutants are contained within the separator, thus preventing downstream contamination.

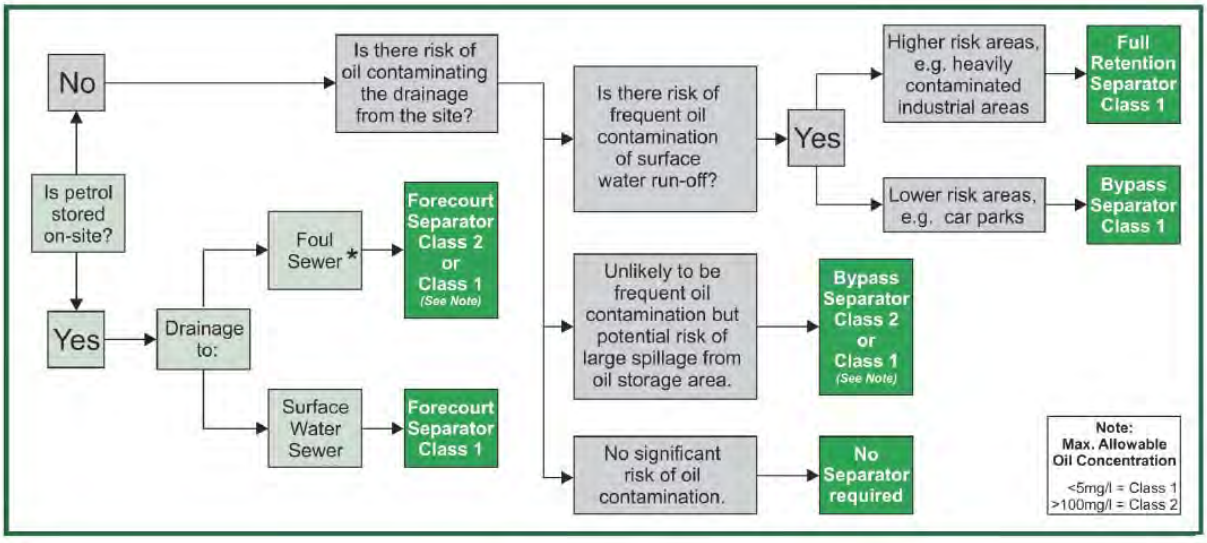
Class II Separator
This type of unit is required where the allowable hydrocarbon concentration is less than 100 mg/l. They are used where the effluent quality requirements are less stringent, but there is still a need to protect the environment by shutting the system down in the event of a spillage. Class II separators are also provided with an emergency closure device.

Full Retention Separators
Full retention separators are used in areas where there is a high risk of hydrocarbon/oil spillage. The full flow of the drainage system is treated, normally equivalent to rainfall of 65mm/hr.

Bypass Separators
Bypass separators fully treat all flows generated by rainfall rates up to 6.5mm/hr. This covers 99% of all rainfall events. Flows above this rate are allowed to bypass the separator. This type of separator is applicable to low risk areas such as car parks, motorways etc.

Forecourt Separators
Forecourt separators are designed specifically for filling stations, in order to retain the maximum spillage from a tanker compartment of up to 7,600litres

Separator Selection
The flowchart below will provide a guide to the selection of the correct separator type for a particular drainage application.



** Licence from Local Authority is required*

15 Year Guarantee & Manufacturers All Risk Insurance

Bypass Range

Application

Bypass separators are used in areas where there is a risk of infrequent light contamination and the potential for oil spillage is small. These areas include:

- Large Industrial Units
- Carparks
- Motorways

The bypass separator is designed to treat the first 6.5mm of rainfall and to allow flows in excess of this to bypass the main treatment chamber.

This means that pollutants washed off the drainage area at the beginning of a rainstorm are retained within the retention chamber of the separator. When the storm intensity increases, the pollutants are left undisturbed within this chamber and the excess flow, which will now be relatively pollutant free, is allowed to bypass.

Each bypass separator features the following:

- Oil Storage Capacity
- Coalescer (Class 1 only)
- Automatic Shut-off Valve

Maintenance

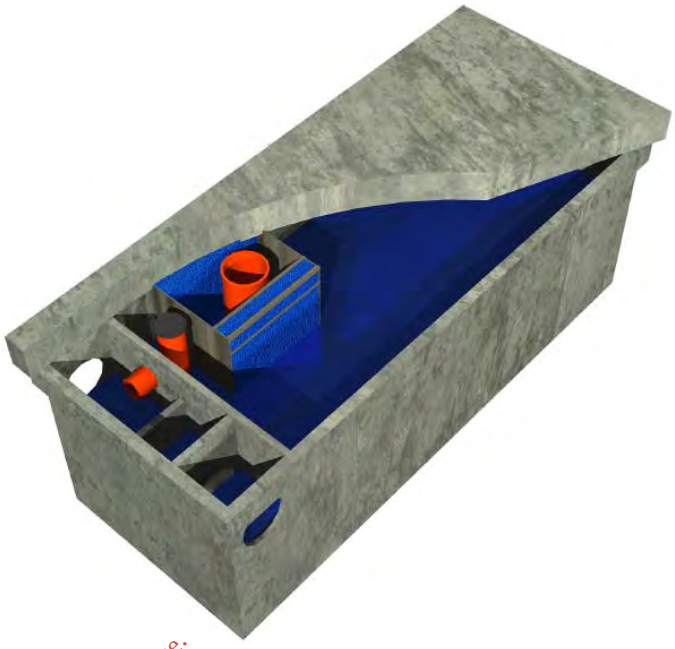
The hydrocarbon pollutants and silt that build up within the separator, should be removed periodically to ensure that maximum effectiveness of the unit is maintained. In the event of a major spillage, the separator should be emptied immediately.

Materials

Carlow Precast bypass separators are manufactured from 70N concrete with steel fibre reinforcement at 40kg/m^3. Larger units contain conventional steel reinforcement as well as steel fibre.

Installation

The unit should be installed on a level bed of sand, gravel or broken stone. The base of the excavation should be level and free from projecting hard points such as rocks or boulders. The separator is lifted into position by our truck-mounted crane, assuming there is suitable access for our delivery vehicle.



Backfilling is commenced as soon as possible after placement of the separators. In most installations, it is not necessary to backfill around the separator with concrete.

Separators are generally sized in accordance with EN-858 and PPG3-(Environment Agency UK) and assume a rainfall intensity of 65mm/hr. Some Authorities use different design criteria from the above. Please contact Carlow Precast's technical department for advice in this case.

Advantages

- Ease of installation
- Speed of installation
- Reduced civil costs - no expensive concrete backfill
- Durability and robustness
- No extra reinforcement in heavily trafficked areas

Accessories

Access covers to suit all loadings are available on request.

Sizes & Specifications

Unit Ref. Code	Nominal Flow Rate(l/s)	Storm Flow Rate (l/s)	Area Drained (m^2)	Nominal oil Storage	Fall Across Unit	Inlet Invert to Base	Standard Pipe Size (mm)
CP4BP	4.0	40	2,200	60 L	75mm	965mm	110 Dia
CP6BP	6.0	60	3,300	90 L	75mm	965mm	150 Dia
CP8BP	8.0	80	4,400	120 L	125mm	965mm	225 Dia
CP10BP	10.0	100	5,550	150 L	125mm	890mm	300 Dia
CP20BP	20.0	200	11,100	300 L	100mm	1455mm	375 Dia
CP33BP	33.0	330	18,333	500 L	100mm	2080mm	450 Dia
CP50BP	50.0	500	27,777	750 L	150mm	2506mm	600 Dia
CP84BP	84.0	840	46,666	1300 L	150mm	3002mm	600 Dia

Carlow Precast can provide intermediate or larger units to suit specific site requirements - sizes and specifications available upon request.

In order to avoid silt contamination, we would recommend Silt Storage to be provided upstream of the Separator.

Collateral Warranty & Professional Indemnity Insurance

Email: separators@carlowprecast.com
Direct Line: R.O.I. 059 915 9550 / U.K. 0870 493 1408

Full Retention Range

Application

Full retention separators are used in areas where there is a risk of regular contamination of surface water run-off oil and/or a risk of larger spills. These areas include:

- Fuel Depots
- Vehicle Workshops

As contaminated water passes through the separator, it is retained long enough to allow pollutants to accumulate on the surface. Carlow Precast full retention separators are single chamber vessels, resulting in the minimum of turbulence, while maximising retention time. The pollutants are retained within the separator, allowing treated water to discharge.

Each full retention separator features the following:

- Oil Storage Capacity
- Silt Storage Capacity
- Coalescer (Class 1 only)
- Automatic Shut-off Valve

Maintenance

The hydrocarbon pollutants and silt that build up within the separator, should be removed periodically to ensure that maximum effectiveness of the unit is maintained. In the event of a major spillage, the separator should be emptied immediately.

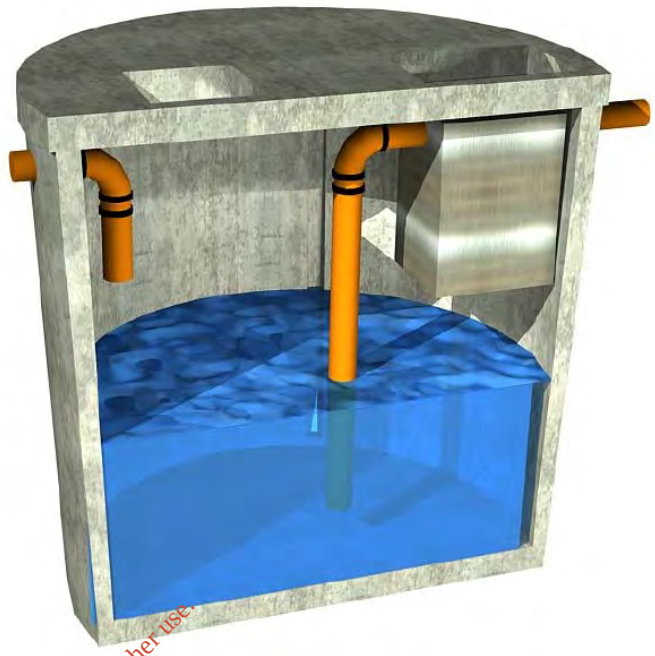
Materials

Carlow Precast full retention separators are manufactured from 70N concrete with steel fibre reinforcement at 40kg/m^3. Larger units contain conventional steel reinforcement as well as steel fibre.

Installation

The unit should be installed on a level bed of sand, gravel or broken stone. The base of the excavation should be level and free from projecting hard points such as rocks or boulders.

The separator is lifted into position by our truck-mounted crane, assuming there is suitable access for our delivery vehicle. Backfilling is commenced as soon as possible after placement of the separators. In most installations, it is not necessary to backfill around the separator with concrete.



Advantages

- Ease of installation
- Speed of installation
- Reduced civil costs - no expensive concrete backfill
- Durability and robustness
- No extra reinforcement in heavily trafficked areas

Accessories

Access covers to suit all loadings are available on request.

Oil level alarms can be fitted to indicate when the separator requires emptying. They are mounted remotely from the unit and are available with an audible or visual alarm. Off-site monitoring is also available from our technical department.

Unit Ref. Code	MAX Flow Rate(l/s)	Drainage Area (m^2)	Nominal Oil Storage (L)	Silt Storage Capacity (L)	Inlet Invert to Base (mm)	Standard Pipe Size O.D. (mm)
CP3FR	3.0	165	30	300	1,825	110 Dia
CP6FR	6.0	330	60	600	1,445	160 Dia
CP10FR	10.0	550	100	1,000	1,800	225 Dia
CP20FR	20.0	1,110	200	2,000	1,850	225 Dia
CP25FR	25.0	1,385	250	2,500	2,400	225 Dia
CP35FR	35.0	1,900	350	3,500	2,400	315 Dia
CP50FR	50.0	2,775	500	5,000	2,400	315 Dia
CP60FR	60.0	3,300	600	6,000	2,800	315 Dia

Carlow Precast can provide intermediate or larger units to suit specific site requirements - sizes and specifications available upon request.

15 Year Guarantee & Manufacturers All Risk Insurance

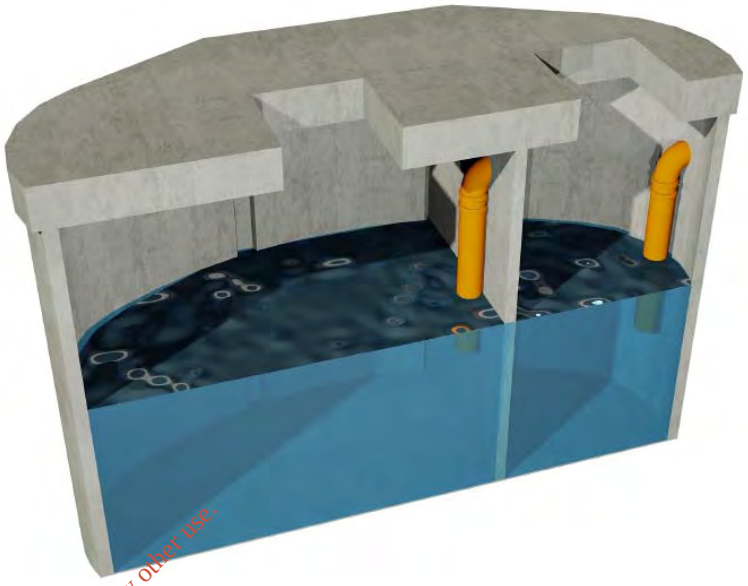
Email: separators@carlowprecast.com
Direct Line: R.O.I. 059 915 9550 / U.K. 0870 493 1408

Washdown & Silt Trap Range

Application

Washdown separators are used in areas where there are cleaning facilities that discharge directly into a foul drain. The unit acts as a preliminary floatation/sedimentation tank, before effluent is discharged. These areas include:

- Car Wash
- Lorry/Bus Wash Bays
- Hire Centres



Washing areas usually discharge emulsifiers such as detergents and soaps, which break down and disperse the hydrocarbon/oil particles. The discharge from the washdown separator must not enter an oil/water separator and must discharge directly into the foul sewer (Permission must be granted by Local Authority).

Materials

Carlow Precast washdown separators are manufactured from 70N concrete with steel fibre reinforcement at 40kg/m^3. Larger units contain conventional steel reinforcement as well as steel fibre.

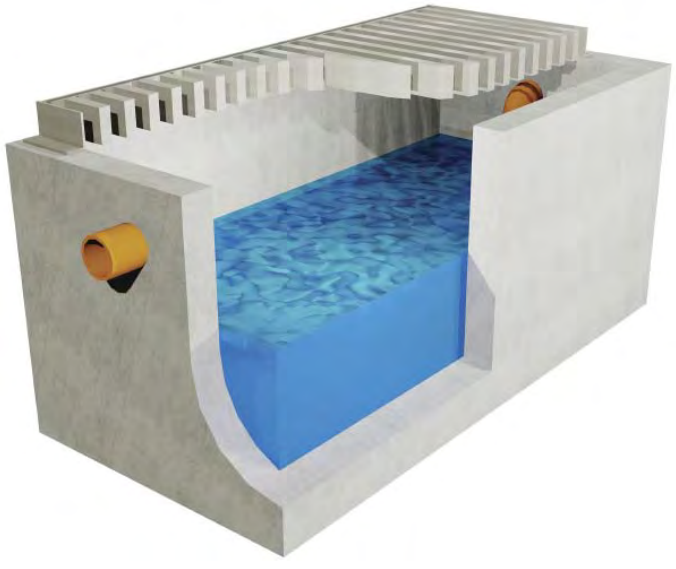
Advantages

- Ease of installation
- Speed of installation
- Reduced civil costs - no expensive concrete backfill
- Durability and robustness
- Inlet/outlet connector to suit all pipework

Sizes & Specifications

Unit Ref. Code	MAX Flow Rate(l/s)	Working Capacity (L)	Silt Storage Capacity (L)	Inlet Invert to Base	Standard Pipe Size O.D. (mm)
CPW300	3.0	1,100	550	1230mm	110 Dia
CPW500	5.0	1,900	950	1790mm	160 Dia
CPW1000	10.0	3,850	1,925	1420mm	225 Dia
CPW1500	15.0	5,800	2900	1825mm	225 Dia
CPW2500	25.0	9,630	4,815	1865mm	225 Dia
CPW3500	35.0	13,500	6,750	2460mm	315 Dia
CPW5000	50.0	19,300	9,650	2460mm	315 Dia
CPW8000	80.0	31,000	15,500	3015mm	315 Dia

Silt Trap Range



Application

Silt traps are designed for use in drainage networks before the flow enters a separator, to remove silt/grit etc. thus preventing contamination of the silt with hydrocarbons.

Materials

Carlow Precast silt traps are manufactured from 70N concrete with steel fibre reinforcement at 40kg/m3. Larger units contain conventional steel reinforcement as well as steel fibre.

Advantages

- Ease of installation
- Galvanised heavy-duty cover
- Reduced civil costs - no expensive concrete backfill
- Durability and robustness
- Inlet/outlet connectors to suit all pipework
- Easy to clean out with excavator

Collateral Warranty & Professional Indemnity Insurance

Forecourt Separator

Application

Forecourt separators are used where oil and petroleum are stored and offloaded. Areas such as petrol filling station forecourts, where there is a risk of spillage of these hydrocarbons into the surface water drainage system.

As contaminated water passes through the separator, it is retained long enough to allow pollutants to accumulate on the surface. Carlow Precast forecourt separators are single chamber vessels, resulting in the minimum of turbulence, while maximising retention time. The pollutants are retained within the separator, allowing treated water to discharge via the coalescing filtration unit. In the event of a oil tanker spillage, the capacity of the separator is such that it capable of containing the entire spill from a tanker compartment (7,600 litres) and also ongoing hydrocarbon pollutants. A shut-off valve will ensure containment and an alarm system will ensure the operator takes action to empty the separator.

Each forecourt separator features the following:

- Oil Storage Capacity
- Silt Storage Capacity
- Coalescer (Class 1 only)
- Automatic Shut-off Valve

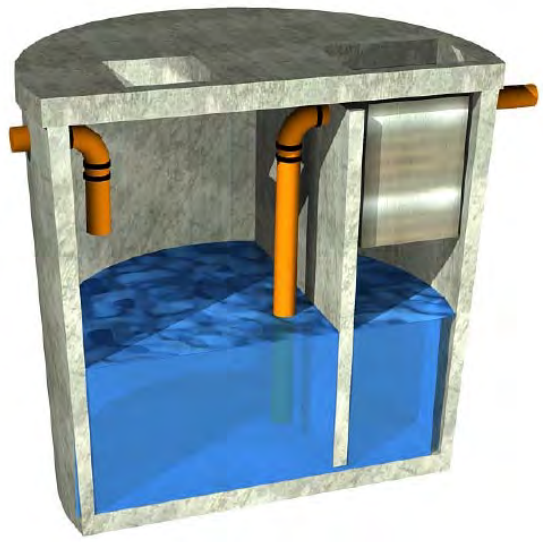
Materials

Carlow Precast forecourt separators are manufactured from 70N concrete with steel fibre reinforcement at 40kg/m3. Larger units contain conventional steel reinforcement as well as steel fibre.

Installation

The unit should be installed on a level bed of sand, gravel or broken stone. The base of the excavation should be level and free from projecting hard points such as rocks or boulders. The separator is lifted into position by our truck-mounted crane, assuming there is suitable access for our delivery vehicle.

Backfilling is commenced as soon as possible after placement of the separators. In most installations, it is not necessary to backfill around the separator with concrete.



Advantages

- Ease of installation
- Speed of installation
- Reduced civil costs-no expensive concrete backfill
- Durability and robustness
- Inlet/outlet connectors to suit all pipework

Accessories

Access covers to suit all loadings are available on request.

Oil level alarms can be fitted to indicate when the separator requires emptying. They are mounted remotely from the unit and are available with an audible or visual alarm. Off-site monitoring is also available from our technical department.

Oil Alarm

An oil level alarm is required to be fitted to all separators in accordance with EN 858-1. Carlow Precast can provide alarm & monitoring of all our separator range.

- Visual Alarm
- On-Site Early Warning & Monitoring
- Full Off-site Monitor & Cleaning Service

Grease Trap

Application

Grease traps are used to trap both settled and floating waste material (fat and grease) and separate out from water before entering main drainage systems.

The Carlow Precast grease trap is a 3-chamber unit with separate access to each chamber.

The CP GST 4000 is suitable for a premises serving up to 1,300 meals per day.

Materials

Carlow Precast grease traps are manufactured from 70N concrete with steel fibre reinforcement at 40kg/m^3.

15 Year Guarantee & Manufacturers All Risk Insurance

CARLOW PRECAST
Concrete Engineering

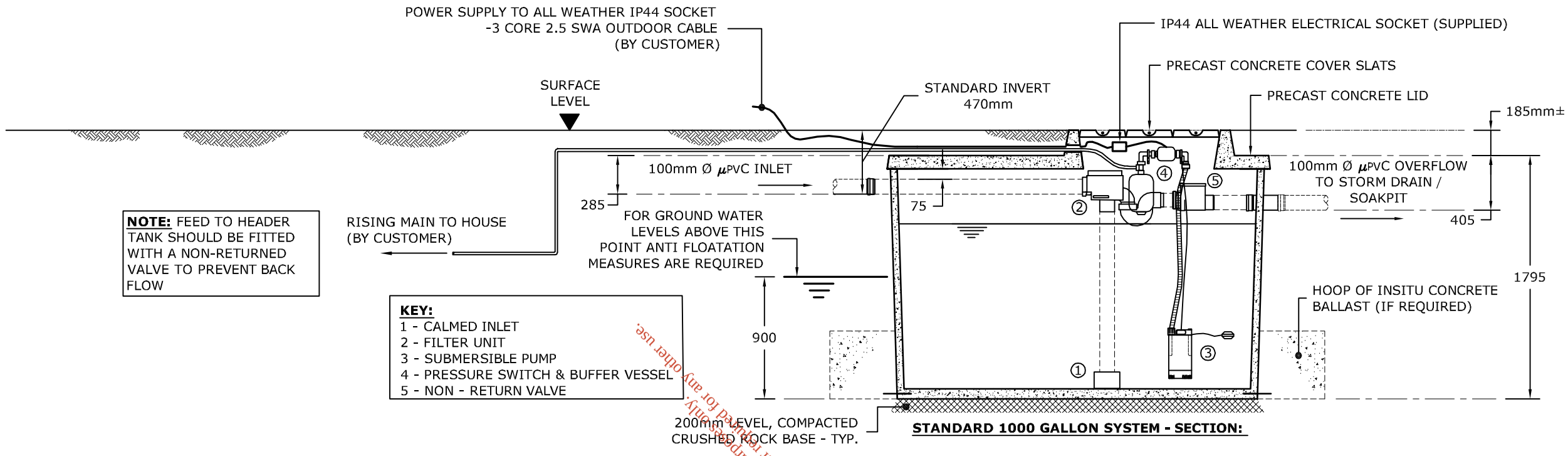
DRAWING TITLE:

GENERAL LAYOUT - STANDARD 1000 GALLON RAINWATER HARVESTING SYSTEM

Drawn By: T. Armstrong

Date: 29/04/09

Revision: E

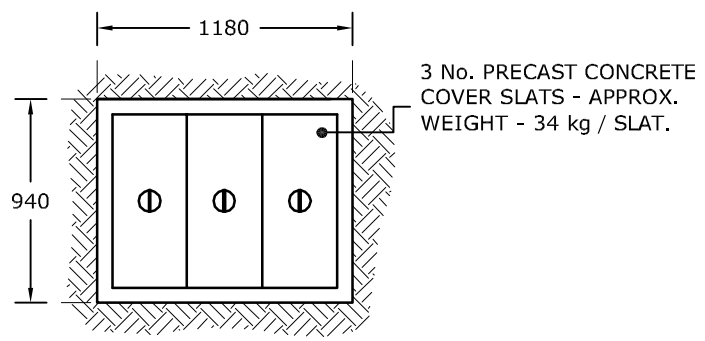


NOTE: FEED TO HEADER TANK SHOULD BE FITTED WITH A NON-RETURNED VALVE TO PREVENT BACK FLOW

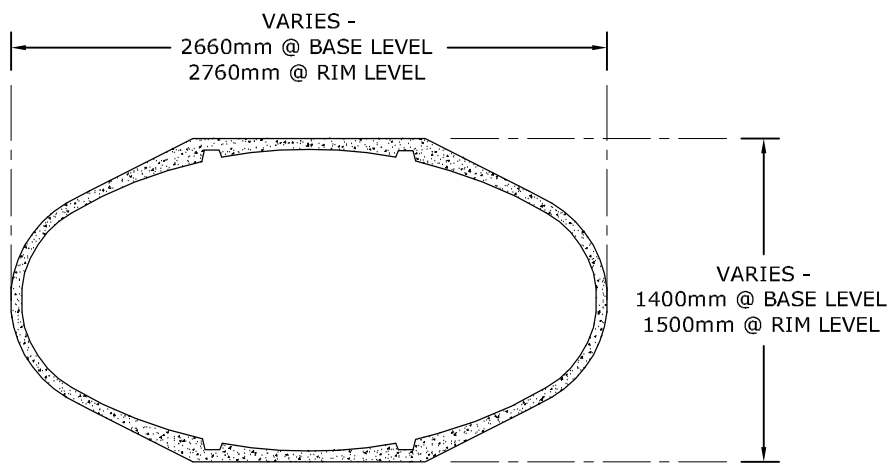
KEY:
1 - CALMED INLET
2 - FILTER UNIT
3 - SUBMERSIBLE PUMP
4 - PRESSURE SWITCH & BUFFER VESSEL
5 - NON - RETURN VALVE

STANDARD 1000 GALLON SYSTEM - SECTION:

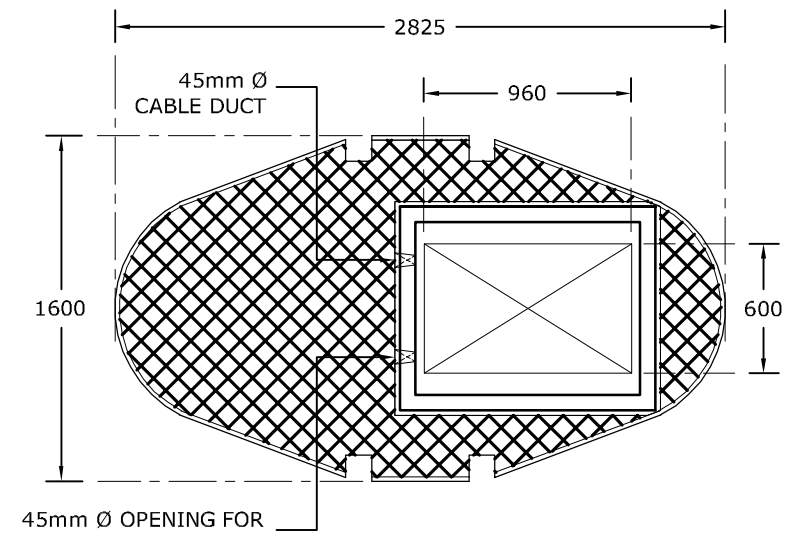
UNIT WEIGHTS:
TANK: 2.5 t
LID: 1.0 t
SLAT: 34 kg



PLAN VIEW - MANHOLE ACCESS OPENING:
SCALE: 1:35



PLAN VIEW - PRECAST CONCRETE STORAGE TANK:
SCALE: 1:35



PLAN VIEW - PRECAST CONCRETE LID:
SCALE: 1:35

Carlow Precast Tanks

Domestic Waste Water Treatment Plant

2-6 PE & 6-10 PE

CPT ZONS® AQUAstar® SBR

NSAI Agrément

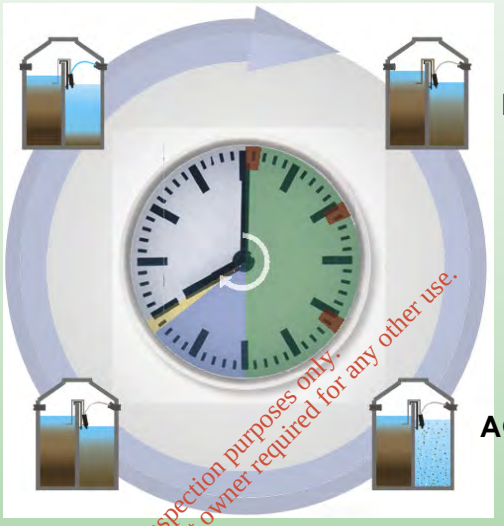
Certificate No: 08/0318
CPT ZONS® AQUAstar® SBR
Carlow Precast Tanks

Type of Plant

The plant works as a sequential batch reactor (SBR). Pollutants from the wastewater are absorbed by the activated sludge and converted into biomass. The micro-organisms are activated by the oxygen intake during the aeration period.

How does it work

The process employs a four-stage cycle: fill, react, settle and empty. Approximately eight hours after commencement, the cycle comes to an end and another cycle recommences. The SBR process is time-based rather than flow-based so there is much more control of the treatment process.



Intended Use

On-site treatment of domestic wastewater. Other effluents may damage the plant or affect its function (please refer to Operation and Maintenance Manual for full list of Solid or fluid substances that do not belong in drain or toilet).

The following effluents cannot be introduced to the plant:

- industrial wastewater that is not comparable with domestic wastewater,
- percolating water,
- cooling water,
- swimming pool runoff,
- rainwater

Usage of eco friendly cleaning agents will allow activated sludge (micro-organisms) to grow up faster and maintain required level. This will cause good plant performance.

Design

CPT Zons AQUAstar system is designed to work in range:

- from 2 to 6 (1200 gallon tank)
- from 6 to 10 (1500 gallon tank)

	2 - 6 PE system	6 - 10 PE system
Max designed population	6 PE	10 PE
Tank size	1200 gallon (5.45m³)	1500 gallon (6.82m³)
Tank weight	5.5 Tonnes	6.3 Tonnes
Primary treatment chamber capacity	2.10m³	3.16m³
Aeration chamber capacity	2.00m³	3.30m³
Designed flow rate	1080 litres/day	1800 litres/day
Designed BOD load	0.36 kg BOD_5/day	0.60 kg BOD_5/day

Installation on site

The product is supplied to the end user as a 'plug & play' package to be installed by the CPT Zons AQUAstar operative. It is delivered on a platform-bodied truck with rear-mounted articulating crane and placed in its final position in the excavation by the driver.

Client is to prepare:

- Proper size excavation (please refer to the drawing on the following page) with level base free from projecting hard points such as rock or boulders
- Approx. 100-200mm sand, gravel or broken stone layer at the base
- The sides of the excavation should be so battered as to minimise risk of slippage or collapse.
- Easy access to the lorry with articulating crane

Pipe Connections:

- Inlet: 100mm Ø µPVC pipe connection from the house to the tank.
- Outlet: 32mm Ø reinforced hose from the connection at the tank to the distribution box at polishing filter

Cable Connections:

- 230V supply protected by a 20A RCBO and fed with a 3 x 2.5mm² S.W.A cable. Leave sufficient cable to reach the tank to ensure connection is possible. Connection with AQUAstar unit must be made by customer's electrician with IP65 rate (waterproof) provided junction box.

Notes:

- The AQUAstar tank is designed for maximum 1.0m overburden. Higher level of overburden must be consulted with structural engineer.
- Garbage grinder in the kitchen may cause food wastes rotting in the tank which may cause bad smell from the tank.

Recommendations:

- Installation of standard inspection manhole at the CPT Zons AQUAstar tank inlet side. This will allow to easily remove any possible blockages from the inlet pipe.
- Installation of domestic grease trap at the kitchen outlet pipe. According to EPA 2000 Manual - Grease should not be allowed to enter the reactor. Major problem in the drainage system in dwelling houses is the build up of grease and waste solids in the drainage system. While the grease is still warm it flows freely but once it cools it solidifies and eventually blocks the pipes. The grease trap can be easily installed in new and existing waste water systems where 110mm piping is already being used.

Soil polishing filters

Soil polishing filters should be used to treat wastewater from mechanical aeration systems which AQUAstar is. These filters are employed to reduce micro-organisms, phosphorus, and nitrate nitrogen. Soil polishing filters may comprise *in situ* soil, improved soil or imported soil. There grass growth is allowed, there can be a large reduction in NO3-N. These soils should have percolation values (P or T) in the range of 1-50. Dosing may be by gravity or by pumped arrangements. Please contact us for soil polishing filter type and size recommendation (Mob.: 086 1735964 or e-mail: aquastar@carlowprecasttanks.com).

CPT Zons does not provide design and installation of soil polishing filters. CPT Zons may recommend trenches length or area according to EPA Manual. Client may ask County Council for established list of approved site assessors.

Operator Control

Daily control

Ensure that plant is in operation by checking the beacon installed above the tank. Green led confirms that plant is in operation, when green led is off that means that there is no power supply. Red led on beacon indicates malfunction in operation and alarm message is displayed on the MULTICOM control unit. In this case contact Carlow Precast Tanks office for advice.

Monthly controls

Check if there is sludge in the plant's outflow and if inlet and outlet pipes are not blocked.

When the end user is absent for a longer period, he must ensure that the operation controls are executed by another person.

Sludge disposal

The wastewater's solid deposits (sludge) are retained in the plant's primary settlement chamber. These solids must be disposed by an authorized waste management company.

To guarantee optimum function of the plant, we recommend sludge removal only when required. Sludge removal must be performed when the primary settlement chamber's sludge content exceeds 50 %. Ensure that only the primary settlement chambers are emptied, not the aeration tank. Otherwise, the bacteria which perform the biological treatment are lost and the plant must be reseeded.

After de-sludging the primary settlement chamber must be refilled with clear or rain water. Refill from the middle chamber, so that possible remaining sludge is transferred into the first primary settlement chamber.

Energy usage

		2	4	6	8	10
AQUAstar kit energy usage	kW/d	1.61	2.37	3.00	3.29	3.55
	kW/year	586.30	866.00	1096.00	1199.30	1294.60
Running Cost*	€ / week	1.61	2.38	3.02	3.30	3.56
	€ / year	84.14	124.28	157.28	172.11	185.77
	€ / year*PE	42.07	31.07	26.21	21.51	18.58

*assuming €0.1435 per 1kW

Warranty

CPT Zons AQUAstar guarantees AQUAstar waste water treatment system for 12 months from the date of installation.

Warranty entitles the customer to an annual maintenance and service visit when AQUAstar kit is checked and tested, pumps are cleaned and an effluent treated sample is taken for analysis. These also entitles customer to free emergency call outs. Emergency technical line: +353 87 7516254. Whenever problem can't be solved via phone, service technician will be sent on site. If a CPT Zons appliance shows a defect during the period covered by warranty, the appliance shall be repaired by CPT Zons. The customer will not be charged for the cost of labour or parts. If there is no service contract in place after the warranty period, a standard call out charge will be charged.

Service

Warranty period can be exceeded for next years by signing on Service Contract which will be forward to the client near the end of warranty period.

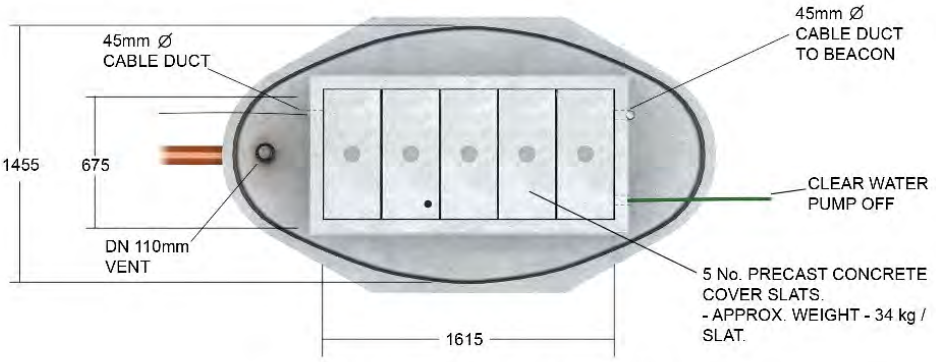
Maintenance

Plant maintenance must be executed by personnel trained in the maintenance of AQUAstar treatment plant at least once a year.

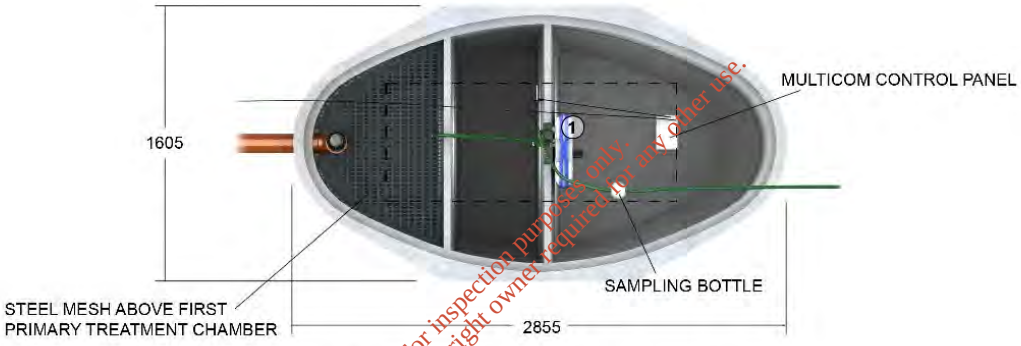
Certification

CPT Zons AQUAstar is certified by Irish Agrément Board. Certificate no: 08/0318. Irish Agrément Board Certificates establish proof that the certified products are 'proper materials' suitable for their intended use under Irish site conditions, and in accordance with the Building Regulations 1997 to 2007.

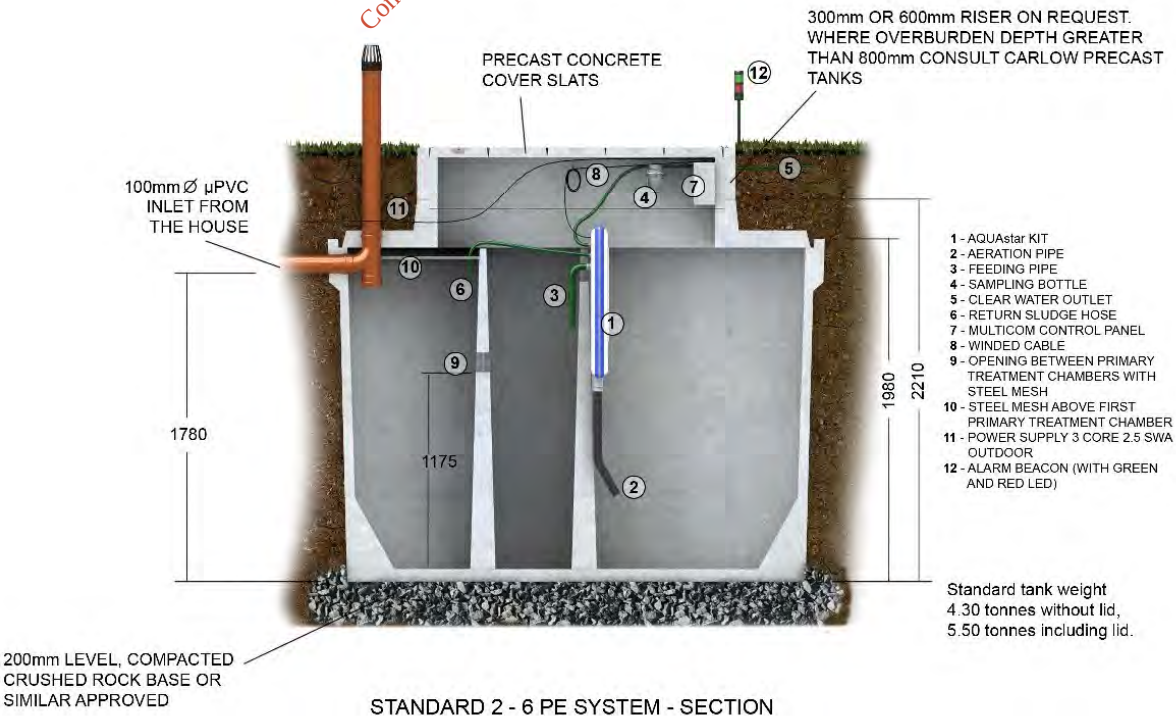
CPT Zons AQUAstar® conforms to the standards of the German authority, DIBt, and the European Norm EN 12566 part 3.



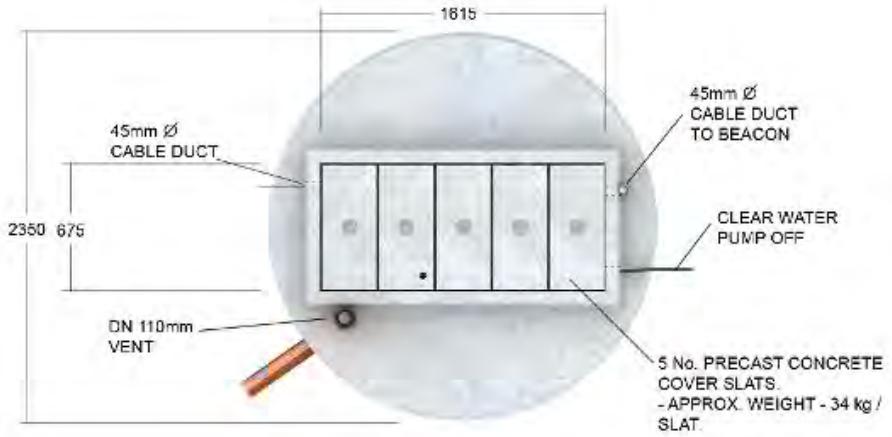
PLAN VIEW - PRECAST CONCRETE LID



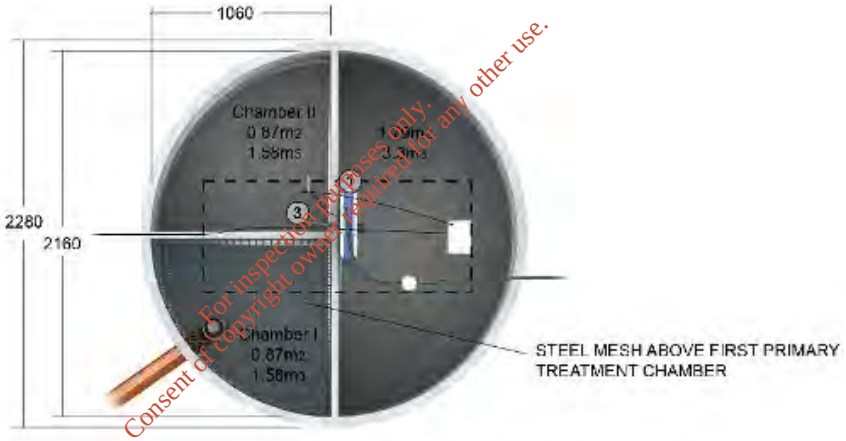
PLAN VIEW - PRECAST CONCRETE TANK



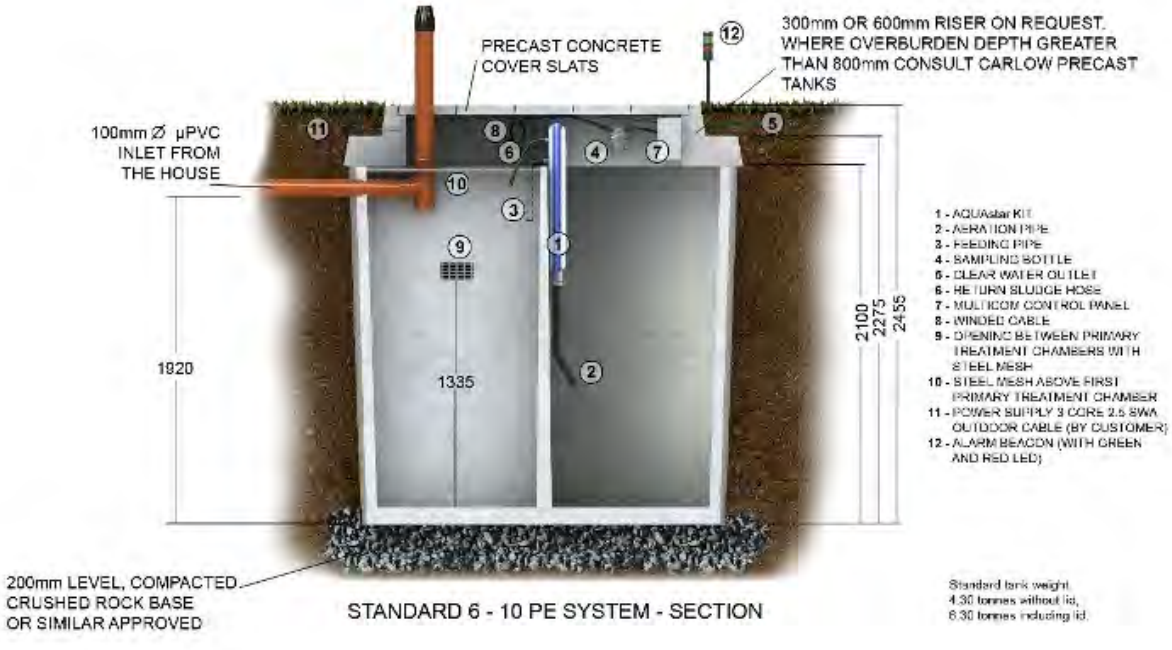
STANDARD 2 - 6 PE SYSTEM - SECTION



PLAN VIEW - PRECAST CONCRETE LID



PLAN VIEW - PRECAST CONCRETE TANK



STANDARD 6 - 10 PE SYSTEM - SECTION

AQUAstar® SBR Domestic Wastewater Treatment Plant Advantages:

- Free delivery and installation nationwide.
- Small footprint in the garden.
- No unsightly working parts visible over ground.
- Fully programmed control unit installed.
- Fully tested and commissioned prior to delivery.
- Short lead times.
- No concrete base required.
- No concrete backfill required.
- Complete package – no extra parts required.
- Nitrogen removal off - the - shelf
- Power saving by automatic save mode
- 12 month guarantee.
- Maintenance contracts available.
- 15 years structural guarantee.

Bord Agrément na hÉireann
Irish Agrément Board

CERTIFICATE NO. 08/0318

Carlow Precast Tanks, Kilnock, Ballon, Co Carlow, Ireland
Tel: +353 (059) 9159100
Fax: +353 (059) 9159202
Email: cptaquastar@carlowprecasttanks.com
Web: www.carlowprecasttanks.com

CPT Zons® AQUAstar®

Systémes de Traitment des Eaux Résiduaires
Abwasser Aufbereitung

The **Irish Agrément Board** is designated by Government to issue European Technical Approvals.

Irish Agrément Board Certificates establish proof that the certified products are **'proper materials'** suitable for their intended use under Irish site conditions, and in accordance with the **Building Regulations 1997 to 2006**.

The **Irish Agrément Board** operates in association with the **National Standards Authority of Ireland (NSAI)** as the National Member of UEAtc.

PRODUCT DESCRIPTION:
This certificate relates to the **CPT Zons® AQUAstar®** Wastewater Treatment System for Single Dwellings.

The system incorporates the **CPT Zons® AQUAstar®** kit and uses the Sequential Batch Reactor **(SBR)** process to treat domestic wastewater, from dwellings with a population equivalent of up to ten persons.

The system is comprised of a three chamber concrete tank which is installed underground. The system is available in two treatment capacity ranges, for up to 6 PE and for 6 to 10 PE.

USE:
The product is for use as a mechanical aeration packaged treatment plant, for domestic wastewater treatment for a population equivalent of up to 10 PE. The system should be designed, installed and used in accordance with the EPA.

Wastewater treatment manual – Treatment Systems for Single Houses 2000.

MANUFACTURE AND MARKETING:
Marketing and Tank Manufacture
Carlow Precast Tanks,
Kilnock,
Ballon,
Co Carlow
Tel: +353 (059) 9159100
Fax: +353 (059) 9159202
Email: cptaquastar@carlowprecasttanks.com
Web: www.carlowprecasttanks.com

CPT Zons® AQUAstar® Kit Manufacture:
Rhebau GmbH
Dusseldorf Strasse 118
D-41541 Dormangen
Germany

Part One / Certification 1

1.1 ASSESSMENT

In the opinion of the Irish Agrément Board (IAB), the **CPT Zons® AQUAstar®** Wastewater Treatment System is satisfactory for the purpose defined above, and can meet the requirements of the Building Regulations 1997 to 2007, as indicated in Section 1.2 of this Certificate.

1.2 BUILDING REGULATIONS 1997 to 2007

REQUIREMENT

PART D – MATERIALS AND WORKMANSHIP

D1 - The **CPT Zons® AQUAstar®** Wastewater Treatment System, used in accordance with this Irish Agrément Board Certificate, can meet the requirements for materials and workmanship.

D3 - The **CPT Zons® AQUAstar®** Wastewater Treatment System, as certified in this Irish Agrément Board Certificate, is manufactured from proper materials and is fit for its intended use. See Part 4 of this Certificate.

PART H - DRAINAGE AND WASTE DISPOSAL

H1 Drainage systems

The **CPT Zons® AQUAstar®** Wastewater Treatment System when installed, operated and maintained in accordance with this Certificate, can meet Building Regulation requirements.

H2 Septic tanks

The **CPT Zons® AQUAstar®** Wastewater Treatment System is a mechanical aeration wastewater treatment system, for the treatment of domestic wastewater, when designed, installed and used in accordance with the EPA *Wastewater treatment manual – Treatment Systems for Single Houses 2000*.

The quality of effluent from the **CPT Zons® AQUAstar®** Wastewater Treatment System can meet the Building Regulation requirements.

Information on the design capacity, ventilation, safety and location requirements is given in this Irish Agrément Certificate. See Part 3 and 4 of this certificate.

Part Two / Technical Specification and Control Data 2

2.1 PRODUCT DESCRIPTION

2.1.1 System Details

The **CPT Zons® AQUAstar®** Wastewater Treatment System is a Sequential Batch Reactor **(SBR),** mechanical aeration wastewater treatment system for treatment of domestic wastewater, from dwellings with a population equivalent of up to ten persons.

The **CPT Zons® AQUAstar®** Wastewater Treatment System settings are configured prior to installation, and subsequently adjusted at first service, to suit the actual hydraulic and biological loading on the system. These loadings must remain within the maximum loadings specified for the unit.

The system elements and specifications are given in Table 1 and Figures 1 and 2.

The treatment design criteria are given in Table 2.

The tank is sub-divided into three chambers i.e. two interconnected primary settlement chambers and the third and final activation chamber. The **CPT Zons® AQUAstar® kit,** located in the activation chamber, is electronically controlled by the **MULTICOM® 100** control unit/alarm. The control unit is fitted in an insulated box, on the riser wall, above the activation chamber.

The system should be connected to the domestic power supply via the IP 66 rated junction box provided. It is connected to the dwelling served, through a residual current circuit breaker.

100 mm diameter inlet and 32 mm diameter (1 1/4 “) outlet pipe connections are provided and provision is made for ventilation.

All chambers are accessed via pedestrian duty reinforced concrete access covers, which are designed to be flush with ground level. The **CPT Zons® AQUAstar®** unit can be readily removed from the activation chamber for servicing or maintenance.

Discharge from the tank is by pumped discharge.

2.1.2 Treatment process

The **CPT Zons® AQUAstar®** Wastewater Treatment System uses activated sludge/sequencing batch reactor technology to biologically treat domestic wastewater.

The treatment process steps are as follows:

1 Pre-treatment: Domestic wastewater flows by gravity, into the primary chambers, which provide for the settlement and storage of primary and surplus sludge, act as a buffer for the inflow and provide additional storage capacity if required.

2 Treatment: When the wastewater in the primary tank reaches the required level, a fixed volume is siphoned

into the activation chamber, using an energy saving fluid transfer mechanism.

In the activation chamber, the oxygen supply to the micro-organisms is managed, to create aerobic and anaerobic/de-nitryfing[1]. conditions. Pollutants are absorbed by the activated sludge and converted into a biomass. Excess activated sludge is returned to the primary chamber, to maintain a sludge volume of 400 ml/l in the activation phase.

3 Settlement period: When the six hour[2] activation phase is complete, the aeration/agitation system is switched off and the two hour settlement phase commences. The activated sludge settles on the base of the chamber.

4 Discharge: The treated effluent is then pumped from the activation chamber to the polishing filter, and the treatment cycle recommences.

The plant automatically operates a three month start up programme. The certificate holder recommends injecting the activation chamber with 30 litres of activated sludge per person to accelerate growth of activated sludge.

During times of continuous low flows, or when the dwelling is un-occupied, the **CPT Zons® AQUAstar®** waste water treatment plant system automatically switches to economy mode. This reduces agitation and aeration times, and requires less electricity, while maintaining functioning activated sludge in the system.

2.2 MANUFACTURE

2.2.1 General

The tank body, with integral walls and floor, is cast in the inverted position, in a single pour, using C55/65 self compacting, fibre reinforced concrete.

The tank cover and access covers are cast in conventionally reinforced C55/65 self compacting concrete.

The **CPT Zons® AQUAstar®** kit, which is assembled from proprietary components, is quality checked, then fitted to the activation chamber baffle wall, using stainless steel wall mounting brackets, prior to dispatch. The **MULTICOM® 100** is also fitted, prior to dispatch.

The tank cover is sealed in place using bitumen tape sealant and primer.

The connection cable and IP66 socket, alarm beacon, sampling bottle, inlet and outlet pipe connections and labels are fitted prior to dispatch.

2.2.2 Product range

The system range and design details are shown in Tables 1and 2, and Figure 1 and 2.

2.2.3 Ancillary items

The system is supplied with all the required components in place.

Distribution boxes for the treated effluent are available from the Certificate holder but are outside the scope of this Certificate.

All components in contact with effluent are made of stainless steel, ABS, uPVC or polypropylene.

2.2.4 Quality control

The Certificate holder operates a quality management system and continuous quality control is exercised during manufacture. Quality controls include checks on incoming raw materials and ancillaries, concrete cube test, equipment calibration, operational testing of **CPT Zons® AQUAstar®** kit, visual inspection and water tightness testing.

2.3 DELIVERY, STORAGE AND MARKING

2.3.1 The Certificate holder delivers the **CPT Zons® AQUAstar®** waste water treatment plant to site on a platform-bodied truck with rear-mounted articulating crane. The Certificate holder installs the unit in the excavation, in accordance with ***CPT Zons® AQUAstar® SBR Installation Guide*.**

All lifting equipment and procedures shall comply with the requirements of the Safety, Health and Welfare at Work Act 2005. The Certificate holder's instructions shall be followed to avoid damage to the tank during off-loading and installation.

All works associated with the excavation, and access to it, must be fully in accordance with best practice and all relevant statutory requirements.

The unit is normally delivered to site for immediate installation. However if on site storage is necessary, the tank should be stored upright, on stable, level ground, of adequate bearing pressure, with the cover in place to prevent ingress of water. The tank should only be lifted when empty; water should be pumped out if necessary.

2.3.2 The unit is marked as follows:

- adhesive label bearing: unique serial number, IAB identification Mark incorporating the number of this Certificate, Certificate holder's details, model type and population equivalent ;
- Concrete access covers incorporate the IAB logo;
- Inlet and outlet pipe connections are identified.

[1] *The effluent nitrogen levels are influenced by temperature and background levels in local water supply.*

[2] *The values given are approximate. Process times are modified at commissioning and servicing to suit actual design flows.*

Table 1: CPT Zons® AQUAstar® System elements and specifications

Component	Properties
Wastewater Treatment Tank	
Tank body	C55/65 steel fibre reinforced concrete
Tank cover	C55/65 conventionally reinforced concrete
Access covers	C55/65 conventionally reinforced concrete
Risers	300 mm or 600 mm high C55/65 steel fibre reinforced concrete
Minimum cover to reinforcement	30mm
Design codes	BS 8110-1:1997 *Structural use of concrete – Code of Practice for design and construction*; I.S. EN 12566-3 *Small wastewater treatment plants for up to 50 PT – Part 3: Packaged and/or site assembled wastewater treatment plants* and Bekaert *Dramix Design Guidelines for Steel Fibre Reinforced Concrete Structure 1996*.
Permissible Loading Tank body Tank cover/access covers	2.5 KN/m^2 UDL and 800mm soil overburden (Maximum 2 risers)[3]. Pedestrian loading **The tank should be fenced off to prevent animal or wheel loads**
Tank Weight 10 PE 6 PE Access cover	4.3 tonne without cover; 6.3 tonne with cover 4.2 tonne without cover; 5.5 tonne with cover 40 Kg (maximum)
CPT Zons® AQUAstar® Kit SBR Kit including submersible pumps, flow control valves, gas sensors; float switches, effluent transfer, aeration, agitation and sludge return mechanisms, sampling bottle and **MULTICOM® 100** unit.	
MULTICOM® 100 control unit Electronic SBR control unit incorporating Visible and audible alarms Methane Gas monitoring system Storage of performance data Self test mechanism Fibox EKUM180T IP66/67 rated insulated enclosure	
Connection Cable	9 x 1.0 mm^2 x 5 m connection cable with connector
Inlet pipes connection	100 mm diameter inlet drainage pipe connection to IS 424: 1990 and EPDM wall seal
Outlet pipe connection	32 mm reinforced hose and adaptor
Beacon	Telemecanique Harmony XVE

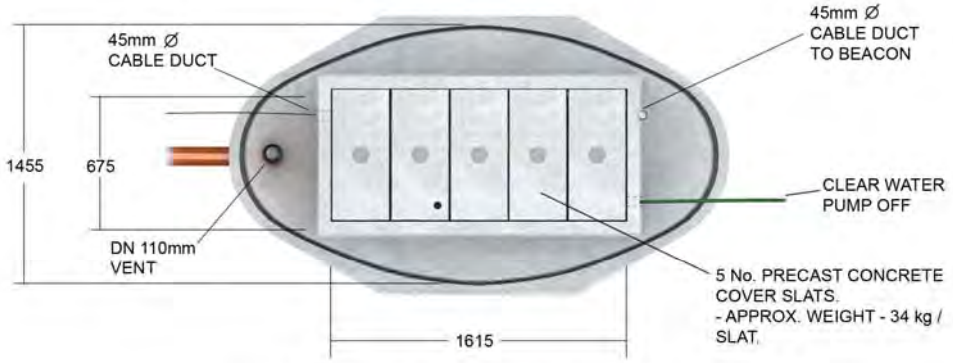
[3] *Tanks which are installed under higher loading conditions are outside the scope of the Certificate. Please contact Carlow Precast Tanks for further information.*

Table 2 **CPT Zons® AQUAstar® System - Biological Process Design and Settings**

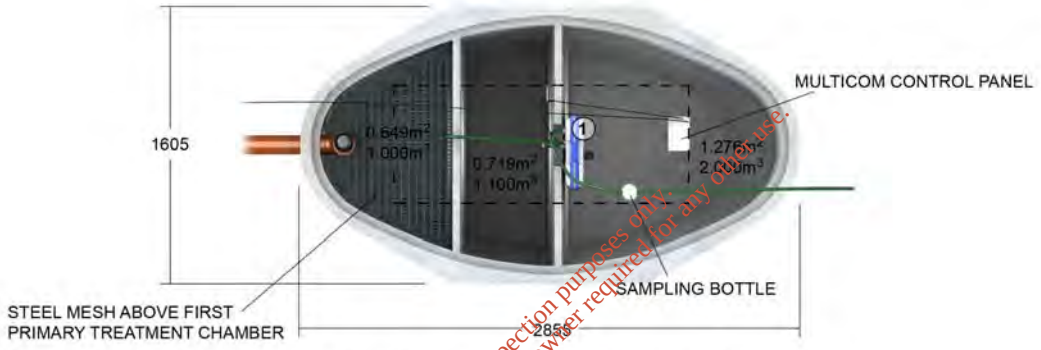
CPT Zons® AQUAstar® 2 to 6 PE Unit			
	2 PE system	**4 PE system**	**6 PE system**
Design PE	2 PE	4 PE	6 PE
Tank size	5.45m^3 (1200 gallon)		
Total treatment capacity	4.10 m^3	4.10 m^3	4.10 m^3
Storage in event of failure, including buffer storage (assuming tank full at time of failure)	1.58 m^3	1.62 m^3	0.38 m^3
Primary treatment chamber volume	1.35m^3	1.38m^3	2.06m^3
Primary treatment chamber water level	0.98m	1.0m	1.51m
Primary treatment chamber surface area	1.37m^2	1.37m^2	1.37m^2
Activation chamber volume	1.28m^3	1.32m^3	1.98m^3
Activation chamber water level	1.0m	1.03m	1.55m
Activation chamber surface area	1.28m^2	1.28m^2	1.28m^2
Designed flow rate	0.36 m^3/day	0.72 m^3/day	1.08 m^3/day
Designed BOD load	0.12 kg BOD_5/day	0.24 kg BOD_5/day	0.36 kg BOD_5/day
Aeration on / Aeration off	3min. / 15min.	4min. / 15min.	6min. / 15min.
Save Mode Aeration on / Aeration off	1min. / 15min.	2min. / 15min.	2min. / 15min.
Tank de-sludging period	Annual or as specified by service technician		
Energy consumption*	1.16 kWh/day	1.45 kWh/day	1.94 kWh/day
CPT Zons® AQUAstar® 6 to 10 PE unit			
	6 PE system	**8 PE system**	**10 PE system**
Max designed population	6 PE	8 PE	10 PE
Tank size	6.82m^3 (1500 gallon)		
Total treatment capacity	6.460 m^3	6.460 m^3	6.460 m^3
Storage in event of failure including buffer storage (assuming tank full at time of failure)	2.91 m^3	1.72 m^3	0.54 m^3
Primary treatment chamber volume	1.89m^3	2.53m^3	3.16m^3
Primary treatment chamber water level	1.09m	1.45m	1.82m
Primary treatment chamber surface area	1.74m^2	1.74m^2	1.74m^2
Activation chamber volume	1.98m^3	2.64m^3	3.30m^3
Activation chamber water level	1.11m	1.47m	1.84m
Activation chamber surface area	1.79m^2	1.79m^2	1.79m^2
Designed flow rate	1080 litres/day	1440 litres/day	1800 litres/day
Designed BOD load	0.36 kg BOD_5/day	0.48 kg BOD_5/day	0.60 kg BOD_5/day
Aeration on / Aeration off	6min. / 15min.	7min. / 15min.	8min. / 15min.
Save Mode Aeration on / Aeration off	2min. / 15min.	3min. / 15min.	3min. / 15min.
Tank de-sludging period	Annual or as specified by service technician		
Energy consumption*	1.94 kWh/day	2.16 kWh/day	2.36 kWh/day

Note 1: System settings have been derived from *Prüfinstitut für Abwassertechnik-RWTH Aachen Final Test Report for RHEBAU Zons Aquastar SBR System* September 2004. Testing of the *RHEBAU Zons Aquastar SBR System* was carried out in accordance with EN 12566-3. The design is based on DIN 4261-2: 1984 *Small sewage treatment plants; plants with sewage aeration; application, design, construction and testing,* using the influent loadings stated above.
Note 2: 'PE' refers to the population equivalent.
Note 3: The system settings are initially configured for the design PE, and should subsequently be adjusted, during servicing, to accommodate the actual hydraulic and biological loading on the system.

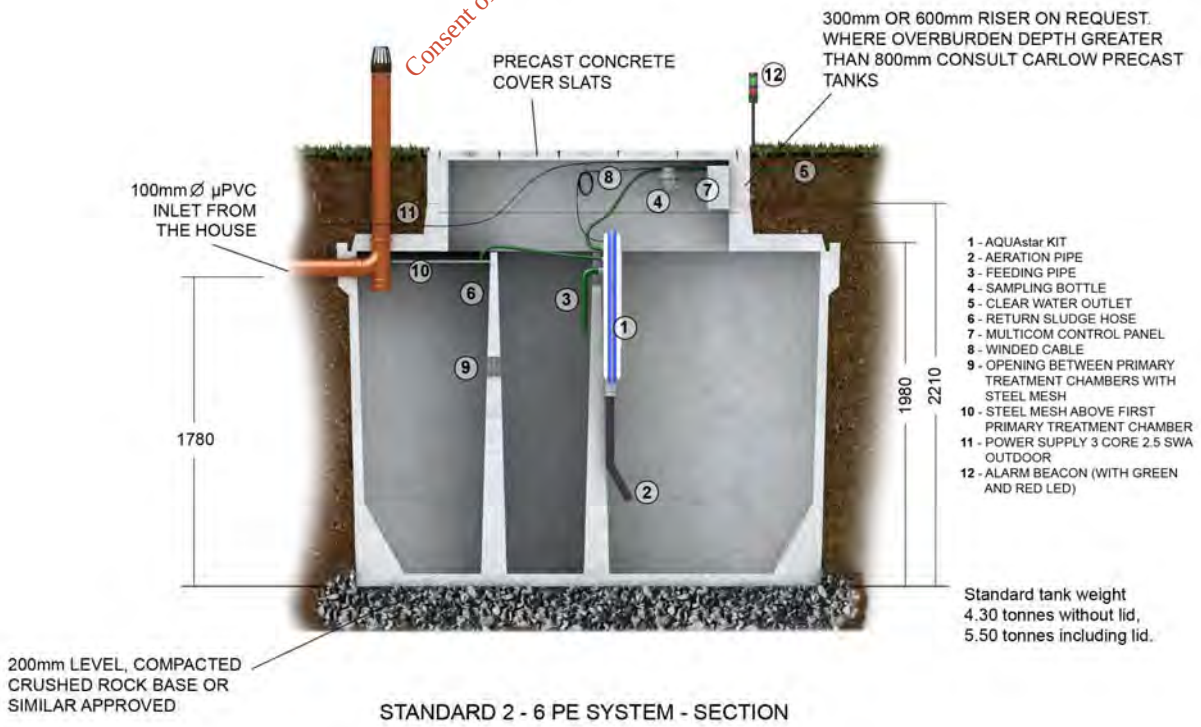
Fig 1: CPT Zons® AQUAstar® System: 2-6 PE Unit; Section and Plan



PLAN VIEW - PRECAST CONCRETE LID

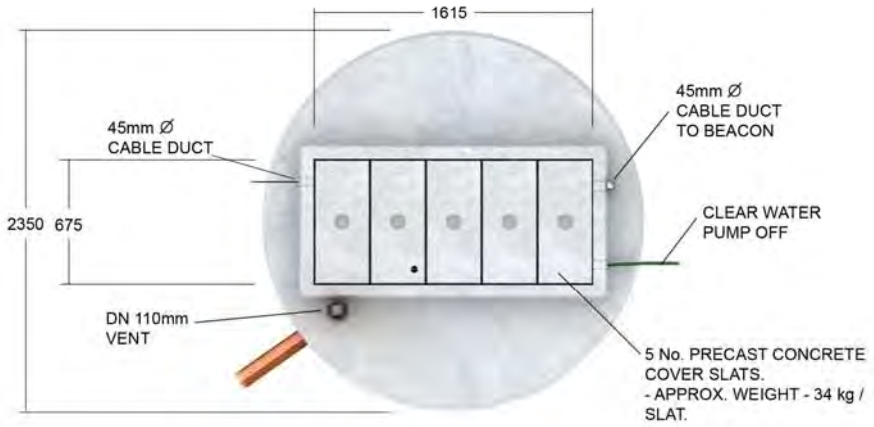


PLAN VIEW - PRECAST CONCRETE TANK

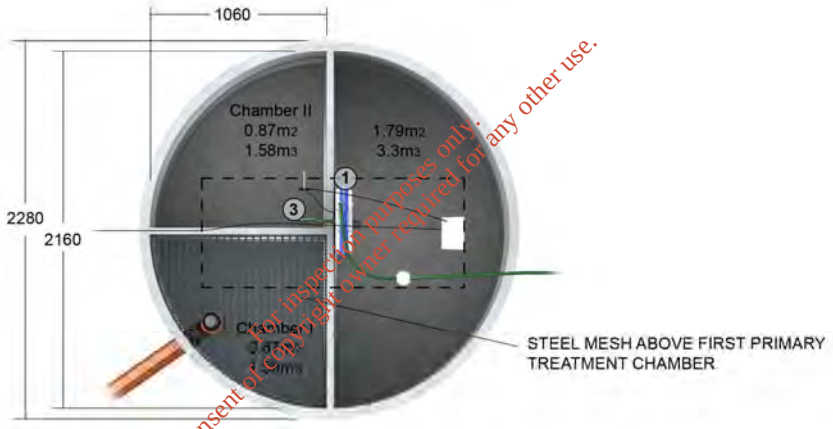


STANDARD 2 - 6 PE SYSTEM - SECTION

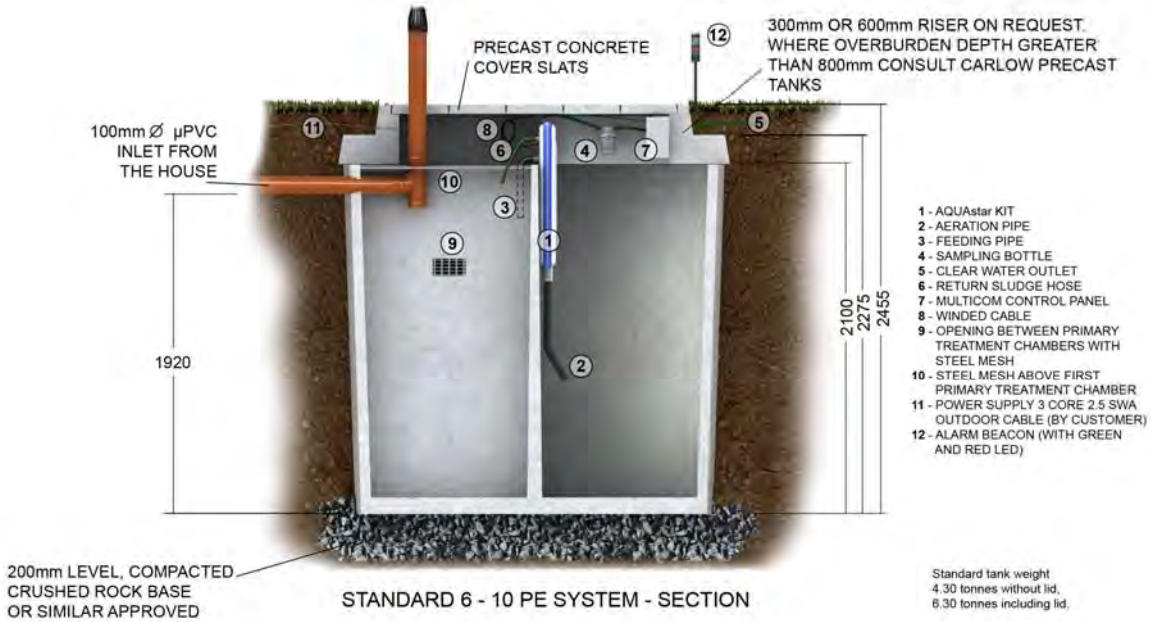
Fig 2: CPT Zons® AQUAstar® System: 6 - 10 PE Unit; Section and Plan



PLAN VIEW - PRECAST CONCRETE LID



PLAN VIEW - PRECAST CONCRETE TANK



STANDARD 6 - 10 PE SYSTEM - SECTION

2.4 INSTALLATION

2.4.1 General

A 'competent person', e.g. an appropriately qualified and experienced engineer, shall conduct a site characterisation/site assessment in accordance with the EPA *Wastewater treatment manual – Treatment Systems for Single Houses 2000*.

Based on this assessment, a 'competent person' should design and supervise installation and commissioning of the wastewater treatment system including all relevant drainage pipe work and connections, vent pipes, manholes, inspection chambers, distribution box, polishing filter and fencing.

The **'competent person'** should ensure that all aspects of installation are in accordance with

- The current Building Regulations
- the conditions of planning e.g. unit loading remains as per design, polishing filter properties and water levels are as specified in the planning submission and
- Cl. 2.4.6 and Part 3 of this Certificate, and that ground conditions are adequate.

2.4.2 Certificate Holder's Installation Policy

It is Carlow Precast Tanks' policy to:

a) deliver, off load, and lift each unit into the excavation provided, using appropriate lifting equipment;
b) supply detailed installation instructions;
c) inspect the excavation for suitability etc prior to installation
d) level the unit for connection to drainage pipe work;
e) commission the unit after installation;
f) carry out a first service (typically within 6 months of start up) to ensure that the system is being used and is operating correctly.

The reminder of the installation (including electrical) shall be carried out by '**competent persons**' in accordance with the installation instructions provided (see Cl 2.4.3).

2.4.3 Electrical Works

Electrical connections shall be strictly in accordance with the Certificate holder's instructions, the current versions of ET101 *National Rules for Electrical Installations* and ET 207 *Guide to the National Rules for Electrical Installations As Applicable To Domestic & Similar Installations*, published by the Electro-Technical Council of Ireland (ETCI).

All electrical works, and connections to the mains supply board, shall be carried out by a '**competent person**', using materials suitable for the purpose (230v supply protected by a 20A RCBO and fed with a 3 x 2.5mm^2 S.W.A cable). Cable should be of sufficient length to reach from the dwelling to the furthest point on the tank.

Electrical cables shall be protected from accidental damage e.g. by a suitable conduit or use of S.W.A cable.

2.4.4 Site Works

The excavation shall be of sufficient size to permit placement of the unit and back filling and to allow for timbering and sheeting. There should be sufficient area on site to permit excavation, dumping of excess spoil, backfilling, handling and installation, without causing damage to the unit or the ancillary equipment.

Care shall be taken to prevent accidental damage arising from blows from tools, or concentrated loads on the unit during installation.

2.4.5 Health and Safety

Excavation, placing and backfilling should be carried out strictly in accordance with the requirements of the Safety, Health and Welfare at Work Act 2005 and all other relevant legislative requirements.

2.4.6 Procedure

a) Equipment and materials

All plant and materials necessary for the installation should be on site before excavation commences.

b) Tank Installation – dry site[4]

The tanks shall be installed generally in accordance with the certificate holder's instructions and the following particular requirements are noted:

1. Excavate a pit with battered sides; minimum dimensions as follows:
2 – 6 PE unit: 3.6 m x 2.5 m x 2.0 m below incoming invert level
6 – 10 PE unit: 3.0 m x 3.0 m x 2.2 m below incoming invert level.

2 The base of the excavation to be level and free from projecting hard points eg rock or boulders. Voids and soft spots to be removed. A level bed of approximately 200mm sand, gravel or broken stone is preferred. If necessary e.g. in poor ground, a firm level concrete base is to be provided. The concrete to be of suitable grade (minimum 35N), and thickness, (minimum 150 mm).

3. The tank to be lowered onto excavation base, by Carlow Precast Tanks, and checked for line and level. If adjustments are required, the tank to be removed from the excavation and placed in a safe position on level ground. Adjustments to be carried out by the Customers operatives. No work to be carried out beneath a suspended tank.

When the tank is level, and in line with the incoming drain and the distribution chamber, lifting devices to be removed and backfilling can commence.

4. Care to be taken to prevent damage to external flanges or pipe work. Access covers to be in place at all times, and the unit to be ballasted, during backfilling.

5. Backfilling to commence as soon as possible after placement, using selected self-compacting pea gravel or suitable granular material, (compaction factor of 0.2 or less, all rocks and large stones removed). Suitable excavated material may be used ie compactable and free from large stones and cobbles. Backfill in layers not exceeding 600mm depth and lightly compact each layer, taking care not to damage the tank. The backfilling should be scheduled to permit connection of drainage pipe work. The unit is designed for a maximum of 800mm overburden.

6 In the event of damage to any element of the chamber, lid, manhole cover or connections, the certificate holder should be contacted and an appropriate repair method developed. In an extreme case, effective repair may be impractical and Carlow Precast Tanks may direct that the tank should be replaced.

4 A dry site is defined as one where the local water table never rises above the base of the treatment unit.

c) Additional requirements for wet sites[5]

Installation in a wet site may be precluded by site considerations in relation to effluent disposal.

7. A 250 mm hardcore sub-base is laid, compacted and levelled.

8. The excavation is kept dry by pumping excess water using a site pump/sump hole/suction hose arrangement. De-watering should be continued for as long as necessary and at least until the concrete has set.

9. The excavation is then lined with a continuous layer of 1200 gauge polyethylene sheet. The installation should then continue in accordance with the requirements for dry sites. The grade and thickness of the concrete base should be designed to suit site conditions (minimum 250 mm thick, grade 35N).

10 Where a high groundwater level is expected, the tank may be temporarily filled with water to eliminate risk of floatation. Carlow Precast Tanks can advise on provision of permanent anti-floatation measures if necessary.

d) Drainage Connections
The tank is provided, at the inlet and outlet, with the necessary connections (see Table 1). These should be connected, via a flexible connection to allow for differential movement, (eg 300mm length of pipe with flexible joints), to the drainage system. Suitable adapters shall be used for connection to other types of pipe work.

e) Ducting
Where necessary to protect the electrical suply cable, a 100 mm uPVC duct should be laid from the marked connection point on the unit to the power supply.

f) Completion of backfilling
When connections to drainage pipe work are complete and ducting in place, continue backfilling, terminating approximately 200 mm below ground level. The remaining backfilling should be completed to ground level, using selected non-angular excavated material or topsoil.

2.5 LOCATION

The units should be sited so that adequate access is available for safe installation, subsequent maintenance and de-sludging of the unit. De-sludging should be carried out by means of a de-sludging tanker, which requires access to within 30m of the unit. The separation distances given in the EPA manual apply unless otherwise agreed with the Local Authority.

2.6 TREATED WASTE WATER DISPOSAL

The treated wastewater is to be disposed of in accordance with the EPA manual, and any relevant planning conditions

2.7 DESIGN FOR PLANT MALFUNCTION

2.7.1 Alarm
An audible and visual alarm is supplied to indicate power failure, compressor breakdown or high water levels.

2.7.2 Storage provision - plant malfunction
The minimum storage volumes available in the event of plant malfunction, are given in Table 2.

[5] *A wet site is defined as one where the local water table can rise above the base of the treatment unit.*

2.8 COMMISSIONING/FIRST SERVICE

2.8.1 Certificate holder's Responsibilities
Carlow Precast Tanks shall carry out commissioning of the unit, in the factory prior to dispatch. Commissioning shall include the following:

- Checking that all control unit and **CPT Zons® AQUAstar® kit** settings, including orientation of the aeration pipe, are correct;
- Performing a test run to check unit is functioning correctly;
- Recording serial numbers etc;

After installation, Carlow Precast Tanks operative will:

- Commission the unit and issue a commissioning report. Copy to be given to the client, with a copy of the ***CPT Zons® AQUAstar® SBR*** *Operation and Maintenance manual* , ***CPT Zons® AQUAstar® SBR*** *Installation and Operation Guide for* ***MULTICOM® 100 and CPT warranty****.*

2.8.2 End User Responsibilities
The end user is responsible for

- ensuring that the tank has been correctly and safely connected to a power supply and contains sufficient water to enable start up (water level should be at least 200mm above base of the **CPT Zons® AQUAstar® kit;**
- contacting Carlow Precast Tanks to notify when operation of the system commences ;
- informing Carlow Precast Tanks if there are any differences between the design basis and the current operational requirements eg population served (PE)

Note: The certificate holder recommends the system is primed as per CL 3.2.3.

2.9 SERVICING AND MAINTENANCE

2.9.1 End User Responsibilities
The end user is responsible for ensuring that the system:

- is operated in accordance with the design conditions;
- is maintained correctly by 'competent persons';
- is de-sludged at regular intervals in accordance with the Certificate holder's instructions
- does not cause pollution to soil or ground water;
- does not constitute a health or safety hazard.

2.9.2 Certificate holder's Responsibilities
The Certificate holder should:

- offer service and maintenance contracts by 'competent persons';
- have the facility to carry out repair work if required.

The service, which should only be carried out by trained personnel, includes checking:

- history/functioning of the **MULTICOM® 100** control unit and alarm signals;
- all mechanical and electrical parts necessary for plant operation including pumps, valves, gas warning system and float switch;
- sludge content in the activation chamber (Target value 250 to 500 ml/l) and adjusting running time of sludge return pump if necessary;
- Visual inspection of effluent in sample bottle; checking of oxygen content (required >1ml/l); checking pH value (target value 7 – 8) and temperature; check suspended solids (required value < 0.1 ml/l). If required, a sample should be removed for laboratory testing;
- Sludge content in primary chambers (should not exceed 50% of total volume). Where desludging

is required, the end user shall arrange for sludge disposal
- Removal of AQUAstar unit and general cleaning of components;
- When necessary, perform a smoke test to establish adequacy of ventilation.

A maintenance report, summarising the condition of the system and identifying any actions required, will be copied to the end user.

2.10 ENCLOSURE

The area around the tank and polishing filter should be fenced off to protect it from farm animals and other unwanted traffic.

Part Three / Design Data 3

3.0 DESIGN

3.1 GENERAL

The **CPT Zons® AQUAstar®** Wastewater Treatment System is suitable for the collection and treatment of domestic wastewater and shall be designed, installed, operated and maintained in accordance with the Certificate holder's instructions, the EPA *Wastewater treatment manual – Treatment Systems for Single Houses 2000* and this certificate. The conditions given below apply:

a) Design and selection of the wastewater treatment unit shall be carried out by a '**competent person**' eg an appropriately qualified and experienced engineer, based on an adequate assessment of all relevant information and having regard to the population served and the influent to be treated.

b) The potential suitability of a site, for the installation of such a system, shall be assessed using the methodology outlined in the EPA *Wastewater treatment manual – Treatment Systems for Single Houses 2000*.

c) The system should only be installed in suitable ground conditions ie where a 'competent person' determines the ground conditions, and water table levels, are adequate to support the tank, and to provide for disposal of the effluent in accordance with relevant regulations. If poor ground conditions prevail, e.g. soft ground or shrinking clay, further advice must be sought from a 'competent person'.

d) Ground water and flood levels shall always be below outlet level and the area should not be subject to localised flooding.

e) Adequate provision should be made for access, inspection and maintenance, in the drainage system upstream and downstream of the system, through the provision of manholes, distribution chambers etc.

f) Adequate provision shall be made for ventilation, to ensure that noxious odours and dangerous gases can escape from the system.

g) Storm water run-off e.g. from roofs or paved areas shall be excluded from the system.

h) Good ground working practice shall be followed. Pipe gradients should be in accordance with the EPA manual.

i) The effluent shall be discharged to a suitable polishing filter, designed by a 'competent person', taking into consideration all relevant design information e.g. the detailed site assessment report.

j) The unit shall be sited and installed in accordance with the Certificate holder's instructions, this Certificate, the Building Regulations 1997 – 2007 and any relevant planning conditions. It is recommended that a 'competent person' supervise the installation of, and commission the system.

k) The Certificate holder is in a position to provide the user with the knowledge and competencies necessary to enable compliance with the Building Regulations in all respects, including permitted influent and conditions of use, installation, maintenance and de-sludging requirements, design and installation of the polishing filter and recommendations regarding monitoring.

l) Discharge to the unit should not exceed the design loadings and is limited to domestic effluent. This excludes rainwater, run off from paved areas or areas where animals are housed, effluent with high grease, oil, chlorine or offal content, discharge from garbage grinders or water softeners, Jacuzzis/hot tubs, rags, medicines, pesticides, oil, strong acids alkalis, biological emulsifiers, disinfectants or chemicals/poisons. If necessary, the certificate holder should be contacted for advice.

m) The end user is responsible for ensuring that influent, usage and discharge comply with national and local regulations. The effluent from the unit will normally be within Royal Commission Standard (i.e. suspended solids content less than 30 mg per litre and Biochemical Oxygen Demand (BOD) less than 20 mg per litre) provided that the hydraulic and BOD loadings are within the limits recommended by the Certificate holder for the unit installed (180 litres per head per day and 60g per head per day, respectively).

n) The system should be indelibly marked with the model type and population equivalent such that details are readily available to the householder, for future reference.

o) The Certificate holder or his agent shall maintain detailed records as appropriate e.g. site assessment records, design calculations, percolation test results, commissioning records, installation locations, customer complaints etc.

p) If there is a concern regarding the suitability of the treatment unit for a particular application, the Certificate holder should be contacted for advice.

The Certificate holder recommends:

a) The use of a grease trap between the dwelling and the unit;
b) The use of phosphate free detergents.

3.2 DESIGN BASIS

3.2.1 Structural design

The relevant structural design assumptions and loading conditions are given in Table 1.

3.2.2 Biological Processes - design

The relevant biological design assumptions and loading conditions are given in Table 2. The expected effluent quality and treatment efficiencies are given in Table 5.

3.2.3 Biological Processes - Start up period

A short period of acclimatisation is required after use commences, before the system is fully functioning. This period is generally a few weeks and is normal for any biological treatment plant. The Certificate holder recommends the system is charged by injecting 30 litres of activated sludge (per person) into the activation chamber to accelerate the growth of activated sludge.

Table 5. Wastewater characteristics and treatment efficiency

Parameter	Limits[1]	Mean[2]	MinimumTreatment Efficiency[1,3]
pH	6-9	7.6	n/a
BOD_5 (mg O_2/l)	< 20	11	>85%
Suspended Solids (mg O_2/l)	< 30mg/l	16	>60%
NH_3-N (mg/l)	<10mg/l	0.8	-

Note 1 Wastewater treatment performance standards are taken from Table 2 of EPA Code of Practice Wastewater Treatment Systems for single houses (P.E. <10) Consultation Draft 2007.
Note 2 Data derived from *Prüfinstitut für Abwassertechnik-RWTH Aachen Final Test Report for RHEBAU Zons Aquastar SBR System* September 2004 and testing carried out on systems operating in Ireland.
Note 3 Data examined indicates that the **CPT Zons® AQUAstar® System** can achieve treatment efficiencies significantly in excess of these values, for design loadings.

Part Four / Technical Investigations 4

4.1 ENVIRONMENTAL ASSESSMENT

The biological treatment performance of the **CPT Zons® AQUAstar®** Wastewater treatment system has been assessed using the following information

- PIA RWTH testing of **Rhebau Zons® AQUAstar®** system for 6 PE in accordance with EN 12566-3;
- Calculations to DIN 4261-2;
- Insitu testing of **CPT Zons® AQUAstar®** Wastewater Treatment System for Single Dwellings.

The assessment concluded that the values stated for the parameters listed in Table 5 are consistently achievable over a range of operating conditions, providing the unit is designed, operated and installed in accordance with this Certificate.

4.2 STRENGTH

The Certificate holder's design has been assessed as satisfactory for the loading conditions specified in Table 1. The unit has adequate strength to resist damage from minor impacts during handling but it shall be lifted in accordance with the Certificate holder's instructions.
The cover and frame assembly is suitable for pedestrian traffic only.

4.3 WATERTIGHTNESS

The system, when correctly installed, has been assessed as fully capable of preventing seepage either into or from the surrounding soil. The pipe joints, when correctly made, will be watertight.

4.4 DURABILITY

In the opinion of the IAB the product will have a life in excess of 50 years when installed in accordance with this Certificate. The mechanical and electrical components will require replacement within the design life.

4.5 MAINTENANCE

4.5.1 General

Carlow Precast Tanks strongly recommends that access to the tank interior be restricted to, and all maintenance work be carried out by, Carlow Precast Tanks trained operatives or authorised and competent maintenance contractors.

Cleaning and maintenance should be carried out in accordance with ***CPT Zons® AQUAstar® SBR*** *Operation and Maintenance Manual*.

The **CPT Zons® AQUAstar®** kit can be readily accessed for cleaning and maintenance. Access to the tank interior is via the access covers.

4.5.2 Frequency of inspection

The homeowner should:

- inspect of the system regularly, in accordance with the ***CPT Zons® AQUAstar® SBR*** *Operation and Maintenance Manual*.
- Monitor effluent to ensure ongoing compliance.

4.5.3 De-sludging

The frequency of desludging should be in accordance with the recommendations of Carlow Precast Tanks maintenance personnel and the ***CPT Zons® AQUAstar® SBR*** *Operation and Maintenance Manual*.

The primary chamber of the **CPT Zons® AQUAstar®** system is de-sludged, in the conventional manner, using a suction tanker. De-sludging and sludge wasting should be carried out in accordance with the Certificate holder's instructions and health and safety requirements.
Care shall be taken to avoid damage, to the tank or system components, during de-sludging.

4.6 SAFETY

4.6.1 Safety of personnel

The access covers weigh approximately 40Kg and should be lifted with care. The access covers should not

be left off an unattended tank.

Wastewater treatment plants are potentially dangerous, particularly when being de-sludged. De-sludging shall never be carried out alone. If it is necessary to enter the unit, adequate safety precautions shall be made to ensure the safety of personnel involved. Naked lights, which can cause explosions, shall not be used in the vicinity of the tanks.

4.6.2 Safety of unit

The unit should be positioned, or marked, or protected, to prevent superimposed loading or accidental impact by vehicles.

4.7 TESTS AND ASSESSMENTS

Tests and assessment were carried out to determine the following:

- Water tightness.
- Strength of cover assemblies.
- Resistance of units to hydrostatic and ground pressure.
- Resistance to lifting forces
- Resistance to flotation.
- Environmental performance.
- Concrete cube strength

4.8 OTHER INVESTIGATIONS

(i) The manufacturing process was examined including the methods adopted for quality control, and details were obtained of the quality and composition of the materials used.

(ii) An analysis of test results from samples of effluent was undertaken.

(iii) An assessment of the tank was made in relation to degradation of mechanical properties owing to exposure to sewage, ground water, dissolved salts and dilute acids or alkalis; long-term loading conditions.

(iv) Site visits were conducted to assess the practicability of installation

(v) Bought in components were assessed for suitability for use.

No failures of the product in use have been reported to the IAB.

Part Five / Conditions of Certification 5

5.1 National Standards Authority of Ireland ("NSAI") following consultation with the Irish Agrément Board ("IAB") has assessed the performance and method of installation of the product/process and the quality of the materials used in its manufacture and certifies the product/process to be fit for the use for which it is certified provided that it is manufactured, installed, used and maintained in accordance with the descriptions and specifications set out in this Certificate and in accordance with the manufacturer's instructions and usual trade practice. This Certificate shall remain valid for five years from date of issue so long as:

(a) the specification of the product is unchanged.

(b) the Building Regulations 1997 to 2007 and any other regulation or standard applicable to the product/process, its use or installation remains unchanged.

(c) the product continues to be assessed for the quality of its manufacture and marking by NSAI.

(d) no new information becomes available which in the opinion of the NSAI, would preclude the granting of the Certificate.

(e) the product or process continues to be manufactured, installed, used and maintained in accordance with the description, specifications and safety recommendations set out in this certificate.

(f) the registration and/or surveillance fees due to IAB are paid.

5.2 The IAB mark and certification number may only be used on or in relation to product/processes in respect of which a valid Certificate exists. If the Certificate becomes invalid the Certificate holder must not use the IAB mark and certification number and must remove them from the products already marked.

5.3 In granting Certification, the NSAI makes no representation as to;

(a) the absence or presence of patent rights subsisting in the product/process; or

(b) the legal right of the Certificate holder to market, install or maintain the product/process; or

(c) whether individual products have been manufactured or installed by the Certificate holder in accordance with the descriptions and specifications set out in this Certificate.

5.4 This Certificate does not comprise installation instructions and does not replace the manufacturer's directions or any professional or trade advice relating to use and installation which may be appropriate.

5.5 Any recommendations contained in this Certificate relating to the safe use of the certified product/process are preconditions to the validity of the Certificate. However the NSAI does not certify that the manufacture or installation of the certified product or process in accordance with the descriptions and specifications set out in this Certificate will satisfy the requirements of the Safety, Health and Welfare at Work Act 2005, or of any other current or future common law duty of care owed by the manufacturer or by the Certificate holder.

5.6 The NSAI is not responsible to any person or body for loss or damage including personal injury arising as a direct or indirect result of the use of this product or process.

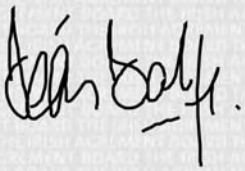
5.7 Where reference is made in this Certificate to any Act of the Oireachtas, Regulation made thereunder, Statutory Instrument, Code of Practice, National Standards, manufacturer's instructions, or similar publication, it shall be construed as reference to such publication in the form in which it is in force at the date of this Certification.

The Irish Agrément Board

This Certificate No. **08/0318** is accordingly granted by the NSAI to **Carlow Precast Tanks** on behalf of The Irish Agrément Board.

Date of Issue: **26th May 2008**

Signed



Seán Balfe
Director, Irish Agrément Board

Readers may check that the status of this Certificate has not changed by contacting the Irish Agrément Board, NSAI, Santry, Dublin 9, Ireland. Telephone: (01) 807 3800. Fax: (01) 807 3842. www.nsai.ie

CARLOW PRECAST
Concrete Engineering

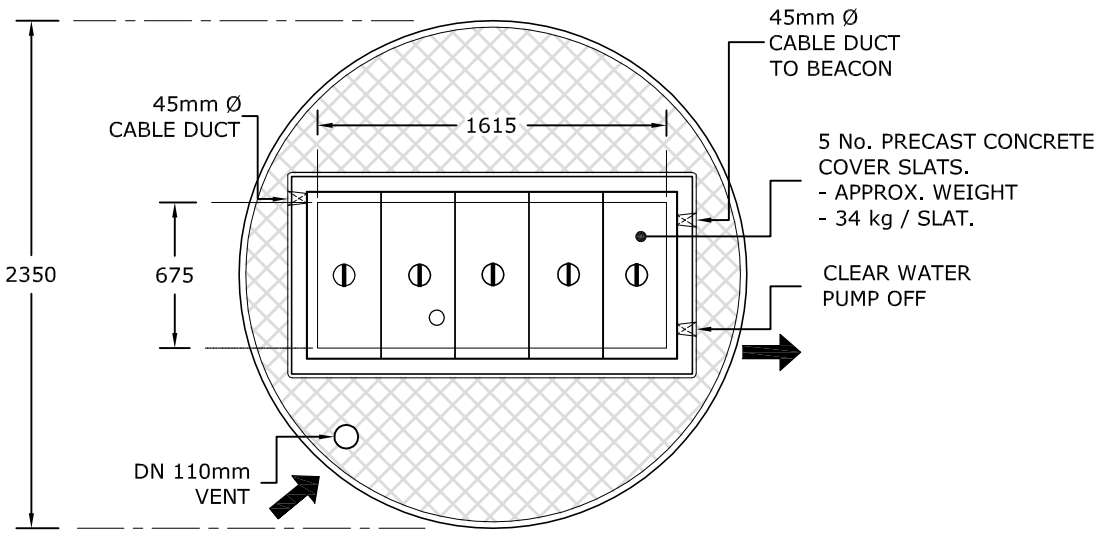
DRAWING TITLE:
AQUA STAR
6-10 PT-SYSTEM
6.8m³ (1500 GALLON) TANK
GENERAL LAYOUT
SHEET 1 OF 1

Drawn By: T. Armstrong

Date: 26/08/10

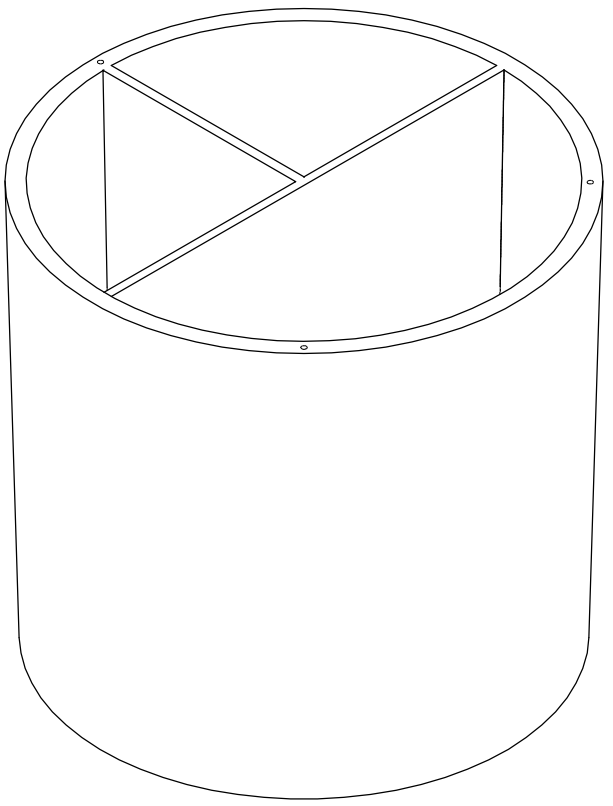
Revision: D

6 - 10 PE system - 1500 gallon tank

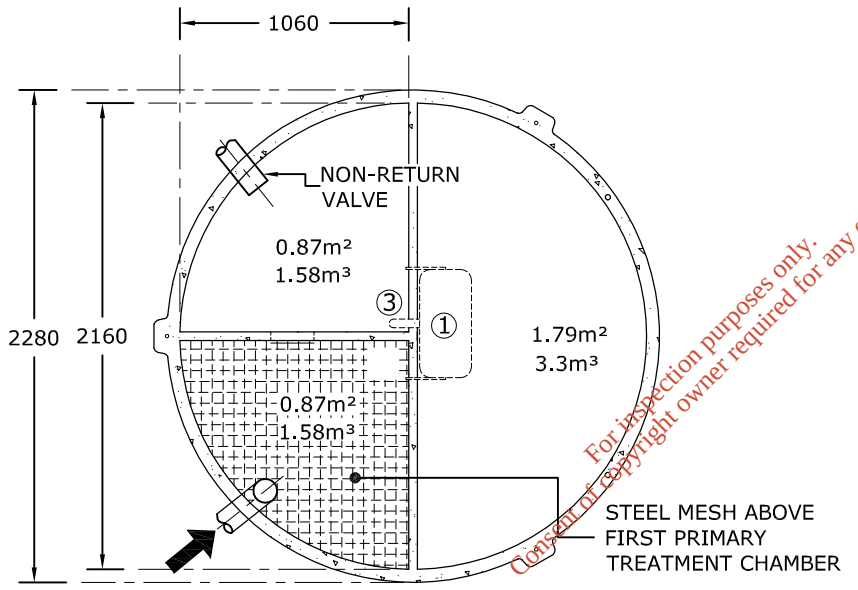


PLAN VIEW - PRECAST CONCRETE LID:
SCALE 1:35

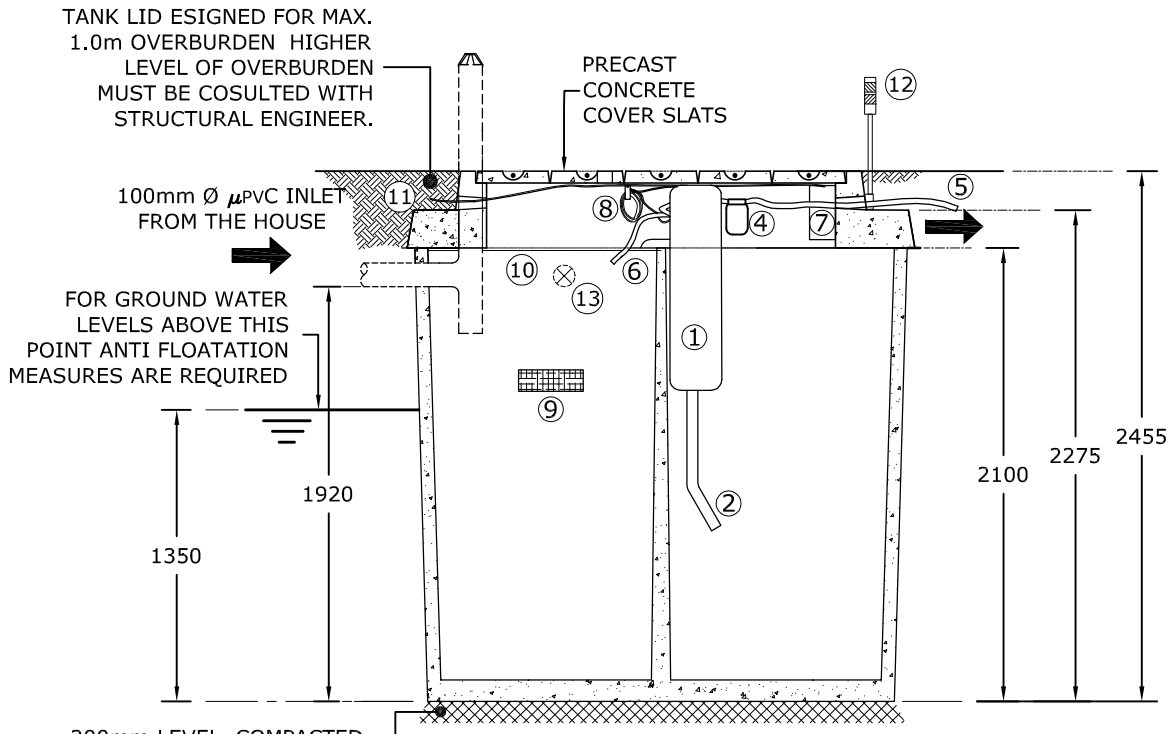
Standard tank weight
4.30 tonnes without lid,
6.30 tonnes including lid.



ISOMETRIC VIEW:



PLAN VIEW - PRECAST CONCRETE TANK:
SCALE 1:35



STANDARD 1500 GALLON SYSTEM - SECTION:
SCALE 1:35

1 - AQUAstar KIT
2 - AERATION PIPE
3 - FEEDING PIPE
4 - SAMPLING BOTTLE
5 - CLEAR WATER OUTLET
6 - RETURN SLUDGE HOSE
7 - MULTICOM CONTROL PANEL
8 - WINDED CABLE
9 - OPENING BETWEEN PRIMARY TREARMENT CHAMBER WITH STEEL MESH
10 - STEEL MESH ABOVE FIRST PRIMARY TREATMENT CHAMBER
11 - POWER SUPPLY 3 CORE 2.5 SWA OUTDOOR CABLE (BY CUSTOMER)
12 - ALARM BEACON (WITH GREEN AND RED LED)
13 - 100mm Ø NON-RETURN VALVE

Appendix D.1.3

Report Re. Suitability of the Site for an Onsite Domestic Effluent Treatment Plant

SITE SUITABILITY REPORT

Please note that the following Site Suitability Report was completed on 29/01/2008 for the purpose of a Planning Application to Fingal County Council. At the time this Site Suitability Report was completed the facility was licensed to Murphy Concrete Manufacturing Limited; however the licence was transferred to Murphy Environmental Hollywood Ltd. (MEHL) on 1/10/2008.

WASTE WATER MAINTENANCE LTD.
D2 Tougher Business Park, Newhall, Naas, Co. Kildare.
Tel: 045 447585/447584. Fax: 045 447584. Email: info@wastewater.ie

SITE SUITABILITY REPORT

Test Compiled By: Waste Water Maintenance
Planning Reference Number: Not Available
Job No: 1977
29/01/08

NAME: Murphy Concrete Manufacturing Ltd.
SITE: Hollywood, Naul, Co. Dublin
Water / Bedrock below ground level: Ground made up from shale fragments from quarry
Average T-Value: <1
Average P-Value: 11
Soil Type: Gleys
Sub Soils: Namurian Rocks-shales & sandstones
Bedrock Type: Dinantian Upper Impure Limestones
Aquifer Type: Locally Important Aquifer-Bedrock which is Generally Moderately Productive
Vulnerability Class: High - Extreme
Ground Water Protection Response: R2(1)
Important Surface Features: Quarry – Limestone & shales

SITE CONDITIONS FROM ABOVE INFORMATION:
The site should be suitable for an on-site sewage system using a partially raised soil mound polishing filter provided good practice is adhered too.

RECOMMENATIONS:

The site is suitable for an advanced treatment system discharging the effluent to a constructed partially raised polishing filter. The mound may be constructed using the top soils on site provided they are similar to those in the tested area i.e. P>1<20. The soils in the proposed percolation area should be scraped before constructing the mound which should be built to a minimum height of 1.0m above existing ground level to allow for a minimum separation distance of 0.9m of suitable soils below the percolation trenches and the shale at all times as added protection to the groundwater/aquifer. The top of the percolation trenches should start from 0.3m below the surface of the mound. The system must be constructed as per the EPA 2000 Wastewater Treatment Manual 4.11 Soil Polishing Filters (see appendix).

The percolation pipes should be rigid pipe not land drainage pipe and there should be a minimum distance of 0.9m of soil between the bottom of the percolation trench and water table or bedrock at all times. The trenches have to be 450mm wide with 2.45m between the centres of the pipes.

Where soils with a T-value >1<20 are used it will be necessary to install 150 linear metres of percolation pipe in the polishing filter. No single length of trench should exceed 20m, therefore the required length of trench must be constructed as a series of shorter trenches.

COMMENTS: This site is suitable for an advanced treatment system e.g. Oakstown sewage treatment plant serving up to 15 staff as long as the above recommendations are adhered too.

If you would like any further information on treatment plants please contact the office.

Regards,

Aidan Comerford
Director

EPA: SITE CHARACTERISATION FORM

(As downloaded from K.K.C. Website)

1.0 GENERAL DETAILS (From planning application)

NAME & ADDRESS OF APPLICANT:	Murphy Concrete Manufacturing Ltd Hollywood, Naul, Co. Dublin				
SITE LOCATION AND TOWNLAND:	Hollywood, Naul, Co. Dublin				
TELEPHONE NO:	c/o Ken Rooney 087-9824322	FAX NO:		E-MAIL:	
MAXIMUM NO. OF RESIDENTS:	Quarry Offices 10-15 Full Time Staff. Canteen-No Cooking	NO. OF DOUBLE BEDROOMS:	n/a	NO. OF SINGLE BEDROOMS:	n/a
PROPOSED WATER SUPPLY: (tick as appropriate)	Mains ✓	private well/borehole		group well/borehole	

2.0 DESK STUDY

SOIL TYPE	Gleys	Other (specify)	AQUIFER CATEGORY	Regionally Important	Locally Important ✓	Poor	
VULNERABILITY	Extreme ✓	High ✓	Moderate	Low	High to Low	Unknown	
BEDROCK	Dinantian Up Impure Lime	Name of Public/Group Scheme Water Supply within 1 km					
Is there a GSI Groundwater Protection Scheme? (Y/N):	Yes	Groundwater Protection Response:	R2(1)	Source Protection Area (None)	SI No	SO No	
Presence of significant sites (archaeological, natural & historical):	None within 150m						
Past experience in the area:	Shale sub soils – fast soakage						

Comments: The soil type suggests possible Clay soils and poor soakage. Groundwater is a target. There is high shale content in area (Quarry) and past experience shows fast percolation rates in sub soils.

NOTE: Only existing information available at the desk study stage should be used in this section

3.0 ON-SITE ASSESSMENT

3.1 Visual Assessment

LANDSCAPE POSITION:	**Back Slope**	**SLOPE:**	STEEP (>1:5)	SHALLOW (1:5-1:20) √	RELATIVELY FLAT (<1:20)

SURFACE FEATURES (Distance to features should be noted in metres)	
HOUSES:	SE>80m SW>120m, Farm to E>200m
SITE BOUNDARIES:	Electric fencing, briar, trees, Quarry to the north & western boundaries
ROADS:	Minor road runs along the southern boundary > 72m
EXISTING LAND USE:	Boundary field to quarry edge (Buffer)
OUTCROPS (ROCK AND/OR SUBSOIL):	None noted within field. Shale noted on banks of ditch/stream edge of quarry. Some broken shale on field.
SURFACE WATER PONDING:	None within 150m (Old Quarry lies to SW of site holds water in pond like area – up gradient and isolated)
LAKES:	None within 150m
BEACHES/SHELLFISH AREAS/WETLANDS:	None within 150m
KARST FEATURES:	Shale & Limestone quarry 40m north & >100m west
WATERCOURSE/STREAM*:	Stream/drainage ditch runs along northern boundary > 38m
DRAINAGE DITCHES*:	Northern boundary >38m
WELLS*:	None within 100m. Groundwater monitoring sump 72m NNE corner of site.
SPRINGS*:	None noted within 150m
VEGETATION INDICATORS:	Trees, briar, grass, occasional thistles, gorse & weeds
GROUND CONDITION:	Firm underfoot

- **COMMENTS:**

No indications of drainage problems on the site which is firm underfoot with no ponding noted. Stream / surface waters is a target but is located 40m from proposed test location. Low density of houses in the area.

3.2 Trial Hole

Trial Hole should be a minimum of 2.1 m deep (3m where have regionally important aquifers)

Depth of trial hole (m):	**1.8m**	**Date and time of excavation:**	**24/01/07**	**Date and time of examination:**	**29/01/07**
Depth from ground surface to bedrock (m) (if present):		Shale encountered from 0.8m & Limestone noted at 1.7/8m			
Depth from ground surface to water table (m) (if present):		Not encountered at time of testing			

	Soil/Subsoil Texture & Classification**	Soil Structure	Density/ Compactness	Colour ***	Preferential flowpaths
0.1 m	SILT/CLAY 0-0.3m	Crumb	Firm	Brown	Rootlets
0.2 m	Threads 8 Rib 100mm Dilates slowly				
0.3 m					
0.4 m					
0.5 m	SILT with some shale	Blocky	Firm	Reddish	Random
0.6 m	0.3-0.8m				
0.7 m	Threads 6 Rib 80-90mm Dilates				
0.8 m					
0.9 m					
1.0 m	SILT/CLAY				
1.1 m	With high shale content	Blocky	Firm	Light Brown	Random
1.2 m	0.9-1.4m				
1.3 m	Threads 8/9 Rib 100/110mm				
1.4 m	Dilates slowly				
1.5 m		Blocky	Soft/Loose	Reddish Brown	Random
1.6 m					
1.7 m	SILT with shale				
1.8 m	1.4 – 1.7m				
1.9 m	Threads 5/6 Rib 60/70mm Dilates				
2.0 m	Limestone at 1.7/8m				
2.1 m					
2.2 m					
2.3 m					
2.4 m					
2.5 m					

Other information

Depth of water ingress:	**None noted**	**Rock type (if present):**	**Shale & Limestone**	**Plasticity and dilatancy results:**	See above	**Likely T value:** <5

EVALUATION: T-value expected to be low i.e. fast percolation expected due to the high shale content in the sub soils.

** See Appendix E for BS 5930 classification
*** All signs of mottling should be recorded
Note: Depth of percolation test holes should be indicated on diagram above.

3.3 **(a) Percolation ("T") Test @ Invert of Percolation Pipe or relevant subsoil layer**

Percolation Test Hole	1	2
Depth from ground surface to top of hole (mm) (A)	1000mm	800mm
Depth from ground surface to base of hole (mm) (B)	1400mm	See Below Comments
Depth of hole (mm) [B - A]	400	
Dimensions of hole [length x breadth (mm)]	300x300	

Each hole must be pre-soaked twice before the test is carried out (from 10.00 am to 5.00 pm and from 5.00 pm to next morning)

Date of test	29/01/07	
Date pre-soaking started	28/01/07	
Time filled to 400 mm	09:05	
Time water level at 300 mm	All water dispersed in <1minute	

Percolation Test Hole No.	1			2		
Fill no.	Start Time (at 300 mm)	Finish Time (at 200 mm)	Δt (min)	Start Time (at 300 mm)	Finish Time (at 200 mm)	Δt (min)
1						
2						
3						
Average Δt				Average Δt		
Average Δt/4 = [Hole No.1] __40_(t_1)				Average Δt/4 = [Hole No.2] __41_(t_2)		

T value* = $(t_1 + t_2)/2$ = __40___(min/25 mm)

Result of Test : T = <1 Water disperses in sub soils in <1 minute.

COMMENTS: Attempted T test but very fast percolation in the sub soils. A partially raised mound filter will be required to slow down the effluent to provide suitable treatment before discharging to groundwater.

- If two very different T test results are obtained and where one of these values fails then a third test should be carried out to determine the representivity of each of the results.

3.3 (b) Percolation ("P")Test @ Ground Level

Percolation Test Hole	1	2
Depth of hole from ground surface (mm)	400	400
Dimensions of hole [length x breadth (mm)]	300X300	300X300
Each hole must be pre-soaked twice before the test is carried out (from 10.00 am to 5.00 pm and from 5.00 pm to next morning)		
Date of test	29/01/08	29/01/08
Date pre-soaking started	28/01/08	28/01/08
Time filled to 400 mm	08:56	08:57
Time water level at 300 mm	09:02	09:15

Percolation Test Hole No.	1			2		
Fill no.	Start Time (at 300 mm)	Finish Time (at 200 mm)	Δp (min)	Start Time (at 300 mm)	Finish Time (at 200 mm)	Δp (min)
1	09:02	09:09	7	09:15	09:33	18
2	09:09	09:17	8	09:33	09:54	21
3	09:17	09:25	8	09:54	10:21	25
Average Δp			23	Average Δp		64
Average Δp/4 = [Hole No.1] _5.75(p_1)				Average Δp/4 = [Hole No.2] _16(p_2)		

P value* = $(p_1 + p_2)/2$ = 10.87(min/25 mm)

Result of Test : P = 11

COMMENTS: Top soils should be suitable for the treatment of effluent.

- If two very different P test results are obtained and where one of these values fails then a third test should be carried out to determine the representivity of each of the results

4.0 CONCLUSION of SITE CHARACTERISATION:

(*Integrate the information from the desk study and on-site assessment (i.e. visual assessment, trial hole and percolation tests) above and conclude the type of system(s) that is (are) appropriate. This information is also used to choose the optimum final disposal route of the treated wastewater).*

Suitable for (delete as appropriate)****:

(a) septic tank and soil percolation system ✓

(b) septic tank and intermittent filter system and polishing unit; or septic tank and constructed wetlands and polishing unit. ✓

(c) mechanical aeration system and polishing unit ✓

****note:** ***more than one option may be suitable for a site and this should be recorded***

and

SUITABLE for discharge to **groundwater**

5.0 RECOMMENDATION:

Propose to install: **An Oakstown BAF Advanced Sewage Treatment System and constructed raised mound polishing filter (percolation area)**

and discharge to groundwater

Conditions (if any) e.g. special works, invert level of septic, site improvement works testing etc.....

A raised mound polishing constructed to a minimum height of 1.0m above existing ground level using the top soils on site from the tested area provided they are similar to those tested i.e. P>1<20. The soils in the proposed area of the mound should be scraped before building the mound.

Signed: _____

Aidan Comerford
Dip. SEA/ EIS Mgmt
FAS/EPA trained site assessor

6.0 TREATMENT SYSTEM DESIGN DETAILS

System Type?	**Oakstown BAF Sewage Treatment System 5000Lites**	**Proposed Discharge route?**	Surface water	Groundwater ✓
Size of Proposed Treatment System?	Primary **Mechanical aeration system**	Secondary Treatment System Capacity (m^3)	Polishing filter (State units - m or m^2)* • ***150m***	
What Quality Assurance is proposed during the following?	Installation & Commissioning Client to appoint compentent installer and comply with conditions set out in EPA guidelines		On-going Maintenance Regular (annual) maintenance of mechanical aeration system.	

*** the calculated percolation area or polishing filter area should be shown on site plan**

7.0 REVIEW (by Local Authority)

Site visit	☐	Date:
Inspection of Trial Hole	☐	Date:
Inspection of Percolation Test Holes	☐	Date:
COMMENTS		
SIGNED:		Date:

Separtation Tables

Where an on-site system is in the zone of contribution of a well, the likelihood of contamination and the threat to human health depend largely on five factors.

- The thickness and permeability of subsoil beneath the invert of the percolation trench;
- The permeability of the bedrock, where the well is tapping the bedrock;
- The distance between the well or spring and the on-site system;
- The groundwater flow direction; and
- The level of treatment of effluent.

Table 3 Recommended Minimum Distance between a Receptor and a Percolation Area or Polishing Filter

			Minimum distance (m) from receptor to percolation area or polishing filter ****				
T or P Value	**Type of soil/subsoil ***	**Depth of soil/subsoil (m) above bedrock (see note 1,2,3,6)**	***Public Water Supply***	***Karst Feature***	***Down-gradient Domestic well or flow direction is unknown (see note 5)***	***Domestic well alongside (no gradient)***	***Up-gradient domestic well***
>30	CLAY; silty, sandy CLAY (e.g. clayey till) CLAY/SILT	1.2 >3.0	60	15	40 30	25	15
10 – 30	Sandy SILT; Clayey, silty SAND; clayey, silty GRAVEL (e.g. sandy till)	1.2 >8.0	60	15	45 30	25	15
< 10	SAND; GRAVEL; silty SAND	2.0 ** 2.0 *** >8.0 ***	60	15	60 40 30	25	15

* BS5930 descriptions

** water table 1.2-2.0m

*** water table >2.0m

**** The distance from the percolation area or polishing filter means the distance from the periphery of the percolation area or polishing filter and not the centre.

TABLE 4: MINIMUM SEPARATION DISTANCES IN METRES

Type of system	Watercourse stream	Lake	Any Dwelling	Site boundary	Road	Slope breaks/cuts
Septic tank; Prefabricated intermittent filters; mechanical aeration systems	10	50	7	3	4	4
In situ intermittent filters; percolation area; polishing filters	10	50	10	3	4	4

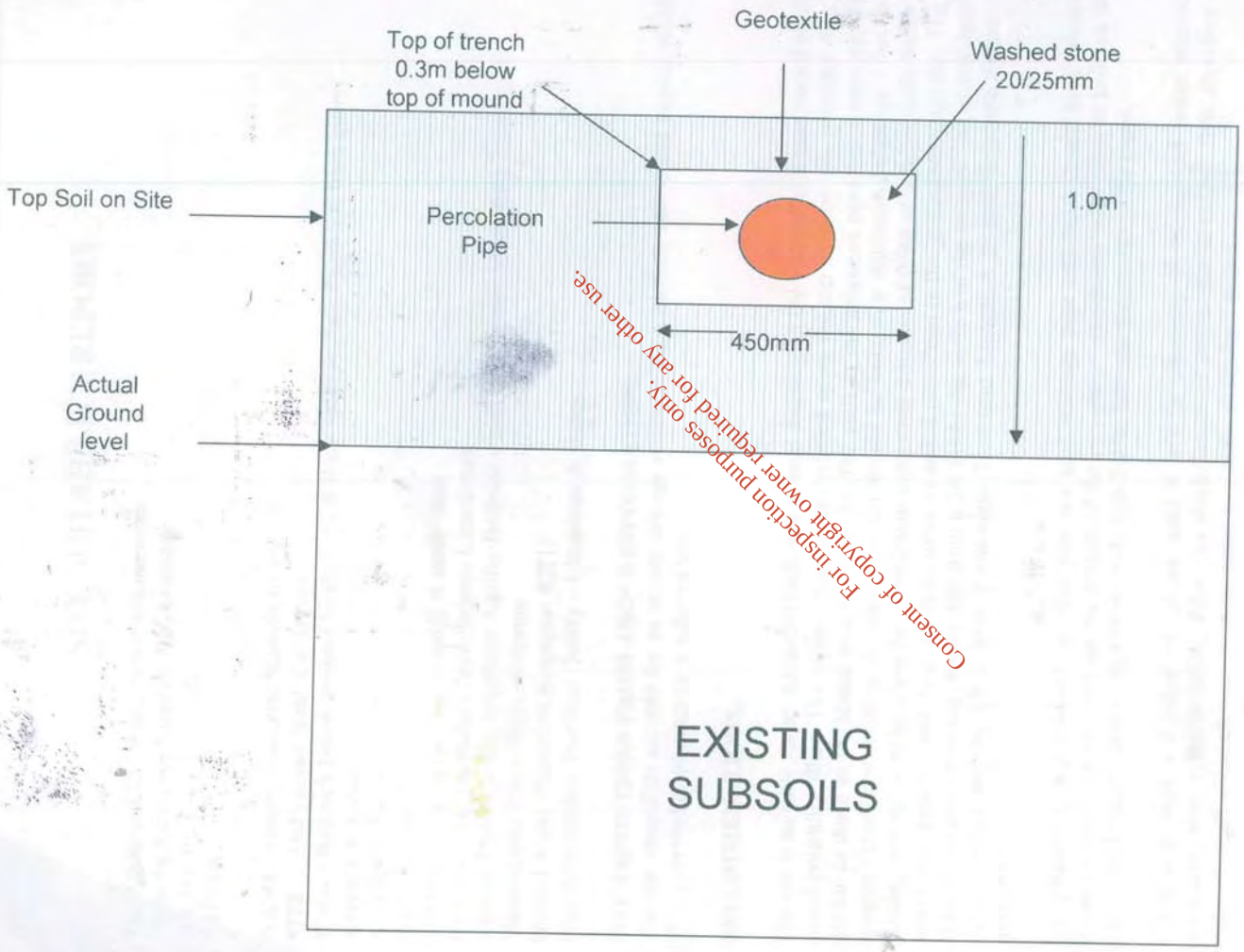
* EPA WasteWater Treatment Manual for Single Houses

Murphy Concrete – Co. Dublin

P-Test Holes

Trial Hole & T-Test Hole

PERCOLATION TRENCH CROSS SETION



Appendix D.2.1

Indicative Phasing Programme

WYG Ireland
part of the WYG group

FIGURE 1: INDICATIVE PHASING PROGRAMME

Cell	Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
		2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036
Phase 1		**1 (0-5)**																									
Phase 2					**2 (3-13)**																						
Phase 3													**3 (11-23)**														
Phase 4																									**4 (23-25)**		
H1	**Construction**																										
	Operation																										
H2	**Construction**																										
	Operation																										
H3	**Construction**																										
	Operation																										
NH1	**Construction**																										
	Operation																										
NH2	**Construction**																										
	Operation																										
IN1	**Construction**																										
	Operation																										
IN2	**Construction**																										
	Operation																										
IN3	**Construction**																										
	Operation																										
Inert Recovery Facility																											
Solidification Plant																											

Hazardous Operations	
Non-Hazardous Operations	
Inert Operations	
Construction Works	
Daily Operations	

Appendix D.3.1

Comparison of Hazardous Cell Lining Technologies

Summary of Composition and Characteristics of Hazardous Cell Lining Technologies

	Single Composite Liner [Note 1]	Double Composite Liner [Note 1]	DAC Liner [Note 2]
Liner Characteristics	Upper component of the composite liner must consist of a flexible membrane liner (FML). This must be a minimum of a 2mm thick HDPE liner or equivalent (with the necessary flexibility to be robust but not prone to excessive cracking/construction difficulties).	Top composite liner must consist of a minimum 2mm HDPE or equivalent FML and a 1m thick layer of compacted soil having a hydraulic conductivity less than or equal to 1 x10^{-9} m/s constructed of compacted lifts no greater than 250mm thick when compacted. Alternatively a 0.5m thick artificial layer of enhanced soil or similar giving equivalent protection as the foregoing (also constructed of compacted lifts no greater than 250mm thick when compacted) Bottom composite liner must comprise as a minimum of 2mm HDPE or equivalent FML upper component	The DAC liner must comprise a multi layered lining system comprising (i) a mastic sealant which can be laid to a minimum density of 1.5 to 2.6 kg/m^2 on slopes up to 1 in 1.6 (ii) a minimum of 80mm thick dense asphaltic concrete having a maximum hydraulic conductivity of 1 x10-^{12} (iii) a minimum thickness of 60mm asphalt binder layer (hydraulic conductivity not less than 5 x 10^{-6} m/s and not greater than 1 x 10^{-4} m/s (iv) a cationic emulsion tack coat as specified in the National foreword to BS EN 13808 or equivalent (v) a minimum 200m granular drainage layer in accordance with the requirements of SHW Clause 803, having a minimum CBR of 30%. The granular material must not contain any plasticity or reclaimed materials. (vi) a separating geotextile membrane

	Single Composite Liner [Note 1]	Double Composite Liner [Note 1]	DAC Liner [Note 2]
Leachate Collection Layer	Minimum 0.5m thick leachate collection layer having a minimum hydraulic conductivity of 1x 10^{-3} m/s	Minimum 0.5m thick leachate collection layer having a minimum hydraulic conductivity of 1x 10^{-3} m/s	Minimum 0.5 m thick leachate collection layer having a minimum hydraulic conductivity of 1 x 10^{-3} m/s
Mineral Layer- **Base and Side Wall Characteristics**	Base and Side Wall Mineral layer comprising a minimum of 5m thick having a hydraulic conductivity less than or equal to 1 x10^{-9} m/s	Base and Side Wall Mineral layer comprising a minimum of 4m thick having a hydraulic conductivity less than or equal to 1 x10^{-9} m/s	Base and Side Wall Mineral Layer comprising a minimum of 0.5m thick having a hydraulic conductivity less than or equal to 1 x 10^{-9} m/s. (Engineered clay is only required 3m up the side wall from the base - Full DAC system as specified above is otherwise continued to top of the cell wall.)

Note 1: Design criteria as per EPA Landfill Manual, "Landfill Site Design", EPA, 2000

Note 2: Design criteria provided by WALO UK

Appendix D.3.2

Submission to EPA to consider DAC as BAT for hazardous landfill liner

Ref: CE07920/DMcD/MC

Date: 28th June 2010

Mr Brian Meaney,
Environmental Protection Agency,
Office of Climate, Licensing and Resource Use,
Headquarters, PO Box 3000,
Johnstown Castle Estate,
Co. Wexford

Re: Submission to EPA to consider a Dense Asphaltic Concrete Lining System (DAC) BAT for a hazardous landfill cell.

Dear Brian,

First of all, on behalf of Murphy Environmental Hollywood Limited (MEHL) we thank you very much for affording us the opportunity to discuss the proposed Integrated Waste Management Facility for Non-Biodegradable Waste including Hazardous Waste, with you on April 23rd last. We found the meeting very beneficial and appreciated the guidance and clarifications provided.

As you are aware, the purpose of this submission is to seek confirmation from the Agency that the proposed dense asphaltic concrete lining system (DAC) for the hazardous cells at the proposed MEHL facility is considered BAT. Our research indicates that when the traditional composite clay and HDPE liners previously used in Ireland (as cited in the various EPA Landfill Design Manuals) are compared with the DAC system, DAC performs markedly better than HDPE and clay lining as it typically has a superior permeability of up to 1 x 10^{-15}m/sec. We hereby submit to the Agency that the DAC lining system for the hazardous cell should be considered BAT on the basis of the information provided below.

PH McCarthy House, Nutgrove Office Park, Nutgrove Avenue, Rathfarnham, Dublin 14
Tel: +353 (0)1 291 4800 Fax: +353 (0)1 298 9521 Email: dublin@wyg.com www.wyg.com/ireland

WYG Environmental and Planning (Ireland) Ltd Registered in Ireland Number: 387419 VAT Number: 6407419J
Registered office: PH McCarthy House, Nutgrove Office Park, Nutgrove Avenue, Rathfarnham, Dublin 14

1.0 BAT Guidance

The EPA document "BAT Guidance Notes for the Waste Sector; Landfill Activities", April 2003 and the EPA landfill manual "Landfill Site Design", 2000 states that the function of a lining system is to protect groundwater, surface water and soils by containing leachate within the landfill; preventing/controlling groundwater ingress and assist in controlling landfill gas migration. Any liner system must achieve consistent performance and be compatible with the expected leachate for the design life of the facility. When selecting a liner system for a proposed facility, applicants must as a minimum meet the requirements of the Landfill Directive 1999/31/EC and be able to demonstrate the performance of any proposed lining systems by appropriate QA testing during construction. For hazardous landfills the EPA landfill site design manual presents two options, a single composite HDPE liner and a double composite HDPE liner and states that the option to be used shall be selected dependent on the nature of the waste materials being deposited. The manual also clearly states that "alternative lining systems may be considered for pre-treated hazardous wastes e.g. solidification, stabilisation and vitrification of hazardous wastes". In our design options appraisal we considered both a single composite and a double composite HDPE liner, however the DAC liner has a much lower permeability and provides much better containment than either of these options and was therefore preferred over the options referred to in the EPA Landfill Site Design Manual. As you are aware at the recent EPA Conference, Mr Rob Marshall of the Environment Agency in the UK has identified an increasing tendency towards the use of DAC liners rather than traditional HDPE and clay lining technologies.

2.0 Proposed Lining System

It is proposed to use dense asphaltic concrete (DAC) to line the base and side walls of the hazardous cells. DAC lining systems are engineered to provide complete containment rather than controlled seepage thus making it a more effective landfill barrier than the single, composite or multiple lining systems traditionally used. DAC systems are commonly used in Europe in rail, road, tunnel, dam and reservoir construction as well as landfills. Information from WALO UK (and parent WALO Bertschinger AG), one of the leading suppliers of DAC in Europe, indicates that 13 landfill cells in the UK have been lined with DAC. WALO have also lined a number of landfill sites in Europe principally in Switzerland, Germany and more recently in Italy, Spain and Poland. Appendix 1 contains various photographs showing the recent lining of a municipal landfill facility with DAC at a UK Landfill site.

The proposed DAC system will comprise the following components;

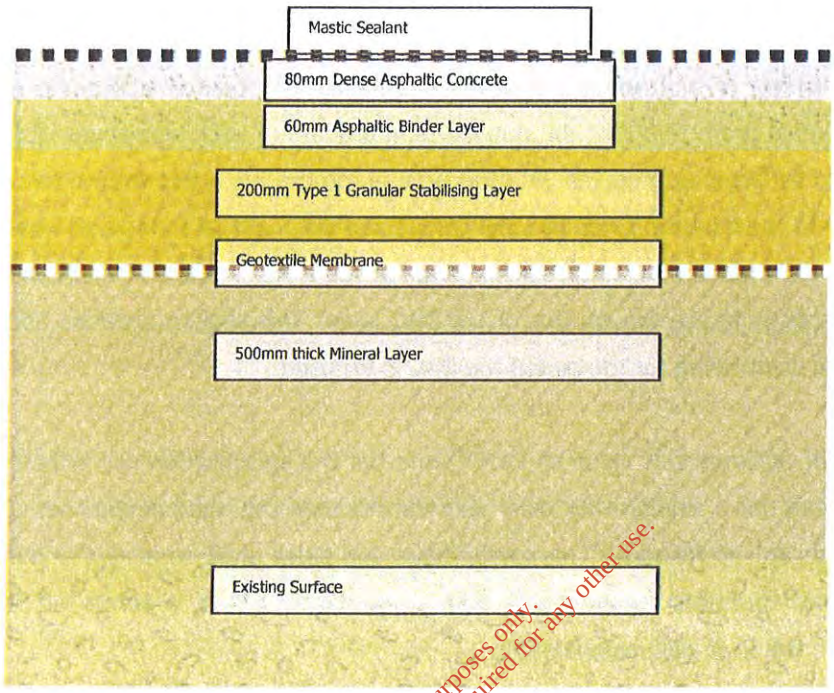


Figure 1- DAC Lining System

Engineered Clay (500mm) – minimum permeability 1 x10^{-9} m/s

The first layer in the DAC system is an engineered clay compacted to a stiffness of >50MN/m2 or a CBR of >20%. This will have a minimum thickness of 500mm.

Stabilising Drainage Layer (200mm) – minimum permeability 1 x10^{-3} m/s

The stabilising drainage layer is the equivalent of the sub base of a road. Its primary function is to provide a stable surface on which equipment required for the construction of subsequent layers can be used. It also serves the function of preventing pressure build up from water beneath the liner whether from seepages or ingress around the edge of the liner. Once the stabilising layer is compacted into place, a bituminous emulsion is sprayed to bind together the fines in the upper layers whilst providing adhesion for the next layer.

Asphaltic Binder Layer (60mm) – minimum permeability 1x10^{-4}m/s

The Asphaltic Binder Layer is a high permeability layer designed to allow steam generated during the construction of the DAC layer to escape. It is an open textured asphaltic layer which also provides a strong stable base against which the DAC layer can be compacted.

Dense Asphaltic Concrete Layer (80mm) – minimum permeability 1 x10^{-12}m/s

The DAC layer is composed of an asphaltic mixture of continuously graded aggregate matrix, laboratory designed for each individual project so that the quantity and grading of each aggregate fraction fills the gaps left in the matrix formed by larger aggregates. Bitumen acts as the binding agent to bind the minerals together and add impermeability to the mixture. Once laid and compacted the material forms a completely impermeable layer that is resistant to deformation but still flexible enough to suit a wide variety of applications. A fine coat of mastic sealant will be applied to the top surface of the DAC layer. This sealant provides additional protection against UV exposure and weathering for the period the DAC is exposed.

The DAC system typically achieves a K value of 1x10^{-15} m/s but the specification will include for a K Value of 1x10^{-12}. The DAC therefore has a significantly lower permeability than the requirements set out in EC Directive 99/31/EC Annex 1 which are as follows; "The landfill base and sides shall consist of a mineral layer which satisfies permeability and thickness requirements with a combined effect in terms of protection of soil, groundwater and surface water at least equivalent to;

- landfill for hazardous waste: K <= 1.0 × 10^{-9} m/s; thickness >= 5 m,
- An equivalent artificially established geological barrier not less than 0.5 meters thick.

The DAC liner containment is double that of the equivalent double composite liner and three times that of a single liner for a hazardous cell.

The required permeability will be demonstrated on-site by laboratory testing including core sampling of test pads. The maximum slope height will be 10m with a maximum gradient of 1 in 2. A stable formation with a CBR of 20% will be provided under the lining system.

The DAC layer of the lining system has the following characteristics;

i) A maximum hydraulic conductivity of 1 x 10^{-12} m/s for the range of hydraulic heads expected on site;

ii) It is unaffected by hazardous and non hazardous landfill leachates;

iii) It does not contain mobile toxic compounds which may pollute surface water or groundwater;

iv) Total air voids content does not exceed 3%;

v) It is unaffected by sunlight, ambient temperatures, frost action and all weathering processes which may be experienced prior to covering with waste;

vi) It is stable on the landfill perimeter slopes both during and after construction;

vii) It is sufficiently flexible to accommodate a differential settlement of the underlying formation amounting to up to 40 mm over a distance of 400 mm without cracking or increase in hydraulic conductivity.

The asphaltic binder layer has the following characteristics:

i) A hydraulic conductivity not less than 5×10^{-6} m/s and not greater than 1×10^{-4} m/s;

ii) An air voids content between 10% to 15%;

iii) It does not contain mobile toxic compounds which may pollute surface water or groundwater;

iv) It is unaffected by sunlight, ambient temperatures, frost action and all weathering processes which may be experienced prior to covering with the DAC layer;

v) It remains stable on the landfill perimeter slopes both during and after construction;

vi) It is sufficiently flexible to accommodate a differential settlement of the underlying formation amounting to up to 40 mm over a distance of 400 mm without cracking or increase in hydraulic conductivity.

vii) It is immediately capable of handling the passing of machinery over the surface without any risk of damage or tearing whatever.

The stabilising drainage layer is a Type 1 sub-base material in accordance with SHW Clause 803 except that the sub-base material must not contain any plasticity or re-claimed materials whatsoever. Transport, laying, compaction and any trafficking of the granular material shall comply with SHW Clause 802. The sub-base material has a minimum CBR of 30%

2.1 Key features of DAC Lining Technology

As outlined above the primary benefits of using DAC as a liner are that it is strong and flexible whilst still being highly impermeable. The other key features of DAC are its resistance to chemical attack and robustness.

Flexibility – As evidenced by its widespread use in a multitude of situations including as a liner for reservoirs at power stations i.e. where large volumes of water are pumped from one reservoir to another lower reservoir on a daily basis causing huge instantaneous changes in pressure on the DAC liner, DAC liners are extremely flexible. WALO have conducted a number of flexibility tests (including Van Asbeck flexibility tests) on DAC lining panels and the ability of the material to flex to a ratio of greater than 1:10 has been demonstrated. This flexibility allows the liner accommodate any differential settlement which may occur. Detailed results for these tests are available on request.

Strength and Impermeability – Long term tests have been carried out on the hydraulic abrasion and resistance of DAC liners to solvents by convection and permeation. Results indicate that solvents such as TCE and a nine component mixture of various common hydrocarbons were not able to penetrate into the mortar film of DAC systems used at landfill sites. DAC is therefore considered durable against chemo abrasive attacks from aggressive solvents. Hundreds of tests on samples with voids of between 1% and 3% have regularly produced hydraulic conductivity initial inflows of <=K 1 x 10^{-13} m/s, tested under a pressure of 1.0 Mpa with outflows producing a K factor of zero i.e. complete impermeability. This is many orders of magnitude less than the commonly accepted K factor of 1 x 10^{-9} m/s for landfill liners.

Given the extremely low permeabilities of the DAC liner system which essentially provides total containment, it is not proposed to install a leachate detection system beneath the DAC liner. It is our experience internationally that DAC lined landfills do not require leachate detection. However, in order to supplement a comprehensive CQA procedure it is proposed to install an access point into the stabilizing drainage layer of the DAC system. In the unlikely event that the DAC system was to leak, this access point will provide a detection facility and can be used to demonstrate the performance of the system for the duration of its design life and beyond.

Resistance to Chemical Attack - In this document we have presented the specifications and composition of the layers that make-up the DAC lining system and as can be seen from this the hydrocarbon content of a DAC barrier is typically less than 8%. When compared to HDPE which is almost 100% hydrocarbon, this clearly reduces the susceptibility of the DAC liner to chemical attack. The DAC layer of the DAC liner is primarily made up of clean graded hardstone aggregates. These aggregates are mixed with a very small quantity of binding agent. A number of experiments have been undertaken by WALO and it has been found that acidic liquids such as leachate from landfills (with a typical pH of 4.8 -5.2) or liquids with a high solvent content can result in

increased temperature of the bitumen and can lead to a slight softening of its structure. However these experiments found that the softening of a DAC barrier is restricted to the top few millimeters only. As the bitumen between mineral components is only a few microns thick any softening will ultimately result in a tightening of the aggregate interlock.

Robustness – When using a conventional lining system, the phasing of landfill construction is generally limited to ensure newly lined cells are not exposed for any significant length of time ahead of tipping. However a DAC barrier is robust enough to withstand exposure for years. The robustness of the system is such that the lining system once cooled cannot be damaged by inclement weather, vehicles crossing it or vandalism. DAC liners require no additional protective layers once laid prior to laying the stone leachate drainage blanket.

Stability on Slopes - On slopes steeper than 1:3, the use of traditional clay and HDPE lining systems are often limited as it can be difficult to achieve the necessary stability. In cases where standard clay and HDPE liners are used, they generally require additional treatment to ensure the liner can support its own weight and withstand down-dragging during and after waste placement. With a DAC system, slopes up to 1:1.5 (34°) have been lined throughout sites in mainland Europe and in the UK without difficulty. Specialist plant including slope finishers on specially designed winches are used to ensure (as shown on the attached photographs of Appendix 1) that a uniform barrier can be installed on steep slopes to the required heights, thereby providing confidence in the integrity of the lining system.

Boundary/Joint Sealing - A lining system is only ever as strong as its weakest point (typically at the joint between panels) and again in comparison to conventional lining systems, we consider the joints in DAC lining systems superior to what could be achieved by a single composite HDPE liner or a double composite HDPE. All joints are sealed in a manner which ensures that the joint is equally as impermeable as any other part of the liner. In order to achieve this the adjoining panels are installed hot to hot. To ensure impermeability of "day" joints (i.e. joints a day or more old) all joints are formed, cleaned and dried and a coat of bitumen is applied. On the next day after cooling of the DAC, the joint area is reheated carefully using an infra red heating system followed by recompaction with vibro- stampers. A wedge formed overlap is created and this is recompacted to ensure full impermeability and durability to the required standards.

3.0 CQA Proposal

In order to ensure the performance required by the specification is achieved, the following testing regime is undertaken;

1. Test a number of possible aggregates, fillers and bitumens in advance of the commencement of works to ensure its suitability for use in the DAC lining system. This testing will include the following;

(i) Particle size distribution of the coarse and fine aggregates to BS EN 933-1 and fillers to BS EN 933-10;
(ii) Flakiness index of coarse aggregates to BS EN 933-3
(iii) Particle density of coarse and fine aggregates to BS EN 1097-6
(iv) Water absorption of coarse and fine aggregates to BS EN 1097-6;
(v) Magnesium sulphate soundness of coarse and fine aggregates to BS EN 1367-2;
(vi) Adhesion to bitumen to coarse aggregates to AASHTO – T182;
(vii) Penetration of bitumen to BS EN 1426
(viii) Softening point of bitumen to BS EN 1427
(ix) Marshall test to BS EN 12697-34 on DAC layer mix and asphalt binder layer to determine air voids in compacted mix. Test to be carried out with 2 x 10, 2 x 20, 2 x 30 blows;
(x) Specific gravity (Maximum density) of mixes to BS EN 12697-5 on DAC layer mix and asphaltic binder layer mix.
(xi) Bulk density of mixes to BS EN 12697-6 on DAC layer mix and asphaltic binder layer mix
(xii) Swelling test on both DAC layer and asphalt binder layer in water at room temperature for 28 days;
(xiii) Hydraulic conductivity of the design mix for both DAC layer and asphalt binder layer.

The design process will develop the optimum DAC mix based on the type of aggregate available locally. During the mix design, suitability tests will be carried out on all the constituent materials. The results of these preliminary tests will be used to design the optimum mix proportions. As part of the mix design, placement criteria will be developed for the monitoring of DAC placement on site.

2. Before proceeding with placing DAC in the Permanent Works, field trials of the DAC shall provide field

verification of the air voids/hydraulic conductivity relationships determined from laboratory testing. Two field trials shall be undertaken to evaluate the following aspects, one on the cell base and one on the perimeter side slopes:

i) Material handling and placement requirements;
ii) Compaction equipment and procedures;
iii) Number of passes of equipment necessary to achieve the specified air voids; (this is a nominal number of passes which may change during the construction works depending upon the temperature of the supplied DAC)
iv) Field testing procedures for compaction and thickness control;
v) "Hot" and "cold" joints including a "day" joint;
vi) Hydraulic conductivity achieved.

Each trial area shall provide a minimum prepared area of 100 m^2. Acceptance criteria for the compliance testing shall be determined from the results of the DAC mix design programme:

The air voids of the DAC layer at each designated position shall be determined by a nuclear density gauge (mean of four measurements at 90° intervals) after each pass of the compaction plant. The air voids measurements shall be continued for four passes of the compaction plant after the required air voids is achieved to fully establish the relationship between air voids and number of passes of the compaction plant. The trial area shall also be subjected to the compliance testing described below.

A report containing and summarising in a clear and concise manner the results of the Field Trials and field and laboratory testing undertaken during the Field Trials shall be made available to the EPA.

3. Compliance testing of the raw materials shall be carried out as follows:

Property	**Test Method**	**Frequency**
Aggregates and fillers:		
Particle size distribution for aggregate and for filler	BS EN 933-1, BS EN 933	1 per 200 tonnes
Flakiness index	BS EN 933-3	1 per 200 tonnes
Relative density	BS EN 1097-3,	1 per 200 tonnes

Magnesium sulphate soundness	BS EN 1367-2	1 per works
Bitumen:		
Penetration	BS EN 1426	1 per 100 tonnes
Softening point	BS EN 1427	1 per 100 tonnes

The temperature of the bituminous material in the batching plant will be taken and recorded at regular intervals whenever the plant is operating. The temperature of materials within the batching plant, and the temperature of mixed materials coming out of the batching plant, shall comply with the requirements of BS EN 13108-1 Table 11. The temperature of bituminous material will be taken and recorded on delivery to the placement area and during compaction.

During the compaction of each panel of the DAC liner, compliance testing shall be carried out by the Contractor to confirm that the plant and techniques have achieved a level of compaction established during the Field Trial to be necessary to obtain the specified hydraulic conductivity- As requested by the Agency at our meeting it is proposed to undertake in situ testing on test pads rather than on final compacted panels. The final details of these tests to include the number, spacing and type of tests undertaken will be agreed with the Agency in advance of works commencement.

Tests are normally undertaken to assess:

i) Temperature of material when laid and being rolled;
ii) Air voids measurement using nuclear density gauge ;
iii) Vacuum testing of all joints;
iv) Core sample taken for air voids and hydraulic conductivity measurement;
v) Depth profiling to predetermined markers.

Compliance testing shall be carried out at the following nominal grid spacing's:

Temperature measurement	: 20 m
Nuclear Density Gauge (NDG)	: 20 m
Vacuum measurement	: 20 m length of joint
Core samples for air voids	: 1 per 15 NDG
Hydraulic conductivity (laboratory)	: 80 m

The nuclear density gauge shall be calibrated by carrying out measurements of air voids at each of five locations

using both the nuclear density gauge and the core density procedure during the field trial.

4.0 Conclusion

All of the information contained within this proposal, demonstrating the characteristics of DAC (Dense Asphaltic Concrete) lining systems, prove that the DAC lining system provides superior containment in comparison to both options for hazardous waste landfilling lining systems detailed in the current EPA Landfill Site Design Manual. We therefore conclude that the DAC liner system should be considered as BAT for hazardous waste landfill lining systems.

Yours Sincerely,

David McDermott
Principal Scientist
On behalf of WYG and MEHL

Michael Cunningham
MD Environmental Ireland
On behalf of WYG and MEHL

Appendix 1

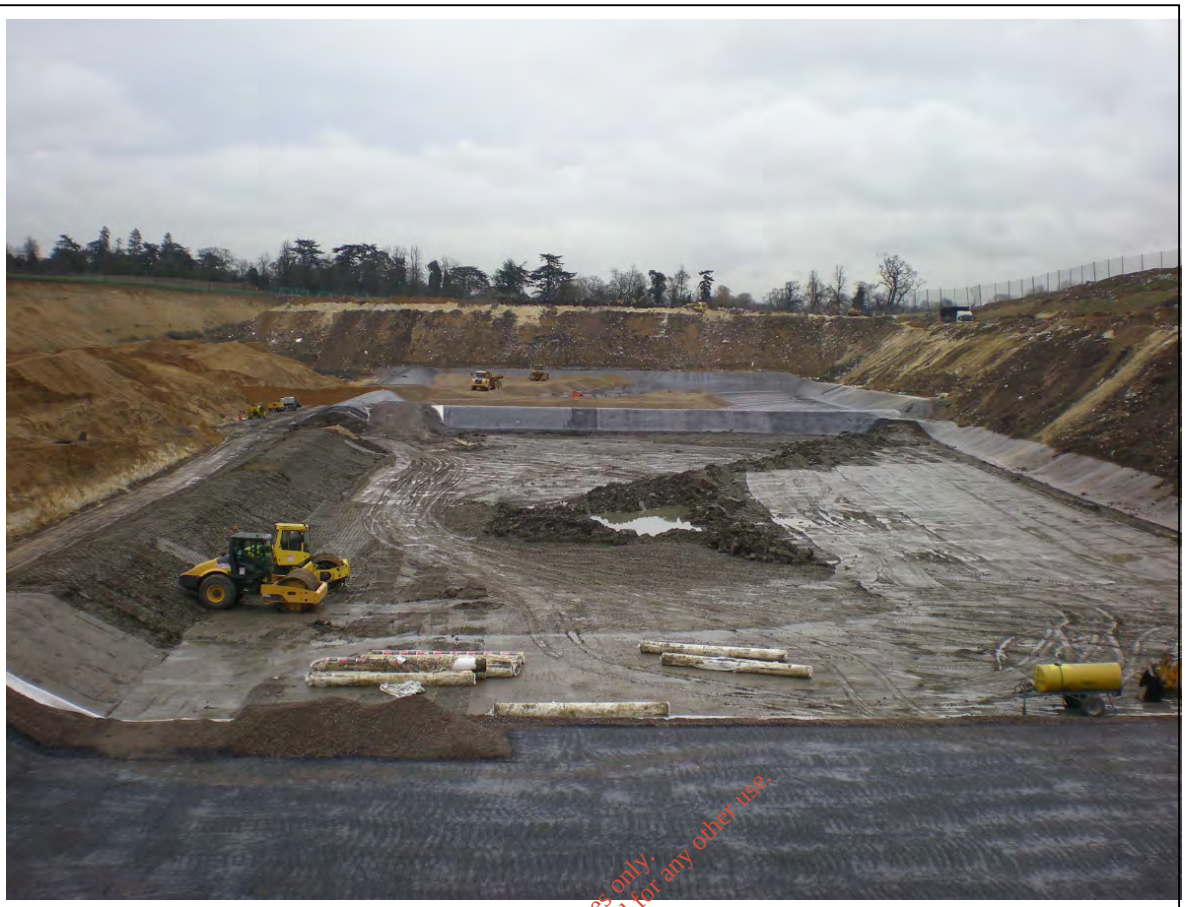


Photo 1 Lining of landfill cells with DAC at a UK Landfill Site
Note: The landfill site name has been omitted for the purposes of this application on confidentiality grounds

Photo 2 Freshly laid DAC liner on the base of a cell at a UK Landfill Site
Note: The landfill site name has been omitted for the purposes of this application on confidentiality grounds

WYG,
PH McCarthy House,
Nutgrove Business Park,
Nutgrove Avenue,
Dublin 14
Tel: +353 01 2914800

Site Location:	Drawing Title:
A UK Landfill Site	**Site Photographs**
Client:	**Project Number:**
MEHL	**CE07920**

Photo 3 Lining of a side slope with DAC at a UK Landfill Site
Note: The landfill site name has been omitted for the purposes of this application on confidentiality grounds.

Photo 4 Lining of a side slope with DAC at a UK Landfill Site – note the steepness of the slope
Note: The landfill site name has been omitted for the purposes of this application on confidentiality grounds.

WYG,
PH McCarthy House,
Nutgrove Business Park,
Nutgrove Avenue,
Dublin 14
Tel: +353 01 2914800

Site Location: **A UK Landfill Site**	Drawing Title: **Site Photographs**
Client: **MEHL**	Project Number: **CE07920**

Appendix D.3.3

List of Reference DAC sites

Appendix D.3.3:
DAC Reference Sites

Selection of DAC Reference Sites
Switzerland and Germany
Source: Walo Group

Name / / Address	*Landfill in DAC*	*Landfill depositing flyashes*	*Contact*	
Deponie Teuftal AG Salzweid 37 CH-3202 Frauenkappelen	x	x	Tel. Fax Managing director	0041 31 754 10 54 0041 31 754 10 55 b.walker@teuftal.ch
Deponie Elbisgraben c/o Amt für Industrielle Betriebe Bahnhofplatz 7 CH-4410 Liestal	x	x	Tel. Fax e-mail Managing director	0041 61 901 73 33 0041 61 925 69 78 elbis@tiscalinet.ch Bernhard Schmocker bernhard.schmocker@bl.ch
Decharge bioactive de Chatillon Commune de Fribourg Rte de la Combe 40 CH-1725 Posieux	x		Tel. Fax Managing director	0041 26 402 10 20 0041 26 401 10 09 Jean-Claude Balmer jean-claude.balmer@ville-fr.ch
Deponie Burgauerfeld Zweckverband Abfallverwertung Bazenheid Zwizach CH-9602 Bazenheid	x		Tel. Fax e-mail	0041 71 932 12 17 0041 71 932 12 10 claudio.bianculli@zab.ch
Deponie Alznach c/o Hürlimann AG Postfach 276 CH-6330 Cham	x		Tel. Fax	0041 41 781 15 88 0041 41 780 17 77
Chrüzlen WIEDAG Holzhausen CH-8618 Oetwil am See	x		Tel. Fax e-mail	0041 44 929 11 47 0041 44 929 20 84 info@grimm.ch
Wissenbüel KEZO Kehrichverwertung Zürcher Oberland Wildbachstrasse 2 CH-8340 Hinwil	x not any more in service	x	Tel. Fax e-mail Waste managment	0041 44 938 31 22 0041 44 938 31 08 info@kezo.ch Armin Oberhänsli armin.oberhaensli@kezo.ch
Deponie Kehlhof Zweckverband Kehlhof c/o KVA Thurgau Rüteliholzstrasse 5 CH-8570 Weinfelden	x			
K+S KALI GmbH Werk Werra Untertage-Deponie Herfa-Neurode Herfagrund D-36266 Herfa	Underground landfill	x	Tel. e-mail	0049 0561 9301 1575 info@ks-entsorgung.com
Deponie Riet Deponiestrasse CH-8404 Winterthur	partial in DAC till 2000 depositing flyashes, currently hazardous waste are being exported into underground landifll in Germany (Herfa Neurode)	x	Tel.	052 242 28 55

WALO BERTSCHINGER AG

Dam and Landfill Construction

Project References

WALO Bertschinger AG

Reference List Dam and Landfill Construction

Landfill Sites

Year	Project	Location	Country	Owner / Builder	Supervisor	Total Area	Length of Slope	Crest Level (m.a.s.l)	Gradient of Slope
1990	Reststoffdeponie Steinbruch Buchserberg Etappe 1	Buchs	CH	Verein für Abfallbeseitigung Buchs	Büro für Kies + Abfall 9000 St. Gallen	13'000 m2	25 m	ca. 680 m	1 : 2.00
1993	Deponie Lienz Lienz / SG	Lienz	CH	KVR, Zweckverband Kehrichtverwertung im Rheintal,Rebstein	Ing. Büro Nüesch + Roth	12'400 m2	10 m	ca. 431 m	1 : 20.00
1993	Deponie Teuftal Mühleberg / BE	Mühleberg	CH	Reststoffdeponie Teuftal, Köniz	Sieber Cassina + Partner AG Ingenieure Geologen Planer 3007 Chur	3'200 m2		ca. 590 m	
1994	Décharge bioactiv de Châtillon Etappe 1	Hauterive	CH	Ville de Fribourg, Direction de l'Edilité Fribourg	CSD Ingénieurs Conseils SA	17'800 m2	22 m	ca. 617 m	1 : 1.50
1994	Deponie Wissenbüel	Gossau	CH	KEZO Hinwil	ACS-Partner AG 8634 Hombrechtikon ZH	9'700 m2	20 m	ca. 518 m	1 : 1.50
1995	Deponie Chrüzlen 1. Etappe	Oetwil a.S.	CH	WIEDAG Oetwil a.S.	CIAG Corrodi Ingenieurbüro AG	14'500 m2			1 : 1.50
1996	Deponie Buchserberg Ausbau Etappe S2	Buchs	CH	VfA Buchs	Ingenieurgemeinschaft Sieber Cassina + Handke AG Metry & Partner AG	4'700 m2	15 m	ca. 658 m	1 : 1.50
1996	Deponie Seckenberg Etappe 1	Frick	CH	Gemeindeverband Abfallbeseitigung GAOF, Frick	Fischer & Schild AG Frick	11'400 m2	25 m	ca. 500 m	1 : 1.50
1996	Deponie Unterrealta Etappe 1 und 2	Cazis	CH	Abfallbewirtschaftungsverband Mittelbünden Thusis, Schweiz	Ingenieurbüro Metry	19'800 m2	40 m	ca. 650 m	1 : 1.50
1997	Deponie Riet Etappe 6, 1. Teil	Winterrhur	CH	Departement Bau Winterthur	Departement Bau Winterthur	5'000 m2	50 m	ca. 465 m	
1997	ISDS Oulens 1ère étape	Oulens	CH	Cridec SA, Eclépens AG Plan, La Tour- de- Peilz	AGPLAN SA Planification La-Tour-de-Peilz	9'000 m2	35 m	ca. 575 m	1 : 1.50
1999	Décharge bioactiv de Châtillon Etappe 2	Hauterive	CH	Ville de Fribourg, Direction de l'Edilité Fribourg	CSD Ingénieurs Conseils SA	15'500 m2	35 m	ca. 626 m	1 : 1.50
1999	Deponie Chrüzlen 2. Etappe	Oetwil a.S.	CH	WIEDAG Oetwil a.S.	CIAG Corrodi Ingenieurbüro AG	5'200 m2	7 m	ca. 580 m	1 : 1.50

WALO Bertschinger AG

Reference List Dam and Landfill Construction

Landfill Sites

Year	Project	Location	Country	Owner / Builder	Supervisor	Total Area	Length of Slope	Crest Level (m.a.s.l)	Gradient of Slope
2000	Deponie "Leigrueb" in Lufingen Etappe 3	Lufingen	CH	DEZU Bülach	Ingenieurbüro Reggli	8'150 m2	7 m	ca. 531 m	1 : 1.50
2000	Deponie Buchserberg, Los 2, Etappe 2	Buchs	CH	VfA Verein für Abfallbeseitigung Buchs / SG	Ingenieurbüro Metry und Partner AG 8832 Wollerau	9'300 m2	20 m	ca. 658 m	1 : 1.50
2000	Regionales Reststoffdeponie "Riet", Etappe 6, 2. Teil	Winterthur	CH	Stadt Winterthur, Abt. Tiefbauten Winterthur	Stadt Winterthur, Abt. Tiefbauten Winterthur	7'000 m2	60 m	ca. 468 m	-
2001	Deponie "Leigrueb" in Lufingen Etappe 4	Lufingen	CH	DEZU Bülach	Ingenieurbüro Reggli	9'000 m2	7 m	ca. 531 m	1 : 1.50
2001	Deponie Chrüzlen 3. Etappe	Oetwil a.S.	CH	WIEDAG Oetwil a.S.	CIAG Corrodi Ingenieurbüro AG	9'800 m2	7 m	ca. 580 m	1 : 1.50
2001	Deponie Teuftal Mühleberg / BE 2. Etappe	Mühleberg	CH	Reststoffdeponie Teuftal, Köniz	ENERGA Beratungs AG 3098 Köniz	9'000 m2	30 m	ca. 715 m	1 : 1.50
2002	Deponie Seckenberg BL 2. Etappe, 2. Teil	Frick	CH	Gemeindeverband Abfallbeseitigung GAOF, Frick	Fischer & Schild AG Frick	10'800 m2	25 m	ca. 500 m	1 : 1.50
2002	Deponie Wissenbüel	Gossau	CH	KEZO Hinwil	ACS-Partner AG 8634 Hombrechtikon ZH	5'500 m2	24 m	ca. 518 m	1 : 1.50
2002	ISDS Oulens 2ème étape	Oulens	CH	Cridec SA, Eclépens AG Plan, La Tour- de- Peilz	AGPLAN SA Planification La-Tour-de-Peilz	16'500 m2	18 m	ca. 580 m	1 : 1.50
2003	Décharge bioactive de Châtillon Etappe 3	Hauterive	CH	Ville de Fribourg, Direction de l'Edilité Fribourg	CSD Ingénieurs Conseils SA	14'900 m2	35 m	ca. 620 m	1 : 1.50
2004	Deponie "Leigrueb" in Lufingen Etappe 5	Lufingen	CH	DEZU Bülach	Ingenieurbüro Reggli	11'900 m2	7 m	ca. 532 m	1 : 1.50
2007	Décharge bioactiv de Châtillon	Hauterive	CH	Route Modernes SA, Fribourg	CSD Ingénieurs Conseils SA	1'700 m2	-	ca. 620 m	-