Chapter 7

Drainage

This chapter looks at the health risks caused by the presence of water[1] in the human environment and how this water can be drained. The purpose of drainage is to remove unwanted water from the human environment [(17)]. It is often difficult to make a clear separation between 'unwanted' and 'wanted' water, as people will usually use surface water, for example for irrigation or watering animals. What is unwanted, however, are the health risks associated with surface water.

From a health point of view, the properties of the surface water are usually more important than its origin. The WES specialist needs to separate the different sources, as different types of structure will be needed to deal with them properly. In the section on surface water and the transmission of disease we will look generally at surface water, while in the section on the practical aspects of drainage we focus on the sources of water and how to cope with them.

Drainage must handle water of different origins: domestic waste water (or sullage), rainwater (or stormwater, runoff), floodwater, and water from natural sources (e.g. springs).

Sullage includes used water (e.g. washing water), water spilled at the distribution point, water from leaks in the system, or from taps. Sullage is usually produced in low volumes, and without seasonal fluctuations.

Stormwater is that rainwater that has not infiltrated into the soil, was not intercepted by the vegetation, and did not evaporate. This surplus water will either collect in depressions in the surface, or flow over the surface until it reaches channels, streams, or rivers, through which it will be evacuated. Stormwater often occurs in large volumes, and is a seasonal problem.

Floodwater is generally water from overflowing rivers or channels. Flooding is a seasonal problem which usually involves large volumes of water [(15)].

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[1] The health risks associated with water in the human environment are normally caused by fresh surface water

Natural water sources can result in unwanted water if the water is able to collect in large puddles or ponds.

In addition, industry, agriculture, mining, and other activities (e.g. medical facilities, abattoirs) may produce waste water. Most of the health risks related to these will be similar to the other types of surface water, but there may be specific health risks related to these types of waste water. These specific health risks are not covered by this manual.

Surface water can exist in many types of reservoirs. Naturally occurring surface water is found in lakes, marshes, natural ponds, streams, rivers, puddles – even leaf axils collecting rainwater can form 'reservoirs'. Artificial reservoirs of surface water include irrigation systems, channels, artificial water reservoirs (e.g. for hydroelectric power generation), overhead tanks, swimming pools, and pits resulting from construction work, agriculture, mining, brickmaking or other activities. Even small 'vessels' like old tyres, drums, blocked roof gutters, empty plant pots, or old cans that accumulate (rain)water may serve as a reservoir for 'surface water'.

Issues concerning drainage other than health

Stormwater, or floodwater, can kill people or animals, and can destroy buildings, roads or crops. Floods can make it impossible for people to move around. Poor drainage can cause landslides and mudflows, which may be a risk to people and their property. Stormwater can erode fertile soil, reducing production.

On the other hand improved drainage may degrade the environment if natural wetlands or ponds dry out or are filled in, if the local water-balance is disturbed, or if organically polluted drainage water is discharged into surface water, using up all its oxygen.

Artificial reservoirs are built to benefit people, for example by providing electricity or water for irrigation. In addition dams may benefit people downstream, as the flow of rivers or streams can be regulated, reducing the risks of floods or draughts. On the down side, people are often displaced and land and property lost when large artificial reservoirs are created. A dam may become a problem if people – or nature – are deprived of the water they depend on. If a dam bursts, a dangerous situation is likely to result.

7.1 Surface water and the transmission of disease

Drainage channels are frequently used for defecating, and the first rains after a dry period will often wash human and animal excreta from the surface into the drainage system. Water used for washing (people or clothes) will often contain faecal pathogens. Sullage or stormwater can therefore transmit faecal-oral infections directly to people and animals. If cattle and pigs can get to the water, they may become infected with beef and pork tapeworm. The chance of direct contact is increased if water stagnates in the drainage system because of blockages caused by soil, refuse, vegetation, or poor design or construction of the system.

If sullage or stormwater is discharged into fresh surface water (e.g. streams, rivers, lakes), the surface water will be polluted with excreta. This will result in a risk of faecal-oral infections and beef and pork tapeworm if people and animals use this water as drinking-water.

Any type of fresh surface water which is contaminated with urine or faeces can become a transmission risk for schistosomiasis. As the pathogen multiply in snails, even a light contamination of the water can create a large potential for transmission. Only fast-flowing rivers and streams, and deep water at a good distance from the shores, will be relatively safe [15]. Schistosomiasis is often associated with irrigation schemes and artificial reservoirs [36].

In addition to schistosomiasis, water-based helminths with two intermediate hosts can benefit from the discharge of faecally polluted drainage water into surface water.

Temporary pools and small containers (e.g. cans, drums, blocked gutters) full of relatively clean water are potential breeding sites for the *Aedes* mosquitoes which transmit filariasis, yellow fever, dengue fever, and several other arboviruses. The eggs of *Aedes* mosquitoes can survive for months outside the water, but must be in the water to hatch.

Where organically polluted water can accumulate (e.g. stagnant water polluted with waste from sanitary structures, organic refuse, or rotting plants), *Culex* mosquitoes, which transmit filariasis and several arboviral infections, can breed. *Culex quinquefasciatus* is often a problem in urban areas.

Where ponds or puddles of relatively clean water form, preferably with some form of vegetation, *Anopheles* mosquitoes, vectors of malaria and filariasis, can breed. *Anopheles* mosquitoes also breed in lakes, rice fields, and calm areas in slow streams [61]. Malaria is a problem associated with the presence of artificial reservoirs [6].

Surface water does not need to be permanent to be a risk; mosquitoes and snails can breed and survive in temporary or seasonal puddles and ponds. Mosquitoes can develop from egg to adult in less than two weeks [80]. Snails transmitting schistosomiasis can survive in ponds that dry up seasonally [5], and one snail can grow out into an infectious colony within two months [73].

A number of other infections could be a risk where drainage is poor.

If drainage water comes in contact with soil, it can become contaminated with soil-transmitted helminths (e.g. hookworm disease, roundworm infection). The soil-transmitted helminths need moist soil in which to breed, an environment which can be created by inadequate drainage. Sandflies, the vector of leishmaniasis, Bartonellosis and several arboviruses, breed in humid, organic soils [61].

Polluted water (e.g. from stagnant water in drainage channels) is a potential breeding site for the domestic fly [21], which can transmit faecal-oral diseases and infections transmitted by direct contact.

Rats are attracted to surface water, and can be a host for a multitude of infections including plague [80].

Turbulent, shallow ‘white water’, which can be created in the spillways of reservoirs, can become a breeding site for blackflies, which can transmit river blindness [6,15].

Table 7.1 presents the infections related to poor drainage.

The health risks of seawater and brackish water

The health risks linked to surface water are mainly related to freshwater.

The health threat of seawater is limited. The chance of transmitting excreta-related pathogens by seawater is small (see Section 6.2.4), and vectors and intermediate hosts can not survive in seawater.

Depending on the water’s salt content, the chances of excreta-related pathogens surviving or being transmitted will be higher in brackish water (water with a salt content between that of seawater and freshwater) than in seawater.

Table 7.1. Disease categories associated with poor or absent drainage

Risk-factors related to drainage

i Water accumulates
ii The drainage functions poorly, or is badly designed

	Faecal-oral infections	Schistosomiasis	Water-based with two intermediate hosts	Soil-transmitted helminths	Beef and pork tapeworm	Leptospirosis	Guinea-worm infection	Spread by direct contact	Vector-borne infections
i Clean surface water		(a)				(b)			(c)
Organically polluted surface water	(d)					(b)		(d)	(e)
Resulting in moist soil									(f)
ii Stagnant water in drainage						(b)		(d)	(e)
Poor disposal of drainage water						(b)		(d)	(e)

(a): as long as some food (plants, organic matter) is present in the water
(b): through rats being attracted to, and contaminating, the surface water
(c): *Anopheles* and *Aedes* mosquitoes
(d): through domestic flies
(e): *Culex* mosquitoes
(f): sandflies

Although most mosquitoes do not like salt water, some can breed in slightly salty water. *Anopheles* mosquitoes are in general more sensitive to salt water than *Culex* and *Aedes* mosquitoes (77). Some species of *Aedes* mosquitoes are able to breed in coastal salt marshes (61).

7.2 Practical issues concerning drainage

This section looks at some practical issues concerning the drainage of sullage and stormwater, and how other sources of surface water can be dealt with. Issues concerning flooding by external water bodies or large artificial reservoirs are not covered as they are complex, and will not normally be dealt with by a WES specialist at field level.

7.2.1 The disposal of sullage

Domestic waste water can often be disposed of where it is ‘produced’ (on-site disposal).

Where waste water is not polluted with pathogens (e.g. water spilt at a hand-dug well or handpump), it can be fed directly into a garden or vegetation. Care should be taken that no ponding can occur.

Soakaway pits and trenches can be used where waste water could be polluted, space is available, and the infiltration capacity of the soil is sufficient. A soakaway will have to be adapted to the physical situation and the characteristics of the sullage to prevent blockage or overloading.

The infiltration surface area ('surface of infiltration') must be adapted to the amount of waste water discharged and the infiltration capacity of the soil. Sand can be assumed to have an infiltration capacity of around 200 litres per m^2 per day. Silt and loam will normally be able to deal with up to 100 litres per m^2 per day. The infiltration capacity of clay will normally be less than 50 litres per m^2 per day. These values are for soil above the groundwater table [(57)]. It must be assumed that the pores in the bottom of the pit will clog with settled material, so only the vertical sides of the pit are used to calculate the surface of infiltration. If a lining is used, only the surface of the bare soil should be considered.

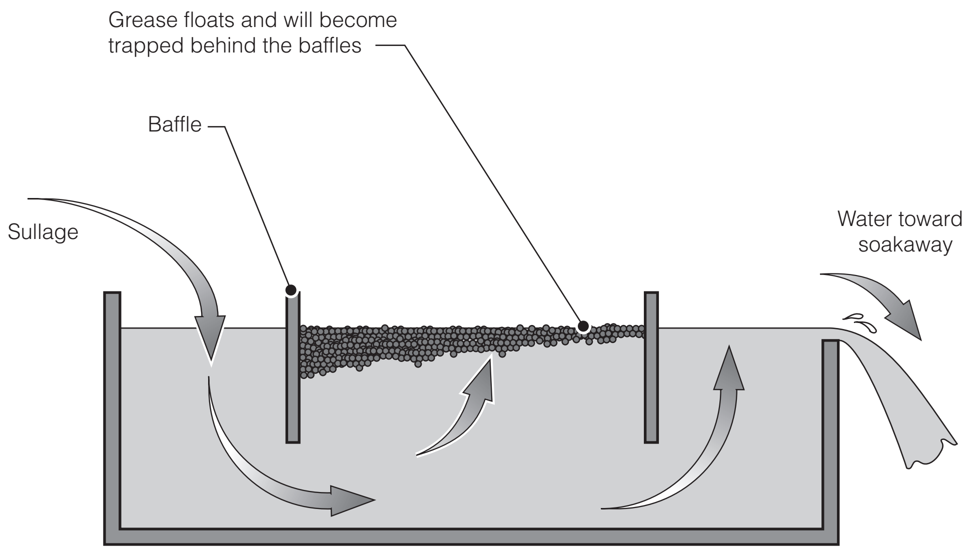

Figure 7.1. Section of a grease trap [(21)]

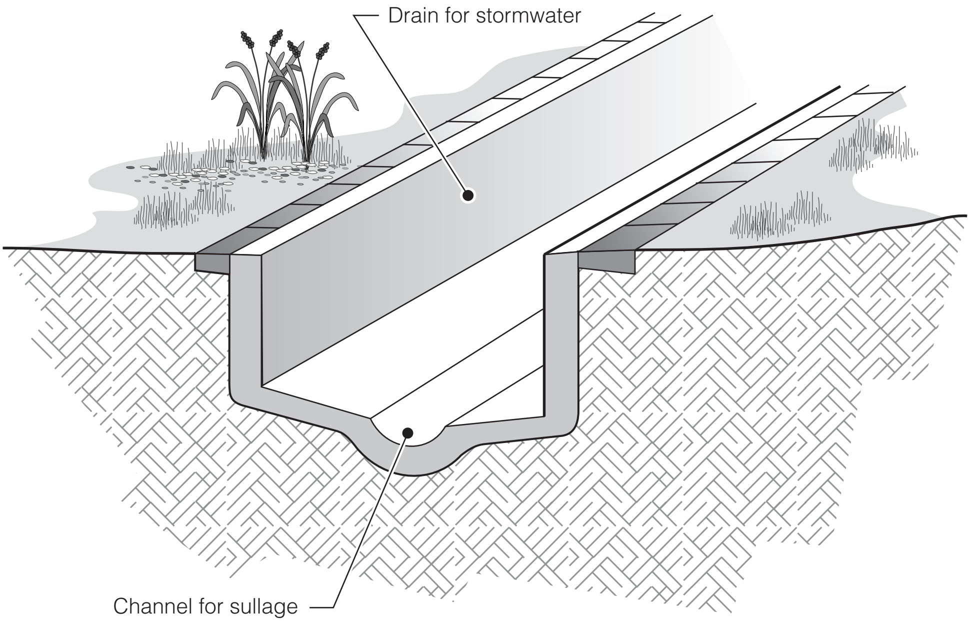

Figure 7.2. Section of a drain for evacuating stormwater and sullage [17]

Where sullage contains solids, they should be removed by straining the waste water or feeding it through a silt trap (i.e. a small reservoir which allows the solids to settle) . If the waste water contains grease or soap, a grease trap will have to be installed. Silt and grease traps should be impenetrable to insects and rats cannot enter. Figure 7.1 shows a model of a grease trap. Regular maintenance is necessary to ensure that these structure function properly.

Where enough surface is available and the climate is appropriate, evaporation pans or beds can be used. Eliminating waste water through evaporation is only possible where the climate is hot, dry, and receives very little rain throughout the year. Wind increases evaporation. Even in these ideal circumstances large surfaces are needed; open water will evaporate 5 to 10 litres per m^2 per day, an evaporation bed with vegetation can probably evaporate around 2 litres per m^2 per day [21].

Where the population density is high or the soil relatively impermeable, on-site disposal may not be possible. If there is a sewage system sullage can normally be discharged this way. If on-site disposal and sewerage are not present or possible, it may be necessary to dispose of the waste water in drains. Figure 7.2 shows a drain which can dispose of sullage as well as stormwater. The small channel in the drain is to discharge sullage, and its rounded form allows small amounts of water to flow at sufficient velocity to keep solids in suspension. This practise is not ideal as people, animals, and insects can come into direct contact with the waste water, but it is better than allowing waste water to pond. The health risks of discharging the waste water will have to be assessed, and if necessary, reduced.

Before considering using existing structures (e.g. pit latrines) for disposoing of waste water, investigate whether the existing structure can cope with the quantity of waste water that is to be discharged. Up to 80 per cent of the water supplied to users may become sullage [(17)].

Annexe 5 can be used to estimate the infiltration capacity of an existing pit already used for excreta. Discharging more liquid into the pit will also increase the distance that pathogens from the excreta in the soil will travel.

7.2.2 The drainage of stormwater

Where stormwater poses a risk to people, animals, or structures, or where it could pond and thus become a health risk, a drainage system will be needed to collect the stormwater and lead it away safely.

The size, type, and finish of the drainage system will depend on the availability of funds and the potential damage a flood could cause. The greater the risk, the greater the amount that should be invested in preventing flooding. Drainage systems need to be designed in combination with other structures (e.g. roads, buildings) to adapt the structures to one another.

In Annexe 6 a method is presented to calculate how much water would be discharged from a catchment area, and the size of the drain needed to discharge this amount of water. This method can be used to design a simple drainage system, or assess whether a proposed design is realistic. The design of a more complex system will be more demanding, and if the reader is not familiar with these procedures the design should be left to a specialist.

Refuse, soil, and the vegetation which accumulates in drainage channels will reduce the capacity of the system, and regular maintenance will be needed to keep it functional. Regular maintenance and inspection will also deal with collapse or other structural damage in the system.

The responsibilities of all actors in maintenance and structural repairs must be addressed early in the planning phase. Drainage systems are usually communal, but the basic maintenance of the system at neighbourhood level (e.g. removing blockages, cleaning the channels) is probably best done at household level [17]. The problem of solid waste management should be addressed in the planning phase of the drainage system as poor management of refuse (e.g. domestic waste or waste from construction) will result in inappropriate waste ending up in the drainage system.

Where the channels are not protected with a lining, erosion can be a problem if water flows at high speed or if the sides of the drains are too steep.

If tools or other materials are required for maintenance, these must be available to those who need them.

7.2.3 Other types of surface water

Temporary ponds or unwanted reservoirs can be filled to reduce the health risks. No new ponds should be created when sourcing the filling material. Where filling is not feasible, the vegetation along the sides of the water can be removed to make it less attractive to snails and mosquitoes, or the shoreline can be made steeper to control the vegetation.

The best way to deal with potential breeding sites for *Aedes* mosquitoes depends on the situation: solid waste must be removed, water tanks and drums must be covered with a lid or mosquito-proof netting, gutters should be maintained, hollow construction blocks or bricks should be filled, containers that are needed but not used should be turned upside down, and holes in trees must be filled [61]. It will only be possible to control *Aedes* by teaching people to be very vigilant and attentive to the problem.

Where springs result in ponding they can be protected (see Figure 5.3) to reduce the health risks.