INTRODUCTION

Drain envelopes and filters are two different techniques used to solve different problems. Drain envelopes are permeable materials, such as gravel, placed around the drains for the purposes of improving flow conditions. Filters for drains are permeable materials, such as geotextiles, placed around the drains for the purpose of preventing fine-grained materials in the surrounding soil from being carried into the drain by groundwater. Table 1 can be used to initially estimate the requirements for further investigation on filters or envelopes.

Table 1 DRAIN FILTER AND ENVELOPE RECOMMENDATIONS

<table>
<thead>
<tr>
<th>Soil Texture</th>
<th>Envelope or Filter Recommendations</th>
<th>Degree of Urgency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravel</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Gravelly Coarse Sand</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Very Coarse Sand</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Gravelly Fine Sand</td>
<td>Filter</td>
<td>Moderate</td>
</tr>
<tr>
<td>Medium Sand</td>
<td>Filter</td>
<td>High</td>
</tr>
<tr>
<td>Fine Sand</td>
<td>Filter</td>
<td>Very High</td>
</tr>
<tr>
<td>Loamy Sand</td>
<td>Filter</td>
<td>High</td>
</tr>
<tr>
<td>Sandy Loam</td>
<td>Filter</td>
<td>Moderate</td>
</tr>
<tr>
<td>Loam</td>
<td>Filter</td>
<td>Low</td>
</tr>
<tr>
<td>Silt</td>
<td>Filter</td>
<td>Moderate</td>
</tr>
<tr>
<td>Silty Clay Loam</td>
<td>None</td>
<td>Moderate</td>
</tr>
<tr>
<td>Sandy Clay</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Silty Clay</td>
<td>Envelope</td>
<td>Moderate</td>
</tr>
<tr>
<td>Clay</td>
<td>Envelope</td>
<td>Moderate</td>
</tr>
<tr>
<td>Peat</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

FILTERS

Filters can be either geotextile or well graded gravel and sand.

Filters are necessary only where there is something in the soil that needs to be filtered out, namely fine sand. If sand is not present, filters are not necessary. Not only do filters add to the cost of drainage but they also constitute an additional barrier to inflow of water and can, therefore, reduce the effectiveness of the drain. Few soils present the danger of sand particles clogging the drainage system.

Most soils contain sufficient amounts of clay or organic matter to form relatively stable aggregates of individual soil particles. Filters in these soils are of no benefit and may of reduce drain performance. Instead of filters, a porous envelope is appropriate to ensure good flow conditions at all times at the interface between drain and soil. Drain rock, pea gravel and similar materials meet these requirements and are used extensively in some drainage applications.

The first step in the design of a proper filter system, either geotextile or sand and gravel, is to perform a particle size analysis of the soil at the drain depth in the field. Using these results and Table 2, the need for a filter can be determined. Usually soils with more than 30% clay content do not require a filter.

GEOTEXTILE

Geotextile filters have been available since the mid 70’s. Corrugated plastic drainage tubing is available with factory pre-wrapped synthetic filter materials. The filter materials are applied to the drain by the
drain manufacturer and are installed in the same manner as a filterless pipe, albeit at an additional cost.

Since most groundwater enters the drain from below, there is great advantage to a completely wrapped pipe, especially in soils with poor cohesion.

Suitable filters may be used to restrict fine particles of silt and sand from entering the drains. A properly designed filter stabilizes the soil around the drain and allows free entry of water. There are two basic types of geotextile filters, knitted and non-woven.

Knitted geotextiles are usually made of polyester or polypropylene filaments that are knitted or woven together. The most common type has a thickness of 1 mm, a weight of 150 g/m² and an Apparent Opening Size (AOS) of 300 microns. For applications requiring more filtration capacity, a sock knitted with velour or pile on one side, that is thicker (< 2 mm), heavier (250 g/m²) and has an AOS of about 100 microns is available.

Non-woven geotextiles are made from several layers of randomly distributed fibres that are rolled pressed and usually interconnected by needle punching. Research has shown that fabrics that are about 2 mm thick are very good for silty soils.

The following equation can be used as a general guide for designing a geotextile filter.

\[ \frac{O_{95} \text{ Fabric}}{D_{85} \text{ Soil}} \leq 2.5 \]  

where \( O_{95} \) is the apparent opening size (AOS) of the geotextile filter and \( D_{85} \) is the size of which 85% of the particles are finer.

<table>
<thead>
<tr>
<th>Clay %</th>
<th>( D_{85} ) of Soil</th>
<th>Recommended Filter</th>
</tr>
</thead>
</table>
| Less than 30% | \( D_{85} \geq 400 \mu m \) | - Any type in which AOS* \( \leq 800 \mu m \)  
- Pin hole pipe (opening \( \leq 800 \mu m \)) |
| 400 \( \geq D_{85} \geq 120 \mu m \) | - Woven or non-woven 25 \( \leq AOS \leq 350 \mu m \) |
| 120 \( \geq D_{85} \geq 2 \mu m \) | - Minimum thickness 1.9 mm  
- Pile or velour surface (density \( \geq 140 \text{ g/m}^2 \))  
- 25 \( \leq AOS \leq 200 \mu m \)  
or  
- Non woven when AOS \( \leq 3 \times D_{85} \) of the soil |
| More than 30% | No filter needed (may need envelope) |

* AOS, EOA and \( O_{95} \) are equivalent terms often used in manufacturers specifications

**Gravel and Sand Filters**

In arid areas sand and gravel filters are used to some extent instead of geotextile filters. Drains usually run deeper and the sand and gravel filters also act as an envelope to improve bedding and permeability characteristics. Filter materials should be well graded. If more than one gradation is used, the layers should be from coarsest to finest material, starting at the pipe.

A minimum thickness of 100 mm is recommended for each layer of the filter.

Limits for the filter material should be established using the following equations:

\[ D_{50} \text{ Filter} = 12 \text{ to } 58 \]  
\[ D_{50} \text{ Base} \]  
\[ D_{15} \text{ Filter} = 12 \text{ to } 40 \]  
\[ D_{15} \text{ Base} \]

From these equations, \( D_{50} \) (the size of which 50% of particles are passing through the screen) of the base material times 12 and 58 will yield the lower limit and upper limit for \( D_{50} \) filter. Provided the filter has...
no more than 5% finer than 0.074 mm and is relatively well graded. The chosen filter material should be checked against the following equation for stability.

\[ D_{15} \text{ Filter} \quad \leq 5 \quad \text{(EQ 4)} \]

\[ D_{85} \text{ Base} \]

The \( D_{85} \) size of the filter material with respect to the opening of the drainpipe should be verified using the following equation:

\[ D_{85} \text{ Filter} \quad \geq 2 \quad \text{(EQ 5)} \]

\[ \text{Maximum drain pipe opening} \]

It is crucial for filters that the material be well graded. A filter material is considered well graded when all particle sizes from the largest to the smallest are present in a balanced way. Once particle size tests are done, it is simple to verify how well graded the material is. The coefficient of uniformity can be calculated using.

\[ C_u = \frac{D_{60} \text{ Filter}}{D_{10} \text{ Filter}} \quad \text{(EQ 6)} \]

where \( C_u = \text{Coefficient of uniformity} \)

\[ C_c = \frac{(D_{30})^2}{(D_{10})(D_{60})} \quad \text{(EQ 7)} \]

where \( C_c = \text{Coefficient of curvature} \)

Equations 4 and 5, in conjunction with Table 3, should be used to verify the material is well graded.

<table>
<thead>
<tr>
<th>Table 3</th>
<th>Requirements for “Well Graded” Filter Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Size of Aggregates</td>
<td>38 mm</td>
</tr>
<tr>
<td>( D_{90} )</td>
<td>( \leq 19 \text{ mm} )</td>
</tr>
<tr>
<td>( D_{10} )</td>
<td>( \geq 0.25 \text{ mm} )</td>
</tr>
<tr>
<td>( C_u )</td>
<td>Sand ( C_u &gt; 4 ) Gravel ( C_u &gt; 6 )</td>
</tr>
<tr>
<td>( C_c )</td>
<td>( 1 \leq C_c \leq 3 )</td>
</tr>
</tbody>
</table>

**GRAVEL ENVELOPES**

The basic functions of a drain envelope is to improve permeability in the zone surrounding the drain. For this reason, the envelope material should have a hydraulic conductivity 7 times higher than the base material. Since envelopes are not designed for their filtration capacity, they do not need to be well graded.

The thickness should be the same as the sand and gravel filter (i.e. 100 mm around the pipe). All the envelope material should be smaller than 38 mm, \( D_{90} \leq 19 \text{ mm} \) and the \( D_{10} \geq 0.250 \text{ mm} \).

**WOOD WASTES**

In past years, drains were installed with a covering layer of organic material such as hog fuel, wood chips, sawdust and straw. The long-term effectiveness of these envelope filters are doubtful. The use of wood waste materials such as hog fuel, chips and sawdust are not recommended due to environmental contaminants from leachates produced by them.

See the BC Agricultural Drainage Manual for more information on filter design and soil sampling.
EXAMPLE: Filter Material

A local drainage contractor wants to find a local source for a material to use as a filter for a drainage project.

1. The first step is to sample the soil at drain depth on the project site and determine the base material. This establishes the base material characteristic curve.
2. The next step is to sample the potential materials from different local pits. Particle size analysis of the pit material is sometimes available from the pit owner.
3. The lower and upper limit for the filter material is calculated from results of the particle size analysis of the base materials.
   \[
   \begin{align*}
   D_{85} &= 0.07 \text{ mm} \\
   D_{50} &= 0.025 \text{ mm} \\
   D_{15} &= 0.006 \text{ mm}
   \end{align*}
   \]
   From EQ 2
   \[
   \begin{align*}
   D_{50} \text{ (Filter)} &\geq 12 (0.025) \text{ Lower Limit} \\
   D_{50} \text{ (Filter)} &\leq 58 (0.025) \text{ Upper Limit} \\
   0.3 &\leq D_{50} \text{ (Filter)} \leq 1.45
   \end{align*}
   \]
   From EQ 3
   \[
   \begin{align*}
   D_{15} \text{ (Filter)} &\geq 12 (0.006) \\
   D_{15} \text{ (Filter)} &\leq 40 (0.006) \\
   0.072 &\leq D_{15} \text{ (Filter)} \leq 0.24
   \end{align*}
   \]
4. Once both limits are calculated, the results from the particle size analysis of the three local pits are overlaid to determine the best filter material.
5. From the following figure, it is apparent that the material from Pit #2 is the best suited for a filter material. If more than one layer is required the first layer then becomes the base material and the process is repeated.
freedom from the problem is not possible, physical removal of the ochre is required at some point.

### 3.1 Low Pressure Cleaning

Low pressure removal of ochre is feasible provided the ochre in the pipe is fresh and gelatinous. An effective method has been developed using a vacuum tanker intended for liquid manure spreading.

When the drainage system is filled with water, the pipe from the tanker is removed from the outlet allowing the system to flush. This will remove a great deal of ochre, however, a second flushing is recommended for better effect.

The relative effectiveness of the flushing will depend on the drag force of the water, which in turn depends upon the pipe grade. A steeper grade pipe will enhance the flushing action.

Flushing on an annual basis can keep a drainage system in good working order even in badly clogged sites.

Care must be taken so that too much pressure isn’t applied to the system as pipe joints could blow out. This method is useful where laterals are connected to a main and are not accessible from an open ditch.

### 3.2 High Pressure Cleaning

High pressure cleaning is required if the ochre has aged and become firmly encrusted onto the tile. Individual drains must be cleaned from the outlet. A high-pressure nozzle with water spraying in a backwards direction propels the nozzle up inside the tile. Because of this type of operation, only straight lines or shallow bends can be cleaned. This method is more practical for laterals ending in an open ditch, otherwise, connections to main would have to be dug up. An alternative is to install a Y fitting on each lateral line near the main. A piece of tubing can then be angled up to the surface and capped and marked thus allowing easy access to the pipe. The length of drain is restricted because of the ability of the nozzle to pull the hose behind it.

Cleaning between corrugations require at least 690 kPa when the drain openings are holes. A pressure of 2756 kPa was found to remove only 30% of the ochre between corrugations when the openings are slits.

This is another reason why large slits should be used in ochre affected areas and why cleaning of many older installations are only partially successful.

Pressures up to 2756 kPa at the nozzle are suggested as the upper limit for sandy soils until more research is carried out. Too high a pressure will cause considerable damage to the envelope of material surrounding the pipe causing sand and gravel to be swept into the tile.

### 3.3 Chemical Cleaning

Persistent aged ochre may only be removed by acids or reduction agents. Fresh ochre can be dissolved with 10% hydrochloric acid, however, it must be added in excess to prevent reprecipitation of iron oxide hydrate.

As the ochre ages, it’s solubility in hydrochloric acid decreases so it is often difficult to estimate the required amount of acid. Since the drains carry water, additional dilution will occur upon introduction to the drain.

The general procedure used is to pump the acid into the drain and dam it up for several hours. The acid-ochre suspension is then repumped into tankwagons and the procedure is repeated with fresh acid. A succeeding flush with water is also required to remove acid residue. All the flushing material must then be disposed of at a safe chemical waste disposal facility.

Sulfuric and Sulfamic acids have also been used with success. Acid cleaning has been used extensively in Southern California but has now been replaced by high pressure cleaning. No acid should be used on drains with synthetic filters.

Chemical cleaning by the above methods is not recommended under any conditions by the BCMAF, due to its dangerous potential.

### 4. CONCLUSIONS

Many techniques tried around the world have been discussed and each has varying degrees of success. It is obvious no single technique will cure all problems and that it is necessary to employ a combination of techniques and to perform regular maintenance on the system. The following are
several worthwhile procedures that can be followed to minimize ochre problems.

1. Laterals should preferably drain into an open ditch rather than a main collector because often only a small area within a field can be problem causing. This will prevent clogging of the entire system and reduce the time required in cleaning.

2. If laterals must join to a main collector, they should be installed with Y connections to the main to allow jet cleaning.

3. Good soil structure is important for many different reasons. It will reduce ochre problems by allowing fast percolation of water through the soil thereby minimizing waterlogged conditions and maintaining good aeration, therefore promoting oxidation of iron in the soil.

4. Avoid using backfill materials other than coarse gravel as other materials will eventually clog.

5. Back flooding of the drain tile can reduce ochre clogging by about 20%.

6. Flushing should be done within the first year rather than waiting for the pipe to severely clog. Ochre is much easier to remove when it has not aged.

7. Drain tubing with large slits or preferably round holes will resist clogging longer than small holes and slits. Drain tubing with cleanly cut holes and slits should be used as ochre will preferentially stick to frayed edges.

8. Use of the drainpipe with biocide will assist in controlling the ochre during the period of severe clogging after installation.

Preliminary test results on the drain tile with biocide show some success, but additional investigations are required before it can be recommended for use.

9. Increased pipe grades will enhance the self-cleaning process and make low-pressure cleaning more effective.