SILT CURTAIN DESIGN GUIDE

CHATOYER

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Spill Containment on Land | Spill Containment on Water | Liquid Containment | Stormwater Protection | Silt & Sediment Control | Bags & Covers | Water Diversion | Spill Control | Asset Protection

IMPORTANT NOTICE: This is an informational guide only. Configurations are determined by known hydrodynamic conditions such as tidal movement, wind velocity and wave height. Chatoyer Environmental does not recommend a purchase decision be made solely by referencing this guide. Advice should be obtained from project specific guidelines and environmental experts to determine silt curtain design requirements. Chatoyer Environmental will not be held liable for errors or omissions. All products must be quoted to ensure clarity and accuracy.

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Introduction

Also known as a turbidity curtain or silt screen, the silt curtain's function is to contain disturbed sediment. A silt curtain provides the necessary environment and time for the suspended sediment to settle to the bottom.

Why Should a Silt Curtain Be Used?

By the nature of the activity, marine construction has varying impacts on the existing ecosystem. The deployment of silt curtains in and around these construction projects is increasingly common as an approach to prevent suspended sediment from migrating. Many waterways have a natural level of turbidity that fluctuates with tidal movements or regional weather patterns such as a monsoon. Generally, the native flora and fauna can cope with natural increases in turbidity. Unnatural increases in turbidity levels over an extended period of time can harm local flora and fauna. Understanding the background levels and fluctuation in turbidity will assist in building reasonable project target levels for turbidity control.

A silt curtain should limit the transport of fine materials towards an ecological site where it is undesirable to have such an input. Examples of sites which may need to be protected are:

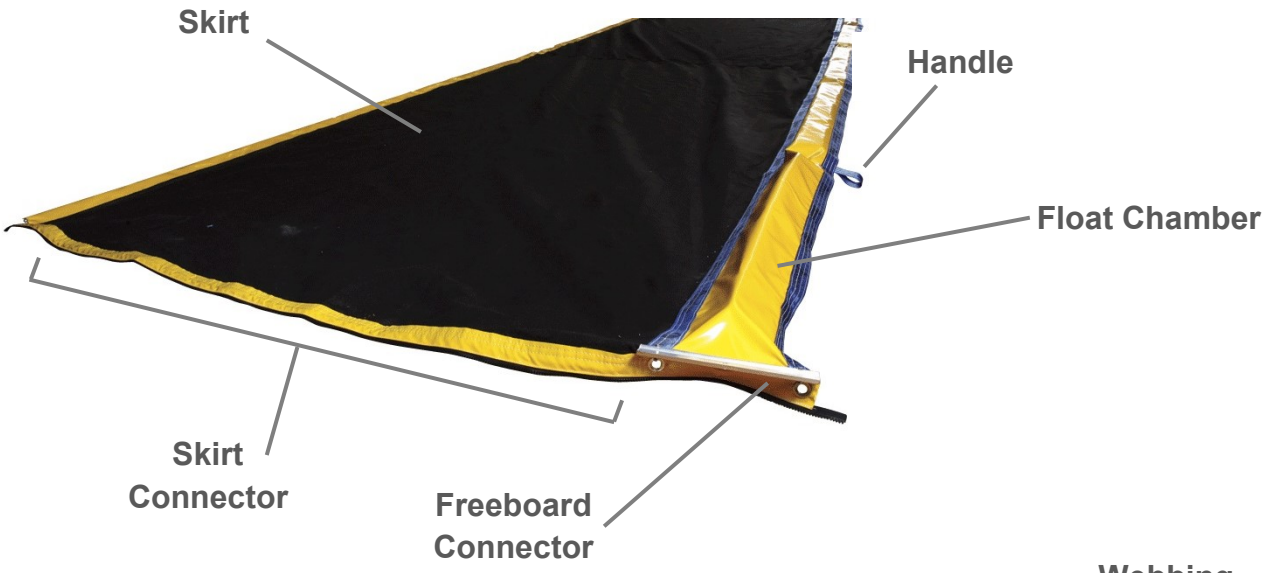
- Ecologically sensitive sites which are sensitive to daylight attenuation (shading) and/or sediment deposition (burial) such as mangroves, sea grass or corals
- Sites that have socio-economic benefits such as tourist locations
- Water intakes used for desalination, cooling water or irrigation

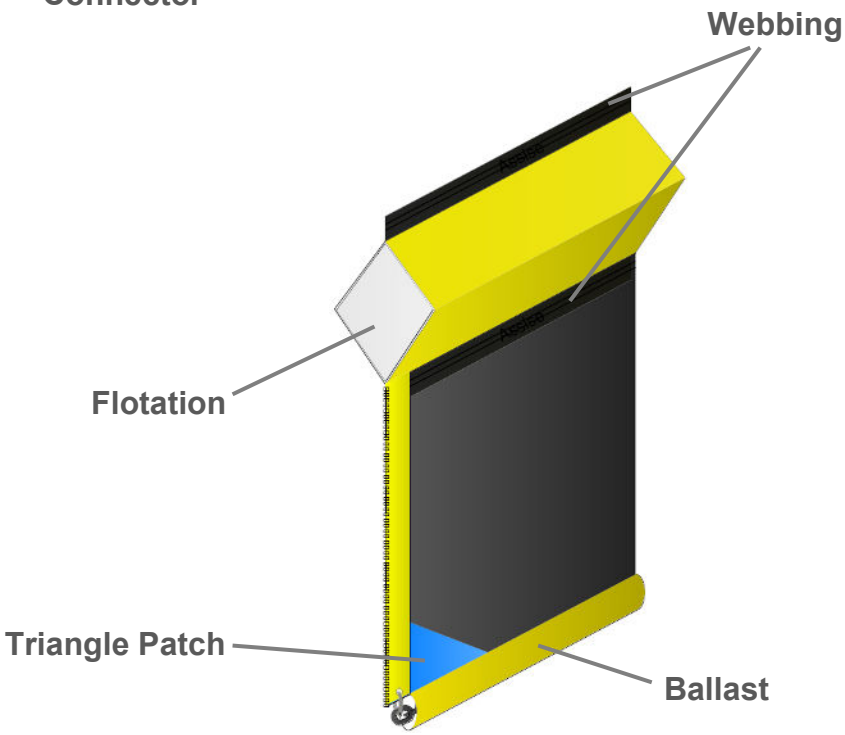
When assessing the viability of using a silt curtain, some considerations are:

- Presence or absence of sensitive receptors
- Suitability of the location given hydrodynamic and operational characteristics
- Regulatory preferences and requirements set for the project

It is a mix of the level of sensitive receptors within the environment and the degree of transport of suspended sediment within the waterway, as a result of activity, that determines the requirement of a silt curtain.

Standard Silt Curtain Components





FREEBOARD
The portion of the silt curtain that sits above the water line.

DRAFT
The submerged portion of the silt curtain.

FLOTATION
Standard flotation consists of high density closed cell, polyethylene foam encased in PVC. These floats are crumble resistant and oil resistant, ensuring continued flotation.

FLOAT CHAMBER
Manufactured from hi visibility, UV resistant PVC for standard designs.

SKIRT
The material used will depend on the conditions in which the curtain will be installed. Our most commonly used option is a 260gsm non woven geotextile fabric that stops anything larger than 90 microns.

BALLAST
The curtain is maintained in position by applying a ballast. Chatoyer's standard is galvanised chain sewn into a continuous chain pocket at the base of the curtain. This ballast extends consistently for the full length of the curtain allowing for continuous tension.

HANDLES
Manufactured from webbing and installed along each curtain section to aid in handling.

WEBBING
Seat belt webbing is incorporated along each curtain. Depending on the class of curtain, it's installed on top of the float, directly below the float and, for large curtains, one between the ballast and skirt. The webbing assists in supporting horizontal forces placed on the curtain.

CONNECTORS
The curtain sections connect together on the freeboard and draft. Specially moulded ASTM F962 z-connectors attach the freeboard sections. These connectors provide strength and durability in the water. For offshore conditions we suggest heavy duty moulded connectors.

Depending on the design, either eyelet and ties (lacing) or heavy duty marine zipper is utilised to connect the skirts on the draft of the curtain. This allows a section of curtain to be replaced if necessary.

ANCHOR POINTS
Attachment points are present on all ASTM F962 z-connectors via stainless steel eye nuts.

TRIANGLE PATCH
These are used to provide extra strengthening on some designs.

Silt Curtain Effectiveness

Silt curtain effectiveness is considered as the degree of turbidity reduction achieved within the controlled area relative to the turbidity levels outside of the area. Factors which affect this effectiveness are:

- The quantity and type of material in suspension
- The characteristics, design and construction of the silt curtain
- The mooring and square metre area of the silt curtain deployed
- The hydrodynamic conditions experienced such as tidal movement, wind velocity and wave height

The silt curtain is not designed to dam the turbid water. Instead, it provides a control for the dispersion of the sediment laden water and allows this suspended silt to settle.

In the instance of typical construction projects and pipeline disposals where suspended solid concentrations are high, a vast majority of the silt drops to the bottom while only about 5% of the sediment remains suspended in the water column.

Promoting Settling: Stokes' Law and How It Applies to Silt Curtains

The goal of the silt curtain is to allow the dispersed silt/sediment time to fall to the bottom. When the water flow and the depth of the body of water are known, it's possible to apply Stokes' Law to work out the distance the sediment will travel in the water before it settles to the sea floor.

Stokes' Law is a mathematical equation that expresses the settling velocities of small spherical particles in a fluid medium. The law, first set forth by the British scientist Sir George G. Stokes in 1851, is derived by consideration of the forces acting on a particular particle and the velocity at which solids will settle out in a column of fluid. This may be any type of fluid including water, air, oil, etc. And any type of solid, varying in different shapes and surface roughness.

Here is a broad example of settlement times in calm water at 20 degrees celsius.

Particle Size (mm)	Description	Time to Settle (1 metre)
0.002	Coarse Clay	80 hours
0.006	Fine Silt	10 hours
0.02	Medium Silt	45 minutes
0.06	Coarse Silt	6 minutes
0.2	Fine Sand	26 seconds
0.6	Medium Sand	3 seconds*
*medium sand in not covered by Stokes' Law - value is assumed		

We can utilise settlement behaviour of different particles to suggest the optimal placement of the silt curtain and how long it should stay in place. The objective is to create a suitably large area to allow the sediment to settle.

Understanding the Impact of Hydrodynamic Conditions

It is integral to the silt curtain design that the hydrodynamic loads are understood. These loads are the forces applied to the moorings and silt curtain resulting from currents, winds and waves. These forces can affect the buoyancy and ballast ratio, optimal skirt depth and choice of moorings and anchors. If the hydrodynamic conditions are not appropriate for the deployment of a silt curtain, it is recommended that an alternative means of silt control is sought.

The main factor associated with hydrodynamic loads on a silt curtain is the drag induced from the skirt. This is a function of current speed and depth of skirt. The loading applied to a silt curtain during exposure to a current *causes the structure to deform due to the opposing anchoring, buoyancy and current forces* (USACE, 1978). Where there is sufficient buoyancy,

the skirt will flare generating a gap between the bottom of the skirt and the sea bed. This flaring reduces the relative height of the skirt to the overall water height and can decrease the efficiency of the silt curtain.

It is widely accepted that the interaction between the water column and silt curtain is a crucial factor in determining the efficiency of the silt curtain. Two parameters that affect this are the interference of the silt curtain on the hydrodynamic flow and the deployed configuration of the silt curtain. Tests show that in situ, there is negligible difference in the hydraulic flows regardless of what skirt material or weave is used in the curtain. Regardless of the skirt material used, the flow is not sufficient to pass through the geotextile hence the water always drives toward the seabed.

The depth of the silt curtain, or the water column penetration, affects the silt curtain greatly. The deeper the curtain, the greater the hydraulic loading which can cause the curtain to flare, resulting in additional horizontal loads. Further, if the curtain penetration is too great, the water that passes beneath the silt curtain will be squeezed through a small gap resulting in possible further erosion of the sea bed and a resuspension of particulate into the upper water column further downstream.

Maximising Effectiveness

Utilising a silt curtain properly is an important part of projects that may disturb environments in waterways. The combination of the correct mechanical design, robust construction and a minimum of anchoring points is the safest, least expensive way to operate a silt curtain system. The upfront cost of a silt curtain is insignificant compared to the costs incurred because of a silt curtain failure.

Site Conditions

- Minimum to mild wave action near the silt curtain is best. Waves generate a heave and surge through the freeboard section. This can cause turbulence at the base of the skirt allowing for dispersion of sediment downstream which may have otherwise settled.
- The gap between the lower edge of the curtain and sea bed must be sufficient to compensate for changes in the water level and related flows associated with tidal movements. As a rule of thumb, we suggest that in currents less than 1.0 m/s, a gap of 0.5m is sufficient to allow sediment laden water to pass through and settle on the sea bed. Where currents are greater and the spacing is not sufficient, studies show

that a jet stream can be created in the lower water levels which can resuspend the sediment downstream.

- Low current velocities (less than 1.0 m/s) are optimal to allow the curtain to hang vertically through the water column and provide sediment with the greatest opportunity to settle.
- Silt curtains must have sufficient ballast to keep the curtain vertical through the water column. Water currents of limited speeds (less than 0.3m/s) can cause the silt curtain to flare if the ballast is not sufficient and reduce the efficiency of the silt curtain.

Deployment Location and Positioning

- Silt curtains must be deployed at a safe distance from construction activity. This ensures the provision of the optimum area for settling and prevents moorings from impacting vessels or machinery.
- A standard flow direction perpendicular to the silt curtain in combination with another structure to create a closed area - such as a break wall or beach – is recommended to generate the greatest efficiency.
- Deploy silt curtains where there is only one source of sediment. If there are multiple sources of sediment, the silt curtain will not work effectively.
- Look to deploy the silt curtain within a 500m range of the source of turbidity for efficient dispersal of the suspended sediment.
- Deploy upstream from any sensitive receptors such as sea grasses or coral.

Appropriate Design

During the design process, environmental conditions must be carefully considered to select the appropriate materials and connection mechanisms. Attention to choosing appropriate materials is essential because:

- Silt curtains will attract a range of extensive biofouling which blocks the permeability of the curtain.
- Water flowing through the skirt material is negligible and the curtain takes a majority of the force loads.
- The weakest point of a silt curtain is where each section of silt curtain is joined.

Silt Curtain Classes

CLASS 1
Low-Risk Applications

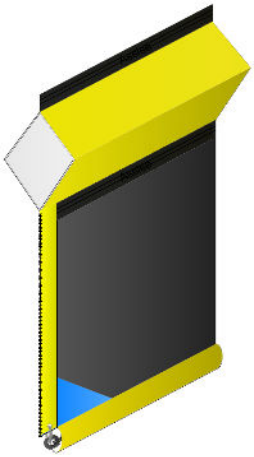
Little to no tidal wave and/or wind forces.

Example: lagoon, pond, stream

CLASS 2
Medium-Risk Applications

Moderate wind and/or water forces.

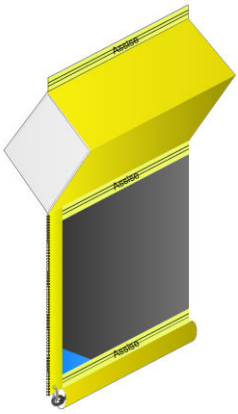
Example: river, calm harbour



CLASS 3
High-Risk Applications

Strong wind and water forces.

Example: open ocean, harbour, river mouth



Design Comparison

	CLASS 1	CLASS 2	CLASS 3
Application of Project	Short term projects in still water	Medium term projects in sheltered water	Long term projects in open water
Float Chamber Material	400gsm PVC	610gsm PVC	900gsm PVC
Float Size	50mm x 100mm	100mm x 100mm or 150mm x 150mm	150mm x 150mm or 200mm x 200mm
High Tensile Webbing Strips	25mm (1T breaking strain) 1 above float chamber	50mm (2T breaking strain) 1 above float chamber 1 below float chamber	50mm (5T breaking strain) 1 above float chamber 1 below float chamber 1 above chain pocket (uses upgraded load strap)
Skirt Depth	Up to 2m	Up to 8m	Up to 20m
Ballast Thickness	6mm	6mm - 8mm	8mm -13mm
Connectors	Marine grade #10 zipper on skirt Bowshackles on float chamber	Marine grade #10 zipper on skirt Standard ASTM962 extruded aluminium Z-connectors on float chamber	Marine grade #10 zipper on skirt Heavy duty ASTM962 extruded aluminium Z-connectors on float chamber
Triangle Patch	None	2 patches	2 patches
Other	Handles Shackles	Handles Shackles Anchoring points <u>Optional</u> Toggle pins Reflective buoys	Handles Shackles Anchoring points <u>Optional</u> External floats Toggle pins Reflective buoys

Silt Curtain Options and Accessories

- External Floats
- Hi-Vis (solar lights, reflective floats)
- Woven Geotextile
- Reinforce With Added Webbing
- Heavy Duty Moulded Connectors
- Anchor Set
- Tidal Riser
- Towing Bridle
- Installation / Removal

Choosing the Appropriate Curtain

Site conditions and project duration are important considerations that play a major role in choosing your silt curtain. Designs are specified to withstand the conditions in the water and around the curtain itself. Whenever unsure, speak to Chatoyer Environmental or their accredited resellers to assess the scenario.

Open or Closed Water

Is the curtain to be deployed in open water or stable (enclosed) waterways?

OPEN WATER – ensure the curtain is robust enough to handle all sea states, tidal flow and wind conditions. You may require external (foam filled LDPE) floats or larger internal floats. Using a heavier duty geotextile and casings will also help with curtain longevity.

ENCLOSED WATER – smaller internal floats will generally suffice however you should understand the tidal influences on variable water depths, currents and winds.

The degree of water currents and winds within the water column will also affect the weight of ballast required, and types of tension members and connector specifications.

Term of Deployment

Is the curtain to be deployed for a time period greater than 12 months?

SHORT TERM DEPLOYMENT – our standard Class 1 or Class 2 will generally be sufficient depending on hydrodynamic conditions during short-term deployment (<12 months in water).

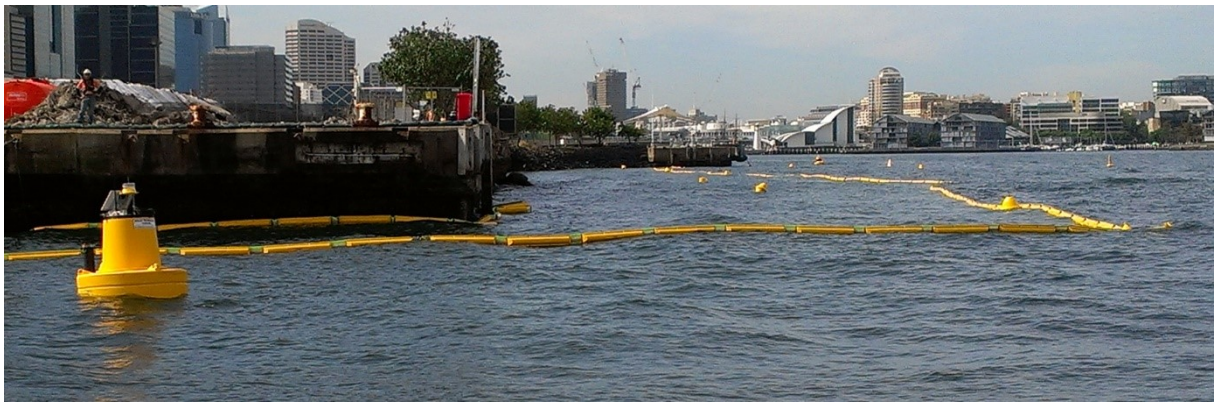
LONG TERM DEPLOYMENT – if the curtain is to be deployed for a period greater than 12 months, we would amend the silt curtain design by increasing buoyancy and ballast while using a heavier grade geotextile and casing material. The philosophy is to design a silt curtain that can withstand a wider range of weather and hydrodynamic conditions due to its extended window of deployment.

Vessel Traffic

Is there vessel traffic in the area of deployment?

YES – the frequency and size of vessels will affect the behaviour of the silt curtain within the vessel wash zone. This can be combated by using increased flotation with heavier ballast. You may also need to gain approval from waterways authorities and consider options to facilitate night time visibility, navigation markers, exclusion zones and more.

NO – a standard curtain with standard installation should be approved.



Quick Reference Chart

Chatoyer has been manufacturing silt curtains since 2009 and have detailed a simple categorisation to assist our clients in selecting an appropriate silt curtain design.

Below is a guide showing our suggestions per waterway and the fundamentals of each design class.

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Suggested Silt Curtain

		Still Water				River / Port			
	Skirt Depth	**1-2m**	**2-6m**	**6-12m**	**>12m**	**1-2m**	**2-6m**	**6-12m**	**>12m**
Class 1	50 mm Float Width	●							
Class 2	100 mm Float Width	●	●			●			
	150 mm Float Width			●	●	●	●		
Class 3	150 mm Float Width						●		
	200 mm Float Width							●	●
Permanent	External HDPE Floats			●	●			●	●

		Harbour				Open Water / Ocean			
	Skirt Depth	**1-2m**	**2-6m**	**6-12m**	**>12m**	**1-2m**	**2-6m**	**6-12m**	**>12m**
Class 1	50 mm Float Width								
Class 2	100 mm Float Width								
	150 mm Float Width	●	●						
Class 3	150 mm Float Width	●	●			●	●		
	200 mm Float Width			●	●	●	●	●	●
Permanent	External HDPE Floats			●	●			●	●

Determining Curtain Depth

Since the purpose of a silt curtain is to disrupt the water flow and allow the suspended sediment to settle, your curtain should be deep enough to facilitate the following:

- Provide sufficient disruption to the water flow (current)
- Remain clear from the sea bed at low tide
- Where required, adhere to EPA or other environmental requirements

Unless required by regulatory or project requirements, a silt curtain does not need to go down to the sea or river bed to be effective. Allow a minimum half metre gap between the curtain and the sea bed at low tide. Silt curtains are intended to promote the settling of sediment by driving particles closer to the sea bed. Water will always find the path of least resistance, therefore the water will pass between the lower edge of the silt curtain and the sea bed. Sediment must be forced deep enough to improve settlement. The gap between the curtain and sea bed provides a significantly more effective pressure release than the porosity of geotextile.

If the silt curtain is too deep, slack can be generated in the curtain skirt at low tide. This can create issues during periods of high wind as the curtain slack will billow and cause considerable forces against the curtain and mooring systems. Examples of airborne silt curtains have been cited due to incorrect skirt depths in wind prone areas.

Some other issues arising with full depth skirts are:

- In calm water, sediment could build up over the ballast chain and start to drag the curtain down. This is also known as ‘making sand’ as the curtain moves back and forth over the bottom.
- In moving water, the curtain needs to be able to move freely allowing the forces of the water to pass through and under the curtain. A full depth skirt increases the surface area of curtain in the water column, increasing the force factors being placed on the curtain.
- Full depth silt curtains may have an adverse effect on marine fauna.

If the curtain is anchored from the foreshore, we recommend the use of a tapered skirt following the gradient of the shoreline. In this scenario, it will be difficult to have a gap between the curtain and shore, but minimising the skirt depth will increase effectiveness.

Drawings for Custom or Standard Designs

Drawings and technical data sheets can be provided by Chatoyer Environmental, as required. Due to the degree of technicality, drawing sign-off by the client is a requirement for all of our customised and heavy duty permanent curtain designs.

Deploying Silt Curtains

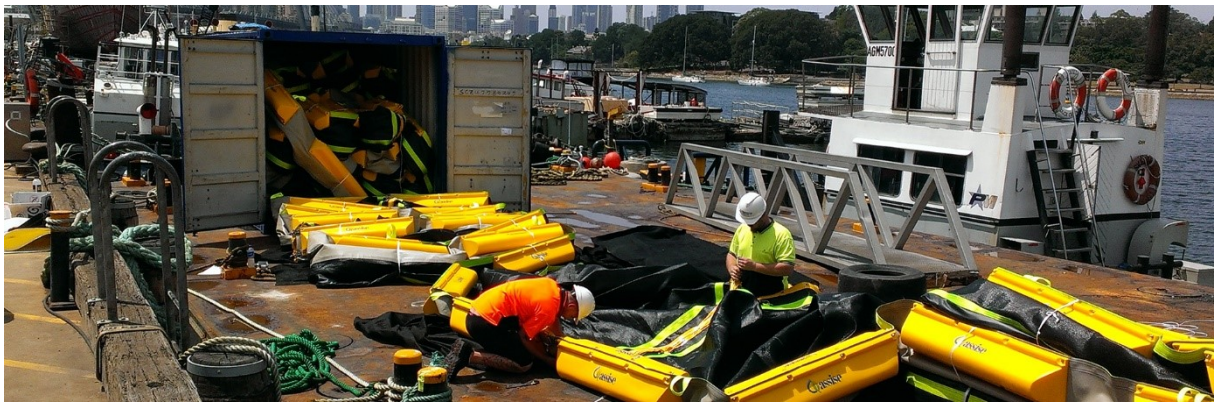
Chatoyer Environmental supplies silt curtains with the skirt furled and multiple sections connected up to a length of 100 metres per pallet. When projects require a large length of silt curtain resulting in numerous pallets, each pallet will be clearly identified and numbered.

Preparation

Pallet sections will be joined in consecutive fashion and pallets should be laid down as near as possible to the deployment zone.

To assist with installation:

- Ensure a large enough area is available to work with the silt curtain prior to deployment
- Coordinate access to the waterways in advance



The anchoring system needs to be installed in the waterway prior to deploying the silt curtain. Anchoring is crucial to maintaining the efficiency of the silt curtain, especially in areas with tidal movement or waves. USACE, 1978 states that *under no circumstance should the curtain be directly attached to pilings or poles driven into the bottom*.

Silt Curtain Installation

Silt curtain deployment can be separated into four traditional configurations:

- Maze
- Open
- Closed onshore
- Closed offshore

Selecting the correct configuration depends greatly on the hydrodynamic conditions, the anticipated application and operational factors such as vessel access. A majority of

configurations are ‘closed’ utilizing a seawall, foreshore or other structure. This configuration increases the efficiency of a silt curtain as it negates horizontal flow bypass.

Once the desired length of silt curtain is connected, the furled curtains can be towed to the desired deployment location at a maximum speed of two to three knots.

Ensure the curtain remains furled and is secured to the anchoring system. After the furled curtain has been anchored, the curtain should be checked to confirm the skirt is not twisted around the flotation chamber. Once the furled and untwisted curtain is anchored in the right location, remove the ties furling the curtain and allow the silt curtain system to drop into place.

In the instance where the curtain needs to be manoeuvred back to its correct deployment position, furl the curtain before dragging the silt curtain through the water. The movement of a silt curtain with its skirt deployed through water places undue pressure on the system.

Inspections and Maintenance

If the silt curtain system is to be deployed for an extended period (greater than 3 months), it is recommended that a visual inspection and maintenance schedule be implemented to check that the silt curtains are not damaged and performing as required. Visual inspections need to be carried out on a basis determined by the Contractor and can range from daily to quarterly. It is common to keep a spare section of silt curtain on site in case of a rip or tear in an existing section. This minimizes project down time since replacement of a panel is often quicker than a repair.

Typical visual inspection and maintenance activities include:

- Checking the silt curtains are maintained in the correct position with no obvious defects or entanglements
- Monitoring the curtain skirt against the sea bed to ensure it is free moving and not held down by sand or dispersed mud
- Replacing worn or broken anchor lines
- Reviewing the integrity of the PVC flotation chamber and connection points such as ASTM connectors and zips
- Removing marine growth from the curtain
- Inspecting the hardware for wear and tear, especially at anchoring points
- Inspecting marker buoys and lights (if required) to ensure they present and operational
- Removing floating refuse trapped by the silt curtain

As visual inspections are limited to the section above and immediately below the water level, it may be necessary to use underwater divers to conduct a more thorough inspection of the skirt and connections. A failure in the curtain resulting in a sediment plume is a typical trigger for such a thorough inspection.

Where an inspection or maintenance has been carried out, an inspection report should be completed. The report should record observations and subsequent actions taken to repair or maintain the silt curtain. The use of photographic records is recommended where available.

Silt Curtain Recovery

Prior to the removal of a silt curtain, all marine works for which the silt curtain was deployed must cease. Further, a visual inspection of water quality within the area protected by the silt curtain shall be conducted to confirm no sediment plumes.

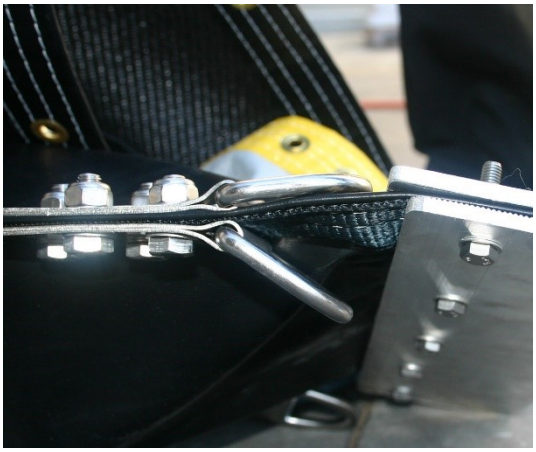
To recover the silt curtain, disconnect the silt curtain from the anchoring points and furl the curtain skirt. Then remove the mooring systems. Tow the system back to the launching site for removal from the waterway and responsible disposal.

Reusing Silt Curtain

Silt curtains can be cleaned and properly stored for reuse. If the curtain has been inspected, is in good condition and deemed suitable for reuse, it can be cleaned down with a high-pressure washer to remove biofouling, silt and sediment from the geotextile.

Once thoroughly dry, the curtain can be repacked on a pallet and stored. If serviced and stored properly, a high-quality silt curtain system can be reused numerous times.

The Chatoyer Advantage



CHATOYER environmental

- ✓ We've manufactured over 80,000 metres of silt curtain since 2009.
- ✓ Our technical experience translates to exceptional design and technical support.
- ✓ We ensure quality construction from our purpose-built factory.
- ✓ Our materials and components are reliable and durable.
- ✓ Our curtains are delivered fully assembled and ready for immediate deployment.

Specify Your Silt Curtain

1) What is the duration of the project?	
2) What is the curtain delivery deadline?	
3) Body of water where the curtain is to be installed? (Ie. Open ocean, river, canal, bay/harbour, pond/lake, ocean shore)	
4) Are there any specific EPA or other environmental requirements?	
5) Where is the location of the silt curtain? (give approximate details if in remote areas)	
6) What is the length of curtain required?	
7) What is the depth of water where the curtain is to be deployed?	
8) Do you know the depth of curtain required? If so, please advise.	
9) What is the average speed of water currents? (if known)	
10) What is the average wind velocity in the area? (if known)	
11) What is the highest possible wind velocity in the area? (if known)	
12) What is the width of the river/canal where the curtain is to be deployed?	
13) If there are tidal influences, what is the depth of water at low and high tide?	Low Tide: High Tide:
14) Any other information?	

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