De-watering Activities – General

SEDIMENT CONTROL TECHNIQUES

Photo 1 – De-watering an isolated work area

Photo 2 – De-watering of sediment prior to removal from a stormwater drain

Introduction

De-watering activities may be required on building and construction sites for various reasons including:

- de-watering excavations and trenches following storms;
- de-watering low-lying land subject to groundwater inflows;
- de-watering drainage channels and other water bodies prior to instream works (Photo 1);
- de-watering sediment basins and other sediment control systems;
- de-watering excavated material prior to its removal from the site (Photo 2).

De-watering processes can also be used to treat sediment-laden water discharged from such things as entry/exit *Wash Bays* and diamond saw cutting.

In each case, all reasonable and practicable measures must be taken to minimise any adverse effects of the de-watering process, including the minimisation of any sediment releases. This fact sheet contains an overview of various de-watering sediment control techniques.

Key Principles

1. First prior should be to retain all sediment-laden water from de-watering activities on the site in a manner that will not cause adverse effects—this may include disposal by irrigation. Only if this option is not reasonable or practicable should other treatment options be considered.
2. The relationship between TSS and NTU is highly dependent on soil type and site activities (i.e. earthmoving, extractive works, rock cutting or grinding). The relationship will also vary as the water passes through the treatment process. Consequently there is no generic correlation between the water treatment process and the achievable TSS and NTU outcomes.
3. Processes based on *settling* generally provide a low treatment standard, unless working with coarse, good settling soils; or settling times that exceed 1-day.
4. Settlement-based processes generally require the use of coagulants (flocculants) when applied to clayey soils.
5. Processes based on *filtration* generally vary in their treatment standard from ‘low’ for filtration through filter cloth, ‘medium’ for filtration through sand filters, up to ‘high’ for filtration through high-tech cartridge systems.

6. Over time, the particle sizes removed by filtering are more likely to be a function of the material that collects on the surface of the filter, rather than the nominal pore size of the filter. If operated at low flow rates (relative to the maximum flow rate) the captured particles can be less than 10% of the pore size; however, at high flow rates particles greater than the nominal pore size can be washed through the filter.
7. Filtration-based processes generally attract increasing operational and maintenance costs with an increasing degree of filtration.
8. Filtration-based processes generally have limited storage capacity for trapped solids, thus any reduction of the concentration of coarse sediments using a pre-treatment process (e.g. *Belt press, Sump pit* or *Sedimentation tanks*) should improve the overall process efficiency.
9. Processes based on artificial gravity, such as centrifuge and hydrocyclone units, generally vary in their treatment standard based on the type of contaminant and the operator's skills.
10. Artificial gravity processes can have a high capital cost and are generally best operated through commercial operators that have experience in the calibration and operation of the units.
11. One of the best ways to minimise the potential environmental harm resulting from the de-watering of excavated areas is to minimise the volume of surface water that is allowed to enter the excavation. This is normally achieved by diverting surface water away from the excavation.

Design Information

All sediment-laden water pumped from a work site must be suitably treated before being discharged from the site or returned to a water body (whether or not the water body is contained within the work site). What is considered 'suitable treatment' will vary from site to site based on numerous social, environmental, construction and economic issues.

The preferred technique for treating contaminated water depends on a number of factors including the volume and frequency of such discharges.

(a) Treatment standard:

The required treatment standard will vary from region to region based on local water quality objectives (WQOs). Site operators should seek advice from the relevant regulatory authority on the required treatment standard.

In the absence of local adopted treatment standards, Table 1 provides recommended default water quality objectives for de-watering operations.

Table 1 – Recommended discharge standard for de-watering operations

Site conditions	Discharge water quality standard
All cases.	Take all reasonable and practicable measures to achieve a 90 percentile total suspended solids concentration not exceeding 50mg/L.
Soil disturbances exceeding 2500m^2, or Projects exceeding $500,000 expenditure, or Post-storm de-watering of sediment basins and stilling ponds.	90 percentile total suspended solids (TSS) concentration not exceeding 50mg/L. Water pH between 6.5–8.5.

(b) Turbidity vs TSS:

To assist in the effective day-to-day operations of de-watering procedures, it is usually preferable for a site-specific water quality standard to be based on the equivalent Nephelometric Turbidity Units (NTU) to improve the response times of on-site water quality testing.

The relationship between turbidity and total suspended solids (TSS) varies widely across the full spectrum of sediments; however, for a given site the relationship generally becomes more stable. The more fines in sediment, the higher the expected NTU for a given TSS.

Sediment generated from the cutting, crushing or grinding of some rocks, such as limestone, can generate large quantities of fine and colloidal material that can make a significant contribution to turbidity levels even if the TSS is low. Water colour, such as resulting from tannins, can also increase turbidity levels relative to the TSS.

Sediment-laden runoff generated from an exposed organic-rich topsoil will generally have a low NTU for a given TSS; while runoff generated from an exposed subsoil will likely to have a much higher NTU for the same TSS.

In the absence of a site-specific relationship, Table 2 provides an alternative NTU-based treatment standard for de-watering operations. Table 2 is based on an **approximate** 'best guess' relationship between TSS and NTU as provided in Equation 1. Equation 1 is likely to be less appropriate for mine sites than construction sites.

$$\text{NTU} = \text{TSS} * (0.9 + 2.9 * (\text{fraction of clay in source material})) \qquad \text{(Eqn 1)}$$

Typical range for streams: $\text{NTU} = 1.0(\text{TSS}) \text{ to } 1.5(\text{TSS})$ (Eqn 2)

Table 2 – Alternative discharge standard for de-watering operations

Site conditions	Discharge water quality standard
All cases.	Take all reasonable and practicable measures to achieve a 90 percentile Nephelometric Turbidity Units (NTU) reading not exceeding 60.
Soil disturbances exceeding 2500m^2, or Projects exceeding $500,000, or Post-storm de-watering of sediment basins and stilling ponds.	90 percentile Nephelometric Turbidity Units (NTU) reading not exceeding 100, and 50 percentile NTU reading not exceeding 60.

(c) De-watering of potential acid sulfate soils:

If water is extracted from a location where the natural land elevation is below 5m AHD, then the site must be investigated for the potential contamination of the water by acidic leachate from actual or potential acid sulfate soils.

De-watering procedures within such areas may require a pre-treatment phase prior to their discharge, whether or not the discharge occurs on-site, or is collected and removed from the site.

The appropriate State agency should be contacted for guidelines on recommended and/or approved treatment processes. Unless otherwise required by the regulating authority, the recommended treatment standard is presented in Table 3.

Table 3 – Recommended treatment standard

Parameter	Treatment standard
pH	6.5 to 8.5
Total iron	Not exceeding 0.3mg/L
Total aluminium	Not exceeding 0.2mg/L

(d) Protection of aquatic wildlife (instream works):

When de-watering instream work sites it is important to instigate appropriate measures to minimise the risk of aquatic wildlife being sucked into the intake pipe. Such measures may include:

- removing trapped animals from enclosures prior to de-watering; and/or
- forming a wire mesh cage or similar fine mesh frame around the intake pipe; and/or
- wrapping the intake pipe in shade cloth (**not** sediment fence fabric); and/or
- placing the intake pipe inside a perforated PVC pipe (holes covered with fine mesh); and/or
- using a gravel-filled and screened *Sump Pit* to house the intake pipe (refer to separate fact sheet).

(e) Sediment controls for the de-watering of excavated material:

The de-watering of material removed from excavations, or dredged from drainage channels, is normally performed by temporarily stockpiling the material within a designated sediment control area, then allowing natural drainage of the material. The process may also be done after the material is loaded into a truck, in which case the truck is required to remain within the sediment control area until sufficient water has drained from the loaded material.

If the material is loaded directly into a truck, then filter cloth can be placed over the loading bay to capture sediment spills.

This practice can be used to reduce the cost and time of rehabilitating the loading bay (such as when maintenance works occur within a park or road reserve).

Photo 3 shows a truck loading bay with a filter cloth splash pad partially folded out of the way while maintenance occurs on the loader.

Photo 3 – Material loading bay

Table 4 outlines best practice sediment control measures for the de-watering of excavated material and earth stockpiles.

Table 4 – Sediment control practices for de-watering stockpiles

Material	Technique	Comments
Clean, non-clayey material (no chemical contamination)	*Sediment fence*	• Non-woven, composite *Sediment Fence* fabric preferred.
	Grass filter bed	• Ensure grassed area remains unsaturated during de-watering operation.
Clean, clayey material (no chemical contamination)	*Compost berm,* *Filter sock*	• Ensure the berm/sock is placed along the contour to achieve even flow distributed along its length. • Ensure water does not bypass around the end of the berm or sock.
	Filter fence (non-woven filter cloth)	• Stockpiled material should not rest against the fence, otherwise the fabric may need to be supported by wire mesh, or aggregate berm. • Woven *Sediment Fence* fabric must **not** be used.
Contaminated material	*Compost berm*	• Seek expert advice on case-by-case basis. • Adequate treatment may not be achieved.

(f) Staged processes:

To achieve the required treatment standard without excessive energy or maintenance costs normally requires the development of a staged treatment process, similar in concept to a wastewater treatment plant. Staged processes are common on large, long-term construction sites, such as within extractive industries and tunnelling operations.

On large sites, or sites that require a high flow rate, a commercial package plant can be designed and operated. Such plants can be assembled within a tower to minimise their footprint, or laid out in a manner and size similar to that of a package water treatment plant or concrete mixing plant.

(g) Technique selection:

Figure 1 provides an indication of the 'potential' outcomes of various treatment processes. Actual outcomes can be highly variable based on the soil properties, the choice of equipment, and the operational flow rate relative to the equipment's maximum flow rate.

Figure 1 follows only the pathway of the liquid output. It should be noted that within each process there will be at least two outputs (i.e. solid and liquid outputs), each of which might require further treatment before discharge or removal for the work site. For some treatment processes a third output will be generated, i.e. the 'backwash'. Thus these treatment processes will produce both a 'clean' liquid discharge and a 'dirty' liquid discharge.

On very small jobs, backwashing can occur off-site if mobile treatment units are used; however, in most circumstances the backwash will require further treatment on the site. The treatment of the backwash water should be considered as a separate process possibly requiring a completely different treatment system.

In some cases the 'solid' (i.e. concentrated sediment) output from each process may require further de-watering and/or treatment before it can be transported from the site.

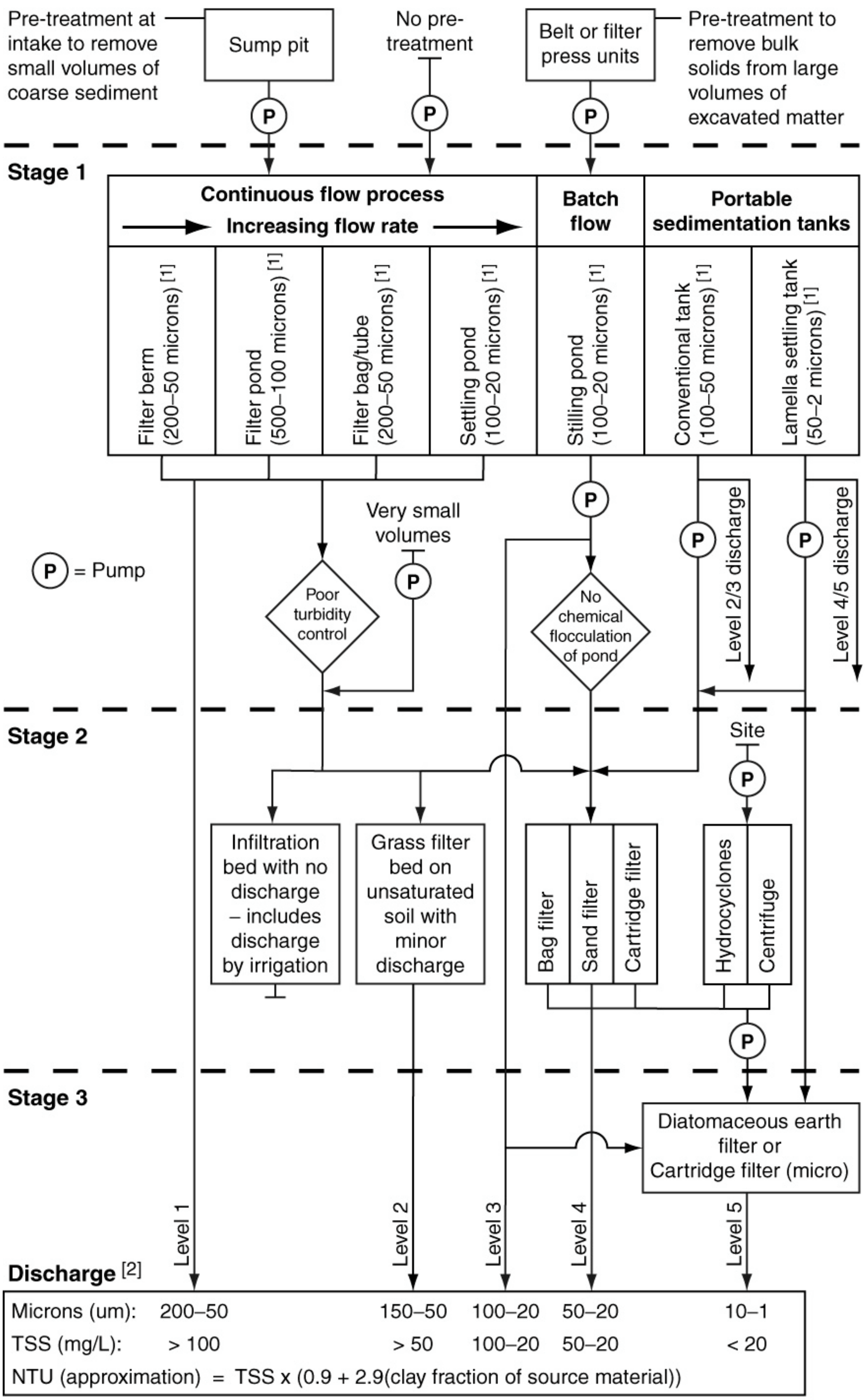
In general terms, the treatment processes shown in Figure 1 increases in complexity towards the right-hand-side of the diagram. Some of the processes, such as lamella settling tanks, hydrocyclones and centrifuge units, can be highly effective if managed by experienced operators, but can also perform very poorly if flow rates are pushed beyond the calibrated settling.

Specialist treatment systems such as hydrocyclones and centrifuge units need to be calibrated for a specific input water flow rate and particle size. Achieving the optimum output water quality may require a significant calibration phase, thus these systems are best used on very large projects where a specific inflow water quality is known to exist and this material has uniform properties throughout the full operational period.

The best advice is to use Figure 1 as an initial guide to the type of system likely to be required on a construction site, then approach appropriate experts within each field of operation to design an overall treatment process that best suits the site conditions.

Photo 4 – Submersible pump de-watering an excavation

Photo 5 – De-watering should not discharge untreated into drains



[1] Approximate critical sediment particle size – results variable depending on design details.

[2] Approximate values only – results vary depending on equipment, operating conditions and soil type.

Figure 1 – Typical staged treatment processes

(h) Overview of treatment processes:

Bag filters (micro filtration):

Process:	• Filtration through small filter bags with a fine micron rating.
Examples:	• Commercial pressure filters containing one or more small, fine-micron filter bags. The bags are typically made of sewn polyester or welded polypropylene.
	• A *bag filter* is **not** the same as a *filter bag*.
Performance:	• Typically a medium treatment efficiency. The capture efficiency of bag filters is typically in the range of 50 to 70% of the nominal pore size. Bags have a nominal pore size of 0.001 to 0.1mm (1 to 100 microns). Typically this relates to a critical particle size in the range of 50 to 100 microns.
	• Initial discharge can be poor until a sediment build-up occurs on the surface of the filter.
	• The filter bags normally need to operate in association with a pre-treatment process, typically a sedimentation tank.
	• Flow rates of around 23m^3/hr per (175 x 750mm) bag, with a full capacity of around 3kg of sediment.
	• Compared to cartridge filters, bag filters have a higher flow rate at a lower pressure drop, and a higher particle capture volume.
Costs:	• Medium cost

Belt Press and Filter Press:

Process:	• Filtration through geotextile belt/filter.
Examples:	• Truck-mounted belt press.
	• Fixed or truck-mounted filter press units.
Performance:	• Performance similar to filter bags.
	• Belt press can be used as a pre-treatment process within very large de-watering projects to reduce the volume of water requiring treatment.
	• Filter press units can be used for high quality treatment of small volumes.
Costs:	• Typically operated on a rental basis.

Cartridge filters:

Process:	• Filtration through commercial cartridge filters.
Examples:	• Commercial treatment units with replaceable filter cartridges.
Performance:	• Typically a high to very high treatment efficiency. The capture efficiency of cartridge filters is typically in the range of 70 to 90% of the nominal pore size.
	• Nominal pore size of around 0.0005 to 0.1mm (0.5 to 100 microns). Cartridge filters used in domestic pool filters capture particles generally in the range of 20 to 100 microns.
	• Cartridges include: string wound (common for rainwater tank filters), melt spun cartridges (for micro filtration) and oil adsorption filters.
	• Industrial cartridge filters are generally able to remove finer particles than sand or bag filters.
	• Flow rate of around 2 to 3m^3/hr per 1m long cartridge for a nominated 10 micron critical particle size.
Costs	• High capital and operational (cartridge replacement) costs.
	• Best used for small jobs, otherwise consider a DE Filter.

Centrifuge:

Process:
- Settlement through induced artificial gravity.

Examples:
- Range from small truck-mounted units to large fixed industrial units.

Performance:
- Flow rates of around 3 to 60m^3/hr of transportable units, up to 1500m^3/hr for industrial units.
- These units are calibrated for a specific input water flow rate and particle size. A highly varied inflow material can produce a highly varied output.

Costs:
- May require high amp, 3-phase power supply.
- High-gravity units can experience high wear rates when treating abrasive-grit-laden water.

Diatomaceous earth (DE) filters:

Process:
- Filtration through diatomaceous earth.

Examples:
- Portable skid-mounted pressure chamber units.

Performance:
- Typically a high to very high treatment efficiency. Critical particle size of around 0.001mm (1 micron).
- One of the few filter-based systems capable of removing clay-sized particles, and thus reducing turbidity levels.
- Flow rate of around 6m^3/hr per kg of diatomaceous earth (single use).
- Disposal of the used diatomaceous earth can be problematic.

Costs:
- Similar cost to sand filters.

Filter bags and filter tubes:

Process:
- Filtration through bag or tubes manufactured from non-woven fabrics.
- The filtration process (and thus output quality) increases after a fine sediment layer is allowed to build-up on the surface of the filter.

Examples:
- A *filter bag* is **not** the same as a *bag filter*. A ‘filter bag’ is a large coarse-micron bag, a ‘bag filter’ is a commercial filter containing one or more small, fine-micron bags.
- ‘Filter bags’ are large square or rectangular bags.
- ‘Filter tubes’ are long tubes (as much as 10m length).

Performance:
- Most geotextile-based filtration systems provide only low treatment efficiency.
- Initial operation removes particles in the range 0.05 to 0.1mm (50 to 100 microns), but can potential remove particles in the range 0.02 to 0.05mm (20 to 50 microns) once partial sediment blockage of the fabric has occurred (but flow rate may drop to around 10L/m^2/min under these partially blocked conditions).
- Maximum flow rates of around 45m^3/hr/m^2.

Costs
- Low cost

Filter fence:

Process:
- Filtration through non-woven fabric.

Examples:
- A vertical sediment fence formed from non-woven fabric rather than traditional woven fabric.

Performance:
- Generally very poor treatment efficiency, but generally high than a woven fabric at low flow rates.
- Best used only for the de-watering of earth stockpiles up-slope of a grass filter bed.

Costs:
- Low cost

Filter ponds, filter socks and filter berms:

Process:
- Filtration of coarse particles through various synthetic and natural materials.

Examples:
- 'Filter berms' are enclosures formed from either a loose compost berm or large compost-filled filter tube. The large compost-filled filter tubes are sometimes referred to as *'Filter Socks'*.
- 'Filter ponds' are circular, vertical sidewall ponds formed from a combination of coarse filter media such as sediment fence fabric, sandbags and aggregate.

Performance:
- Filter berms, if not overtopped, can achieve a low to medium filtration depending on the width of the berm.
- Filter ponds generally have only a low treatment efficiency.

Costs:
- Very low costs

Grass filter beds:

Process:
- Filtration of particulate matter as the water infiltrates into the ground.

Examples:
- Large areas of uniformly graded grass on porous soil.

Performance:
- Medium to high filtration while the soil remains unsaturated.
- Generally very poor performance immediately following rainfall.
- Performance decreases with increasing surface runoff from the grass.

Costs:
- Low cost

Hydrocyclones:

Process:
- Settlement through induced artificial gravity with banks of conical tubes (similar to modern bag-less vacuum cleaners).

Examples:
- Fixed or truck-mounted units

Performance:
- Hydrocyclones can be used to concentrate the sediment, thus reducing the volume of water requiring secondary (polishing) treatment.
- Increasing the throughput of a hydrocyclone system is achieved by increasing the number of cyclones, not by increasing their diameter.
- These systems generally require pre-treatment for the removal of coarse sediments to improve their operational efficiency.
- Flow rates of 0.1 to $1m^3$/hr for a mean particle size of 0.002 (2 microns).
- Flow rates of around $12m^3$/hr for a mean particle size of 0.01 (10 microns).
- Flow rates of around $25m^3$/hr for a particle size of 0.015 (15 microns).

Costs:
- High purchase cost

Portable sedimentation tanks (including lamellae tanks):

Process:
- Gravity-based settling in tanks.

Examples:
- 'Oil-water separators'—commercial prefabricated tanks containing an under-flow weir to separate and retain oils and floating debris.
- 'Portable sedimentation tanks'—including modified mini skips and commercial settling tanks typically in the range of 4 to $40m^3$. Conventional sedimentation tanks are likely to trap particles down to 0.05 to 0.1mm (50 to 100 microns). Heavily baffled, thin-plate 'lamella tanks' operating under appropriate flow rates with chemical flocculation are reported to capture particles down to 0.002mm (2 microns).

Performance:
- Site modified mini skips typical have a low treatment efficiency.
- Commercial settling tanks have a low to high treatment efficiency.

Costs:
- High purchase or construction costs, with medium operational costs.

Sand filters:

Process:
- Filtration through fine granular material.

Examples:
- Commercial sand filters (similar to the systems used on residential swimming pools.
- In-situ sand filters similar to those used for urban stormwater treatment.

Performance:
- Generally not recommended for turbidity control due to poor capture of clay-sized particles.
- Most commercial sand filters provide medium treatment efficiency. Critical particle size of around 0.02 to 0.05mm (20 to 50 microns).
- Most in-situ sand filters provide high treatment efficiency because the effluent is further treated by allowing infiltration into the ground.
- Flow rates of around 7 to 14m^3/hr per 100kg of sand.

Costs:
- High purchase or construction costs, with high maintenance costs.

Sediment basins:

Process:
- Gravity-based settling within open ponds.

Examples:
- Excavated sediment basins operated as either a free draining 'dry' system, or batch flow 'wet' system.

Performance:
- 'Dry' sediment basins generally have a low to medium efficiency similar to a settling pond.
- 'Wet' sediment basins generally have a medium to high efficiency similar to a stilling pond.

Costs:
- Medium to high construction cost, with low operational costs.

Settling and stilling ponds:

Process:
- Gravity-based settling within open ponds.

Examples:
- 'Settling ponds', which are free draining and allow continuous operation.
- 'Stilling ponds', which operate under a batch process—the treated water only being released after achieving a specified water quality.

Performance:
- Settling ponds generally have a low to medium efficiency similar to a 'dry' sediment basin.
- Stilling ponds generally have a medium to high efficiency similar to a 'wet' sediment basin.

Costs:
- Medium construction cost, with low operational costs.

Sump pits:

Process:
- Filtration through aggregate.

Examples:
- Excavated sump pit filled with aggregate that surrounds a vertical standpipe.

Performance:
- Low treatment efficiency.
- Best used as a pre-treatment process to capture coarse sediment.

Costs:
- Low cost

Photo 6 - Belt press

Photo 7 - Cartridge filter

Photo 8 - Filter bag

Photo 9 - Filter berm

Photo 10 - Filter pond

Photo 11 - Filter press

Photo 12 - Filter tube

Photo 13 - Hydrocyclones

Photo 14 - Infiltration bed (permanent installation)

Photo 15 - Mobile treatment unit

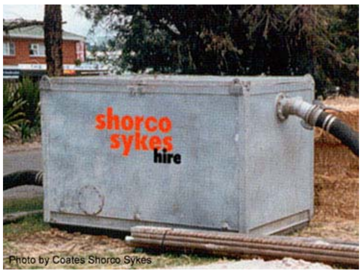


Photo 16 - Portable sedimentation tanks

Photo 17 - Domestic sand filter

Photo 18 - Settling pond

Photo 19 - Stilling pond

Photo 20 - Sump pit showing de-watering pipe exiting from the stand pipe