
Technical Information
Document

COMMUNITY WASTEWATER SYSTEMS

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Foreword

This document is a general awareness publication. It is intended to provide an overview and general appreciation of community wastewater systems including wastewater collection, treatment, and disposal.

Policy and Standards

Policy and standards related to community wastewater systems in First Nation communities are addressed in the DIAND Corporate Manuals System (CMS) policy document "Capital Facilities and Maintenance - Water and Sewage Systems." The Levels of Service Standard and Design Standards established for community wastewater systems are included in the CMS policy document.

Scope

This document presents information on community wastewater systems including wastewater collection, treatment, and disposal. It is intended to provide information to Band Managers and DIAND Funding Services Officers on the various elements of community wastewater systems including the following :

- Wastewater Characteristics and Flows
- Wastewater Collection and Disposal
- Effluent Quality
- Wastewater Lagoons
- Mechanical Treatment Systems

Responsibilities

Community wastewater systems should be designed by a qualified and experienced professional engineer. Drawings and reports should bear the stamp or seal of the licensed professional engineer who is responsible for the design. The engineer should be registered in the province where the project is located.

Part 1: Wastewater Characteristics and Flow

1.1 General

Communities produce both liquid and solid wastes. The community's liquid waste is referred to as wastewater. Wastewater, or sewage as it is commonly termed, is essentially the community's used water which has been fouled by human waste products, food wastes, and cleaning wastes.

Proper disposal of wastewater is beneficial to the community. One key advantage of proper wastewater disposal is the prevention of the spread of disease. Human waste products can contain bacteria and other micro-organisms which cause very serious diseases such as typhoid fever and hepatitis. If wastewater containing disease-causing micro-organisms is disposed of into lakes and rivers which are used for drinking water or recreational purposes, disease has the potential of being transmitted throughout the community.

A second key benefit of proper wastewater disposal is the protection of lakes and rivers from pollution. The disposal of untreated wastewater into our lakes and rivers can cause pollution, which in turn can affect fish populations and can promote the growth of weeds and algae.

1.2 Wastewater Composition

Wastewater is mainly composed of water with small amounts of solid waste products. The solid waste products in wastewater are primarily composed of organic material of animal or vegetable origin. Being organic, the solid waste products in wastewater will eventually decay or decompose. For proper wastewater disposal, this organic material needs to be stabilized or converted to a form which will not cause the spread of disease or pollute lakes and rivers. Inorganic solids also need to be removed to properly treat the wastewater.

Wastewater also contains many bacteria. Although some of the bacteria may be pathogenic or disease-causing, most are in fact harmless. The non-pathogenic bacteria are very useful because they decompose the organic material in wastewater. As a result, non-pathogenic bacteria form the basis of any biological treatment process used in proper wastewater disposal.

1.3 Wastewater Flows

The quantity of wastewater flow from residences and other buildings will vary during the day with peaks typically occurring at mealtimes. This is because people tend to use much greater quantities of

water at specific times of the day, such as at breakfast, dinner, and supper. Also, more water tends to be used during summer months, leading to higher wastewater flows in the summer season. The operator should be familiar with the patterns of wastewater flow in the community. In doing so, if the pattern of flow suddenly changes, the operator is alerted that something may be wrong and can take appropriate steps to correct it.

1.3.1 Daily Water Usage

In a small community, the daily water usage per person depends on the type of water distribution system being used, the presence of facilities requiring large amounts of water (such as nursing stations or industrial operations), and other factors such as community lifestyle.

Refer to the Corporate Manuals System (CMS) document “Capital Facilities and Maintenance - Water and Sewage Systems” for figures on daily water demand per person and peaking factors.

1.3.2 Infiltration

Infiltration is the groundwater that enters the sanitary sewers due to damaged pipes or poor joints. A suitable allowance for infiltration and groundwater inflow should be made when designing sanitary sewers.

Basement or roof drain pipes should never be connected to the sanitary sewer because the resulting higher flows in the sewer following every storm can overload the collection system, possibly causing basement flooding and interfering with the proper operation of the wastewater treatment plant. Storm water should not be collected by the community’s sanitary sewer system.

1.3.3 Future Flows

To assess the future water demand of a small community, the community’s future population must be estimated. A community plan is often a good starting point for estimating future populations as it can indicate any plans for industrial and commercial growth or fire protection. The information gathered on future growth and fire flow along with data on daily consumption rates should provide a fairly accurate estimate of the community’s future water needs.

Part 2: Wastewater Collection and Disposal

2.1 Individual Systems

This is a system in which individuals are responsible for disposal of their own domestic wastes. This can vary from outdoor privies to private septic tanks and disposal fields.

2.1.1 Houses Without Plumbing

For interior use, individual houses with no plumbing may rely on interior non-flush toilets such as honey-bags/pails, composting, or chemical re-circulating toilets. If there is no electrical power available, disposal is limited to honey-bags/pails. With no community collection service, this usually means dumping the sewage on the ground near the house. Greywater, which is the term used to describe all washwaters and kitchen wastewaters, is also disposed of on nearby ground. Both practices can cause serious health problems as flies are free to breed and animals are in direct contact with disease-causing organisms in these wastewaters. The first development in community service is to provide collection and disposal of honeybags/pails to sewage lagoons or special pits at solid waste disposal sites.

For outdoor use, one of the oldest and most basic methods of waste disposal is the pit privy or outhouse. This system should only be used for the disposal of human body waste. A pit dug below the outhouse collects the wastes. Liquid wastes seep into the soil and are eventually decomposed. When the waste in the pit below the outhouse reaches a certain depth from the ground surface, the pit is covered with earth and the outhouse moved to another location. This is an inexpensive option, and if soil conditions are good, it can be a safe method of waste disposal. However, it is inconvenient for users and often produces offensive odours. Also, if wells are nearby, there is a risk of contamination.

2.1.2 Septic Tank Systems

A septic tank system provides full plumbing to each home. This includes showers and/or baths and flush toilets. All wastewater is treated and disposed of by means of a septic tank and soil absorption system.

A septic tank system typically consists of an underground tank and a series of underground pipes leading from the tank into the surrounding soil. The piping network is called a tile field while the purpose of the tank is to remove the solids from the wastewater. The tank should have two compartments and be completely watertight, structurally sound, and resistant to excessive corrosion and decay (refer to Figure 1). A two-compartment tank is preferred to a single-compartment tank because it provides a better removal of the solids from the wastewater.

Settleable solids in the wastewater migrate to the bottom of the septic tank, forming a sludge layer. The organic material in the sludge decomposes into more stable materials. At the same time, greases and other light materials in the wastewater float to the surface of the septic tank and form a scum layer.

From the septic tank, the liquid wastes are discharged into the tile field. Wastewater from the septic tank may flow to the tile field either by gravity flow or by means of a pump. The pipes are perforated to permit the liquid to seep into the soil. The pipes in the tile field are placed in trenches filled with a suitably porous medium, such as gravel. The proper treatment of wastes requires a suitable area of soil to place the tile field. The required lot size depends on many factors including the slope of the land and the type of soil conditions at the site.

In addition, there should be adequate soil depth between the tile field and the water table. Usually this separation is provided so that the wastewater does not seep into the groundwater and pollute any nearby wells.

A certain amount of maintenance should be carried out with a septic tank system. The solids and grease which are collected in the septic tank will accumulate and should be pumped out occasionally by a septic tank maintenance service. If the tank is not pumped out, solids will eventually carry over into the tile field. This will quickly plug and ruin the tile field completely. It is important that the tank be pumped out frequently to prevent this type of blockage.

A septic tank and tile field can be an extremely simple and effective means to dispose of domestic wastes. To ensure its efficacy, a septic tank system should be properly designed, installed, and operated. The design of septic tank systems should satisfy the requirements of provincial and territorial regulatory authorities.

There will be locations, however, where a septic tank system is not suitable. Examples include areas with poor soil conditions (allowing liquid to seep into the soil too quickly or too slowly) or a high groundwater table. In such cases, consideration should be given to a community wastewater system.

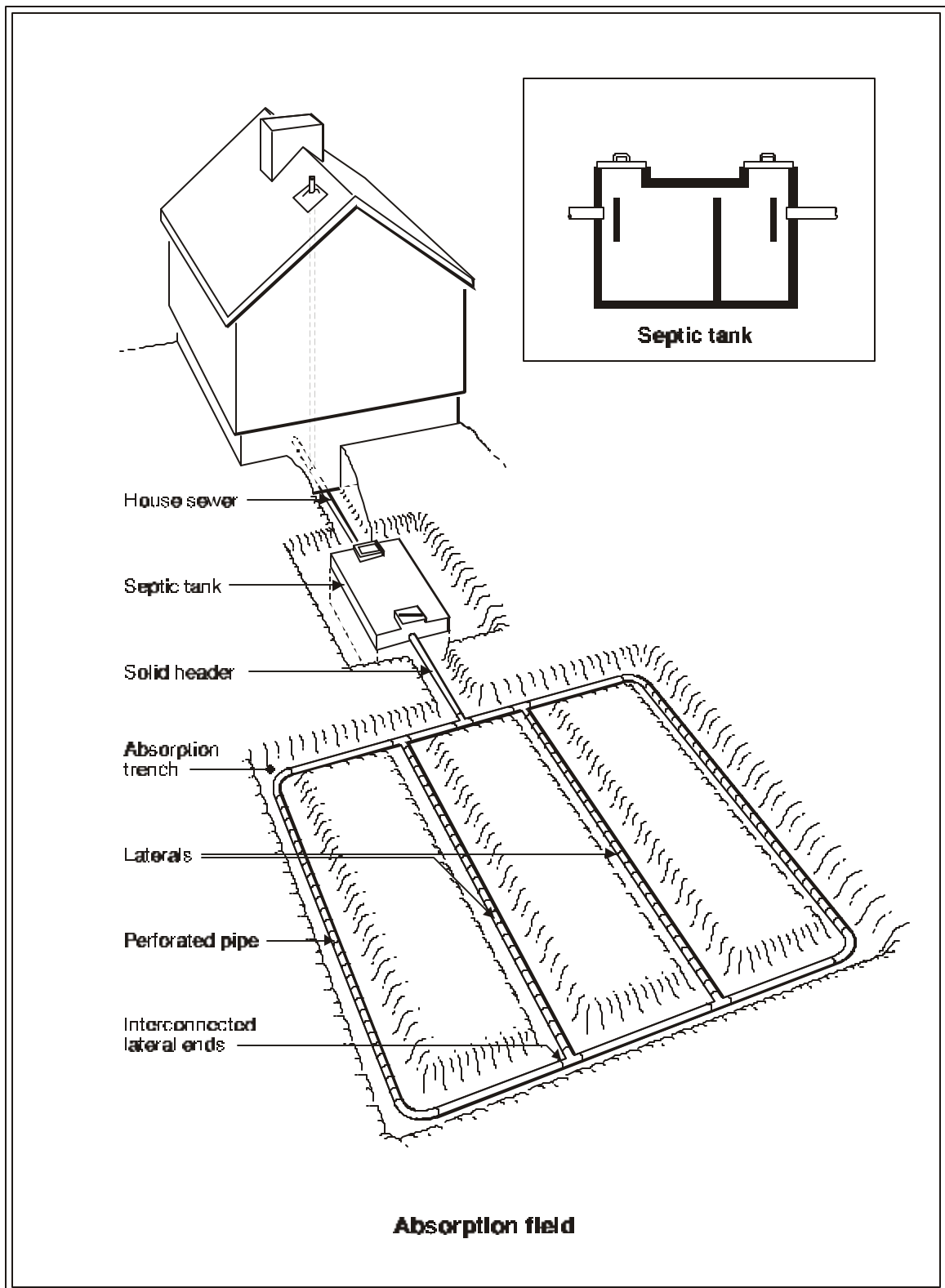


Figure 1: Typical Septic Tank System.

2.2 Community Systems

A community system collects all wastewater from the individual residences for conveyance to a wastewater treatment plant for final disposal. The following presents information on community truck haul systems and fully piped wastewater collection systems.

2.2.1 Community Haul System

In a community haul system, a holding tank is used to store wastewater at the residence until some type of collection/haul vehicle (usually a truck) removes and transports the wastewater to an authorized disposal site. Wastewater is disposed of in a sewage lagoon, mechanical sewage treatment facility, or special site at a solid waste disposal site. Truck haul systems also entail good all-weather access roads, truck storage garages, truck drivers and maintenance personnel.

A truck haul system may be a cost effective delivery system in communities where houses are separated by large distances. Due to the long distances involved, the cost of a fully piped system in such communities is prohibitively expensive.

The design of the holding tanks should depend on dwelling population and frequency of pump-out. The tanks should be structurally sound and resistant to corrosion. The size of the holding tanks and the distance to the disposal site should be taken into consideration when sizing the truck hauling tank.

A disadvantage of the truck haul system is that once it is in place, operation and maintenance procedures are sometimes neglected. If the tank is not checked and pumped out regularly, it can “back-up” into the house or overflow onto the ground surface.

2.2.2 Fully Piped Gravity Flow Collection System

A piped wastewater collection system is an underground network of pipes which collects wastewater from individual residences. The wastewater is carried to a treatment facility before final disposal.

The preferred design, where topography and elevations allow, is the gravity-flow collection system. This design requires that all pipes slope so that the wastewater flows entirely by gravity to the treatment facility. The gravity-flow collection system is preferred because it eliminates the need for pumping facilities and avoids their associated maintenance costs.

Although a gravity-flow collection system is usually the most efficient and safest means of collecting community wastewater, it is not always the most economically viable option. Unsuitable topography, a high groundwater table, structurally unstable soils, or rocky conditions may render the gravity-flow collection system unfeasible. The cost of installing a gravity-flow collection system in a small community with a low population density is also expensive due to the high cost of installing the required pipe between homes that are spread long distances apart. In such cases, a low pressure collection system may be preferred for collecting wastewater from individual homes or buildings. The low pressure collection system is described in section 2.2.3.

This section describes the various components in a gravity-flow piped collection system and their functions.

2.2.2.1 Sanitary Sewer

The sanitary sewer is the pipe through which the wastewater flows as it is conveyed from the residence to the sewage treatment plant. The minimum size of sanitary sewer main for a gravity based system should be 200 mm in diameter.

The sewer main is an important part of the entire system and should be properly installed to prevent leakage or blockage that could interrupt service.

Types of sewer main pipe commonly used are polyethylene (PE), polyvinyl chloride (PVC) and concrete pipe. Other materials such as clay tile can also be used.

- (1) Polyethylene (PE) pipe is light, resistant to chemical attack, flexible, easy to handle, and has excellent flow characteristics. It can also resist cracking or splitting during freezing conditions. This makes polyethylene particularly well suited for northern climates. However, PE pipe is particularly susceptible to deformation if it is not properly backfilled. Insulated polyethylene is available for installations requiring freeze protection. Insulated pipe typically consists of a pipe core surrounded by a polyurethane foam blanket. An exterior jacket or wrapping provides a tough watertight protection for the insulation. Factory-insulated polyethylene pipe made to specification is preferred to field-insulated pipe.
- (2) Polyvinyl chloride (PVC) is also lightweight, easy to handle, resistant to chemical attack, and has excellent flow characteristics. Similarly to PE, it can be insulated to provide freeze protection, however, it is susceptible to brittle fracture in cold conditions.
- (3) The advantages of concrete pipe include its low cost (especially in larger sizes), its resistance to abrasion, and its availability in large sizes and various strengths. The

disadvantages are its heavy weight, which makes it more difficult to install and more expensive to ship to remote locations, and its susceptibility to attack by acids.

2.2.2.2 Manholes

Manholes are access chambers to the sanitary sewer for cleaning, inspection, and maintenance work. If the main sewer becomes blocked, maintenance workers can clear the obstruction by entering through the manholes.

Manholes are placed at regular intervals along straight sections of sewer mains. In straight sections, the maximum distance between manholes should generally be 120 metres. Manholes are also placed wherever the sewer changes direction, elevation, slope, and pipe size.

The design and construction of manholes is becoming quite standardized with precast manholes being used most often. This simplifies procedures and reduces costs.

Figure 2 illustrates a typical precast manhole.

Manholes can be extremely hazardous places to enter if proper safety precautions are not observed. Maintenance or inspections should be carried out by a properly trained work crew having a minimum of two persons. The work crew should have confined space entry training and be equipped with proper safety equipment.

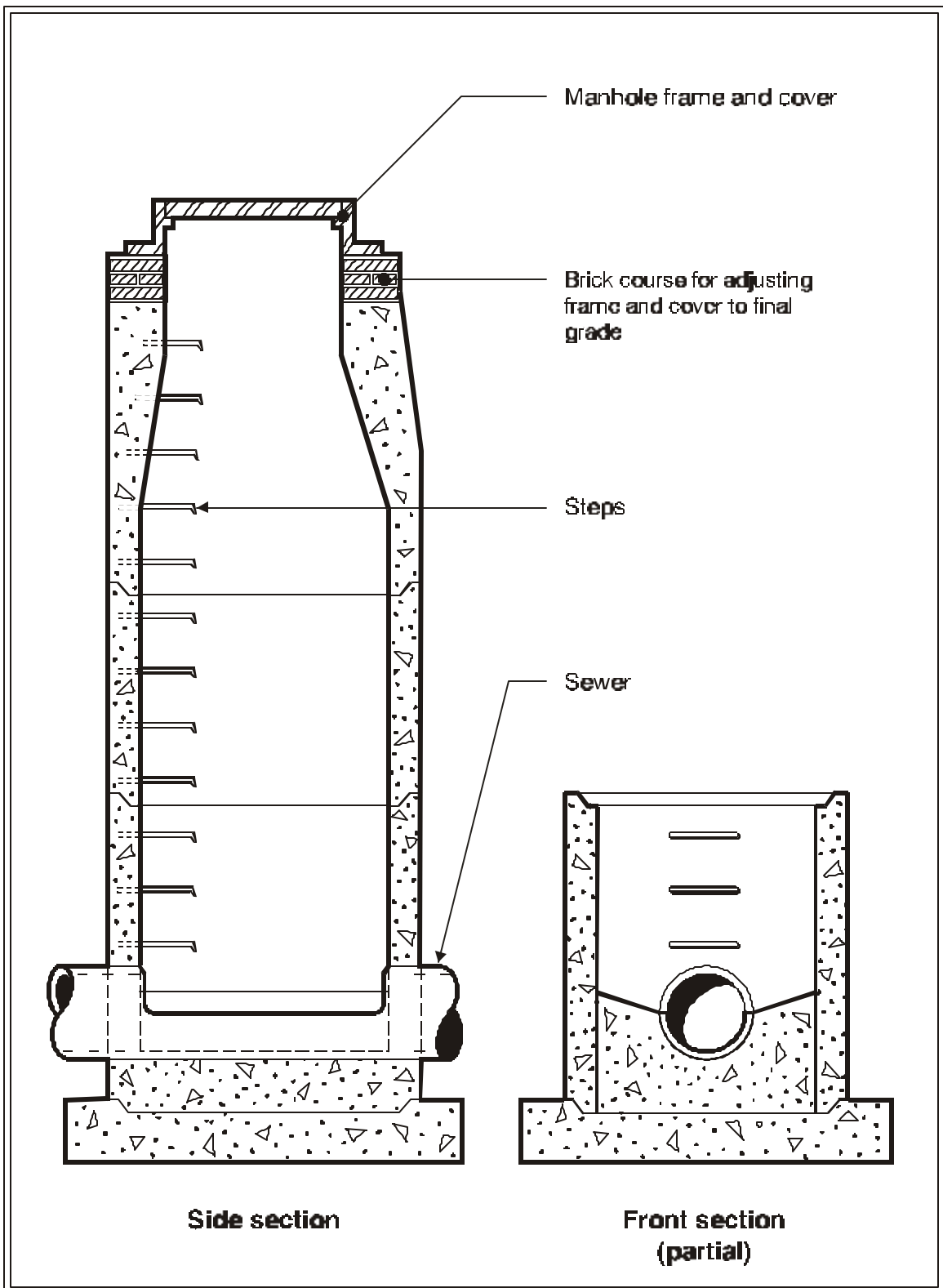


Figure 2: Typical Manhole.

2.2.2.3 House Service Connection

The house service connection consists of piping from the individual residence to the sewer main. Figure 3 shows a typical house service connection for a gravity-flow collection system.

House connections are much smaller in size than the sewer main (usually 100 mm in diameter) since they usually only have to convey wastewater from one individual residence. Materials, joints, and workmanship should be similar to those of the sewer main to minimize infiltration and root penetration.

2.2.2.4 Sewage Liftstation

A sewage lift or pumping station is used in a collection system wherever gravity flow is not possible due to topography or excessive pipe depths. This often occurs where wastewater has to flow over hills or from a low elevation to a higher elevation wastewater treatment facility. Essentially, the lift station pumps the wastewater to a higher elevation so that it can flow by gravity. The pipe which carries the sewage from the liftstation is under pressure and is known as the forcemain.

There are two main types of liftstations, a dry well and a wet well. Both types of liftstations are often pre-assembled package units. In a dry well (Figure 4), the pump suctions the sewage from an adjacent wet well. The exterior of the pump is dry at all times permitting easy inspection and maintenance. A minimum of two pumps should be provided for flexibility of operation. In some installations, backup pumps may be necessary. A sump pump may be added in the dry well to remove any infiltrating water.

In a wet well, the pumps are immersed in the liquid handled (refer to Figure 5). These pumps are called submersible pumps and have to be removed from the unit for maintenance. A minimum of two pumps should be provided, allowing one to be used as a backup if the other fails.

Since this is a mechanical system, its reliability needs to be very high because the gravity flow of sewage to the liftstation cannot be stopped. High reliability is therefore essential in the design of a liftstation. In the case of power or pump failures, sewage pumping stations should be provided with an emergency overflow pipe to prevent sewage from backing up into building basements. Stand-by power equipment may be required where raw sewage overflows might affect drinking water supply sources or swimming areas.

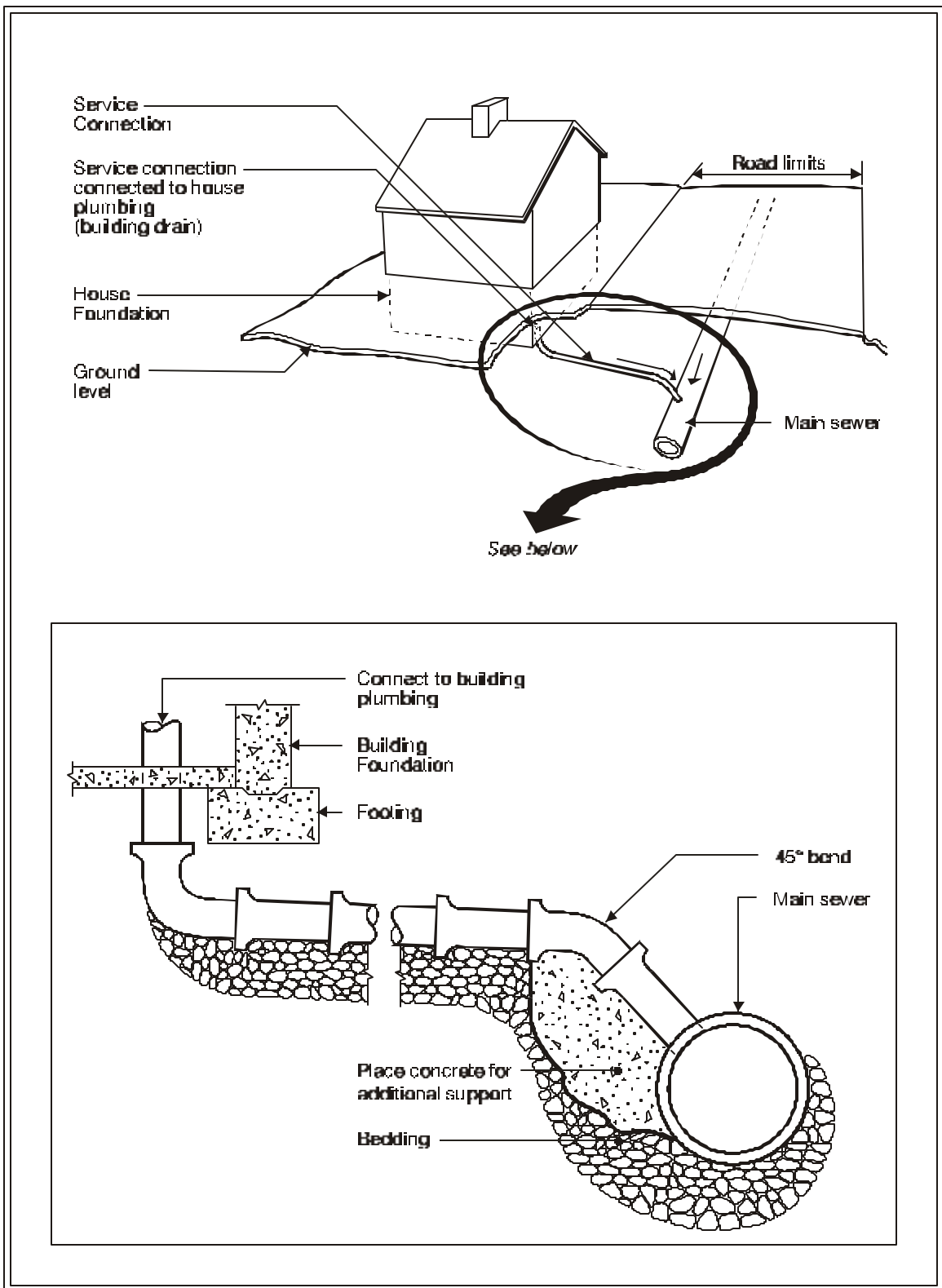


Figure 3: Building Service Connection.

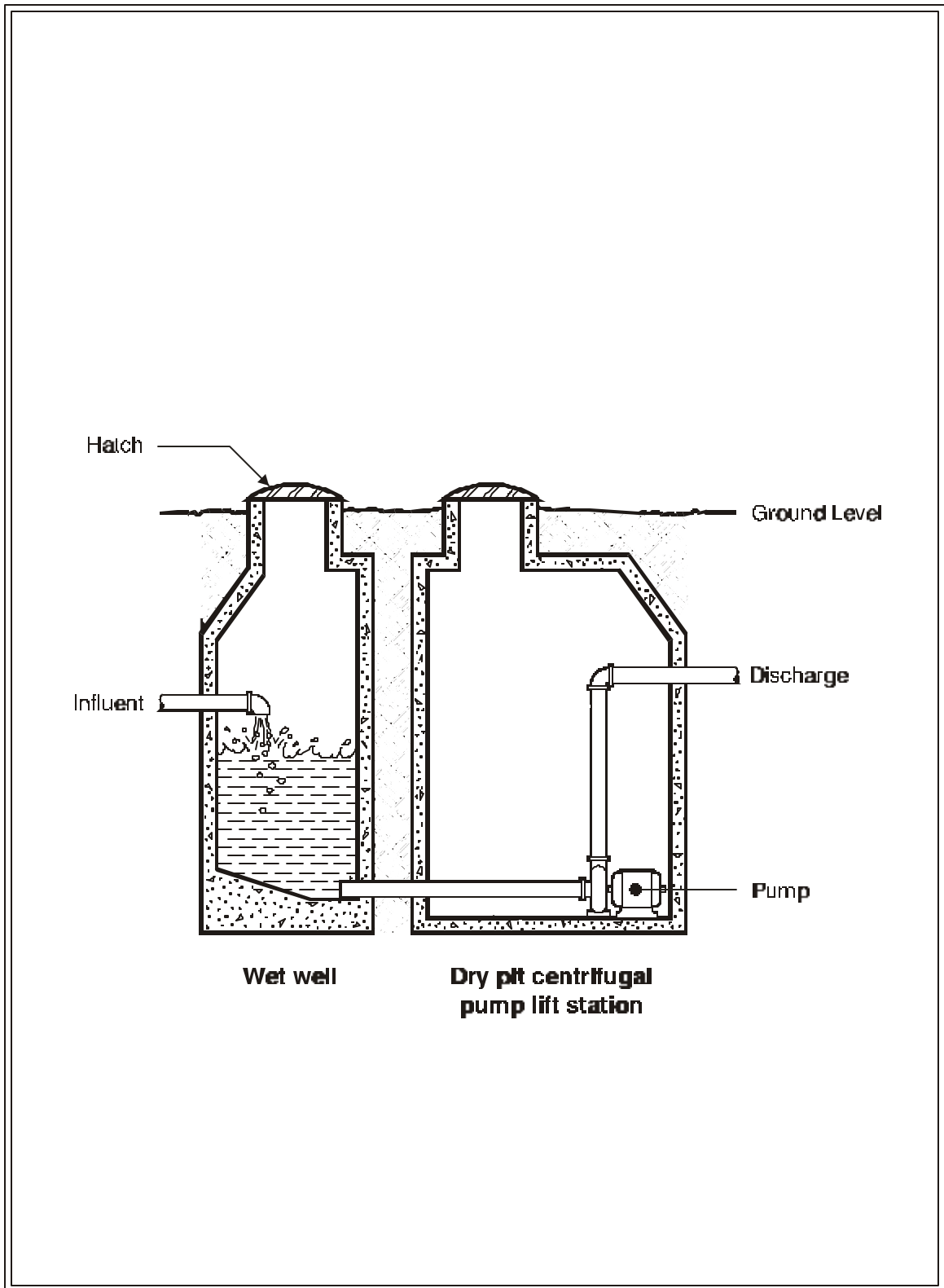


Figure 4: Dry Well Liftstation

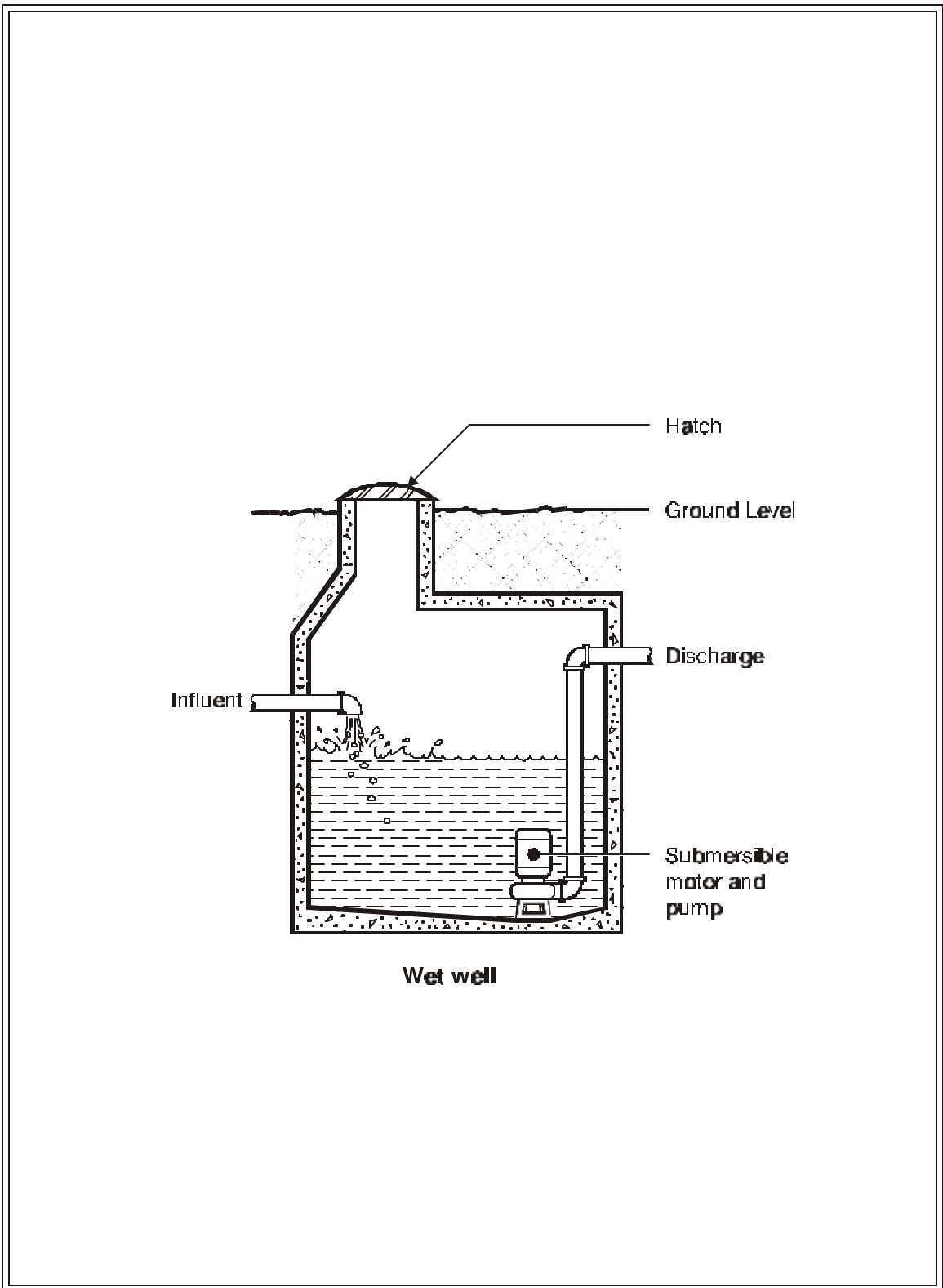


Figure 5: Wet Well Liftstation.

2.2.3 Low Pressure Collection System

In a low pressure collection system, the wastewater from an individual home or building is discharged into a septic tank. The septic tank allows separation and collection of much of the solid material in the wastewater. The partially treated wastewater is then pumped by a small pump located at the septic tank through a small-diameter flexible plastic pipe from the residence or building to a larger diameter gravity-flow/ pressurized sewer main. The sewer main used in a low pressure collection system is smaller than that used in a conventional gravity-flow sanitary sewer.

Two significant advantages of the low-pressure collection system over the gravity-flow system are that the flexible, small-diameter plastic pipe can be placed at a shallower depth than is needed by gravity-flow pipe while still maintaining good frost protection, and that the flexible plastic pipe can be allowed to curve around obstructions. The pipe can also carry wastewater from a low elevation residence or building to a higher elevation sewer main because the wastewater flow is driven by the pump located at the house septic tank.

Part 3: Effluent Quality

3.1 General

The main reasons for treating wastewater are to prevent water-borne transmission of disease and to preserve the aquatic environment. Before presenting the various methods of treatment, the following sections provide information on some common wastewater characteristics and how they affect the treatment process.

The quality of effluents from wastewater treatment facilities should meet the latest edition of the “Guidelines for Effluent Quality and Wastewater Treatment at Federal Establishments” (published by Environment Canada) and provincial regulatory requirements.

The federal approach is to ensure that the design meets federal effluent quality objectives unless provincial requirements are more stringent. Since provincial requirements vary, it is recommended that regulatory (federal or provincial) authorities be consulted.

3.2 Temperature

The wastewater temperature is an important factor for the treatment process. Settling properties are more effective at higher temperatures whereas colder conditions reduce the biological activity that takes place in the treatment facility.

3.3 Biochemical Oxygen Demand

The BOD, or Biochemical Oxygen Demand, is the amount of oxygen that is required to decompose the organic matter in wastewater. This indicates how much organic matter is in the wastewater, which in turn indicates the ‘strength’ of the sewage.

The organic strength of the sewage, as measured by its BOD, is one of the most important criteria used in the design of a wastewater treatment facility for determining the extent of treatment needed. The organic loading on the treatment facility is the BOD of the wastewater being discharged to the facility. BOD is a measurement of the amount of oxygen needed by bacteria to stabilize the wastewater.

By testing the BOD before and after treatment, the efficiency of the treatment process can be measured and the impact of the treated sewage on receiving waters can be predicted.

3.4 Dissolved Oxygen

The bacteria frequently utilized in a biological wastewater treatment process need oxygen to decompose the organic matter. However, since the oxygen required by the bacteria usually exceeds the amount available in the wastewater, additional oxygen must be supplied by means of mechanical equipment such as aerators. The treatment facility should be designed to maintain sufficient dissolved oxygen levels for effective treatment.

Test kits are available with which the operator can determine the amount of oxygen in the wastewater and then establish if there is enough oxygen for the process to work effectively.

3.5 pH

The term pH is a measure of the acidity or alkalinity of a liquid. The pH scale ranges from 0 to 14, with the acceptable range for wastewater typically being 6.5 to 8.5. Acidic water (pH less than 7) will tend to corrode equipment while alkaline water (pH greater than 7) will deposit scale in pipelines.

Good operation may be obtained in the range of about 6.5 to 8.5. If the pH is well beyond the 6.5 - 8.5 range the wastewater should be chemically adjusted to satisfy biological requirements and ensure a stable and healthy biological treatment process.

3.6 Coliforms

Coliforms are a harmless type of bacteria found in the intestines of warm blooded animals. Their presence in wastewater, however, indicates the possibility that pathogenic or disease-causing bacteria might also be present.

Testing for, and ensuring that the number of coliform bacteria in wastewater are kept to a minimum greatly reduces the possibility of disease being spread. Chlorinating the wastewater regularly eliminates most disease-causing bacteria.

To test for coliform bacteria, samples of treated wastewater are collected and sent to qualified laboratories for analysis.

3.7 Settleable Solids

Very fine material in wastewater will settle if the wastewater is still. The settleable solids test indicates how much of the fine material in a sample of wastewater will settle during a set time (usually 30 minutes).

By performing the test on samples of untreated and treated wastewater, the operator can check how efficiently the treatment plant is removing settleable matter.

3.8 Guidelines for Effluent Quality and Wastewater Treatment at Federal Establishments

The latest edition of the “Guidelines for Effluent Quality and Wastewater Treatment at Federal Establishments” gives suggested limits of commonly measured wastewater characteristics, such as Biochemical Oxygen Demand (BOD), as mentioned in section 3.3, Suspended Solids (SS), and other characteristics. The guideline suggests a minimum quality in treatment plant effluents discharged to receiving waters.

Wastewater can be tested for parameters such as BOD or SS and compared with the “Guidelines for Effluent Quality and Wastewater Treatment at Federal Establishments” to check whether guidelines are being met. In the case of BOD, a laboratory test measures how much BOD is in the effluent sample. Comparing this test result to the guidelines for BOD tells the operator if the effluent is acceptable for discharge to the receiving lake or stream.

Sewage treatment systems should be designed and operated in such a manner that the effluent quality suggested in the latest edition of the “Guidelines for Effluent Quality and Wastewater Treatment at Federal Establishments” and other applicable provincial regulatory requirements can be consistently achieved.

Part 4: Wastewater Lagoons

4.1 General

Most First Nation communities use sewage lagoons for wastewater treatment. Sewage lagoons are man-made ponds or dyked depressions which rely on natural processes of mainly bacteria and algae to reduce organic matter to acceptable levels. Lagoons should be placed some distance from the community and oriented in such a fashion that winds do not carry odours towards the residences. The two types of sewage lagoons used are facultative and aerated.

4.2 Facultative Lagoon

Facultative lagoons (refer to Figure 6) are the most common wastewater treatment process used in Canada. The advantages of a facultative lagoon include low capital and low operation and maintenance costs, an ability to handle hydraulic and organic shock loads (ie. a sudden increase in wastewater flow or a sudden increase in organic content of the wastewater), and minimum operator attention. The main disadvantage of facultative lagoons, compared with other treatment systems, is the extensive land area they require.

Facultative lagoon systems should normally be designed as seasonal discharge facilities and should consist of a treatment cell followed by one or more storage cells. No mechanical aeration devices should be used.

4.2.1 Treatment Cell

The degree of treatment produced in the treatment cell is significantly influenced by climatic conditions. During cold weather, biological activity under ice cover is extremely slow, and the treatment process is essentially reduced to settlement of the solids in the wastewater. For this reason, facultative lagoons should be designed for low organic loadings (ie. low organic content on the treatment surface for a given length of time).

The maximum depth of sewage in a treatment cell should be 1.5 m. However, additional depth may be required in areas where thick ice cover develops during winter months, such as in arctic and sub-arctic conditions. For details on the design of lagoons in the North refer to the “Cold Regions Utilities Monograph” published by American Society of Civil Engineers (ASCE).

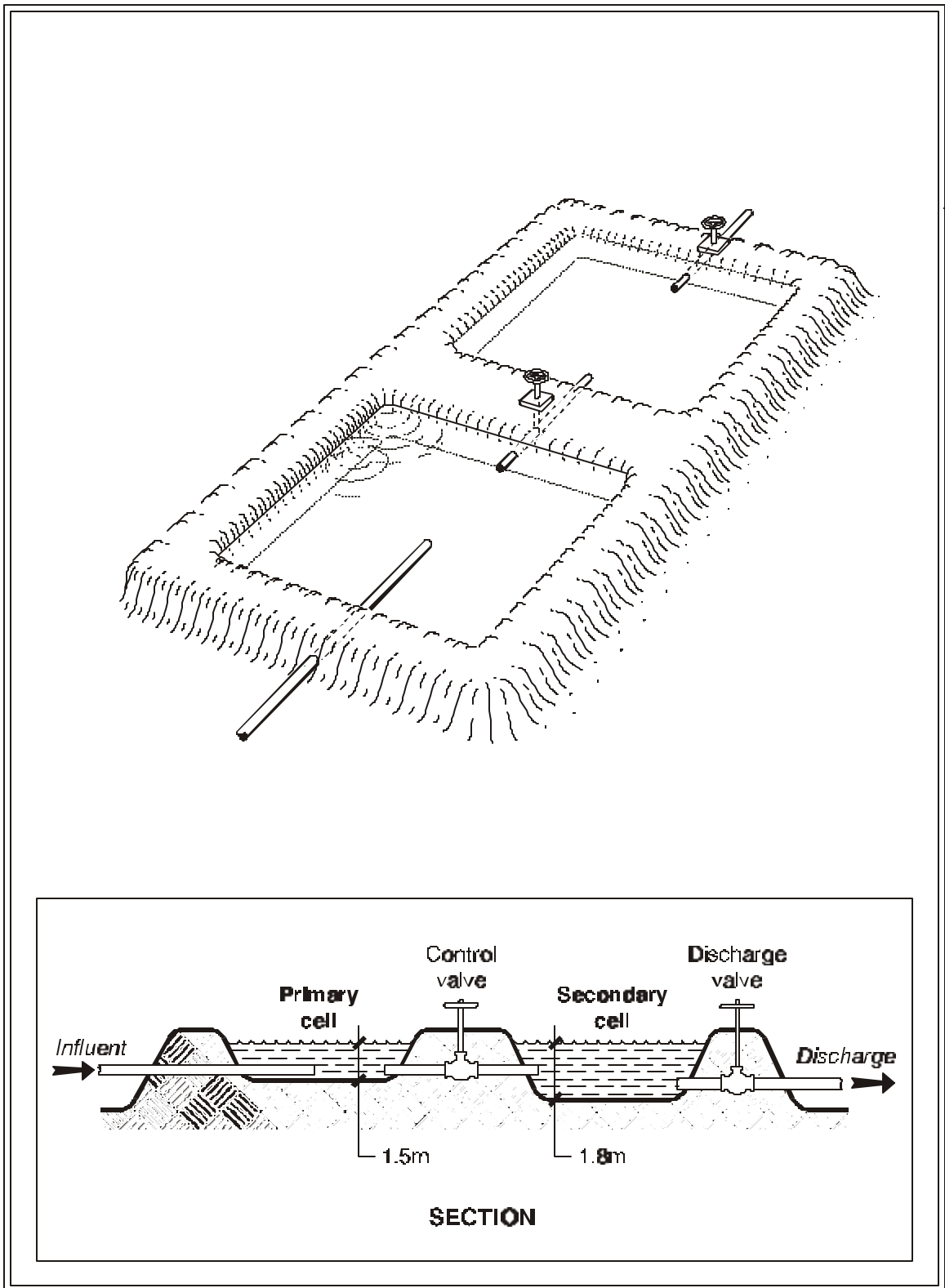


Figure 6: Facultative Lagoon.

4.2.2 Storage Cell

Storage cells should be sized on the basis of storage requirement and maximum allowance depth. The storage capacity is generally established to satisfy regulatory discharge requirements of either once a year (in the fall) or twice a year (in the fall and also in the spring after breakup). Typically, a maximum depth of sewage of 1.8 m should be used.

4.2.3 Berms

Lagoon berms should be properly sloped. Flat slopes may be conducive to emergent vegetation, while steeper slopes may require riprap (a loose assemblage of broken stones) or other stabilization measures to control erosion. In addition, if the berms are too steep, mowing equipment may be unable to operate. Berm slopes should be designed based on the recommendations of qualified and experienced soil consultants.

Like any earthen structure intended to hold water, berms should be protected from overflowing and damage by wave action. To prevent lagoon overflowing, the berms should be built higher than the full operating level by an amount called the freeboard. Erosion of berms at the water's edge can be prevented by the use of riprap, broken concrete rubble, or some other suitable material.

Where applicable, facilities should be provided with measures to prevent berm erosion or ponding occurring when sewage haul trucks are unloading sewage into the lagoon. Examples of measures to prevent berm erosion or ponding include a ramp, a sheet-pile discharge face or a splash pad.

4.2.4 Lagoon Liner

To prevent leakage of wastewater into the soil, a low permeability compacted clay or synthetic liner is placed along the bottom and sloped sides of the lagoon. The liner eliminates the risk of contaminating the groundwater table and polluting any nearby wells. Soil tests to determine the characteristics of surface soil and subsoil should be conducted as part of the preliminary survey to select lagoon sites and to ensure that the minimum required separation between the groundwater table and the bottom of the lagoon is met.

4.2.5 Access, Fencing, and Signage

An all-weather access road, including a truck turnaround area, should be provided to the lagoon site to allow year-round maintenance of the facility. Fencing with an entry gate should be provided to prevent the entry of pedestrians, livestock, and wild animals. Appropriate signs should be posted at intervals along the fence perimeter.

4.2.6 Discharge Procedures

In most parts of Canada, wastewater lagoons may be discharged three or four weeks after ice break-up when the ponds generally return to normal operating conditions, or in the fall prior to freeze-up when effluent quality is best (minimal algae). The wastewater in the secondary cell should be tested, and the results reported to the local authority. If effluent quality is suitable for discharging, the operator should follow local authority guidelines on discharging. Sewage depth should be monitored to ensure there will be sufficient capacity to contain and treat the community's sewage until the next discharge.

4.3 Aerated Lagoons

4.3.1 General Remarks

Aerated lagoons use mechanical aeration to provide dissolved oxygen for biological treatment of wastewater. One type of aeration system consists of air blowers which supply air to weighted tubing near the bottom of the pond. The tubing is laid in a grid which divides the lagoon into hydraulic cells. Air is released from the plastic tubing so as to provide slow moving currents to keep the waste moving within each cell. The spacing between each cell depends upon oxygen requirements. A typical plan of a diffuser layout for an aerated lagoon is shown in Figure 7.

Other types of diffused air systems, such as mechanical surface aerators (rotating paddles that 'mix' the wastewater to increase its oxygen content), are also in use. Mechanical surface aerators should generally not be used in cold climate regions subject to winter icing condition because the paddles of the mechanical aerator may be damaged by ice.

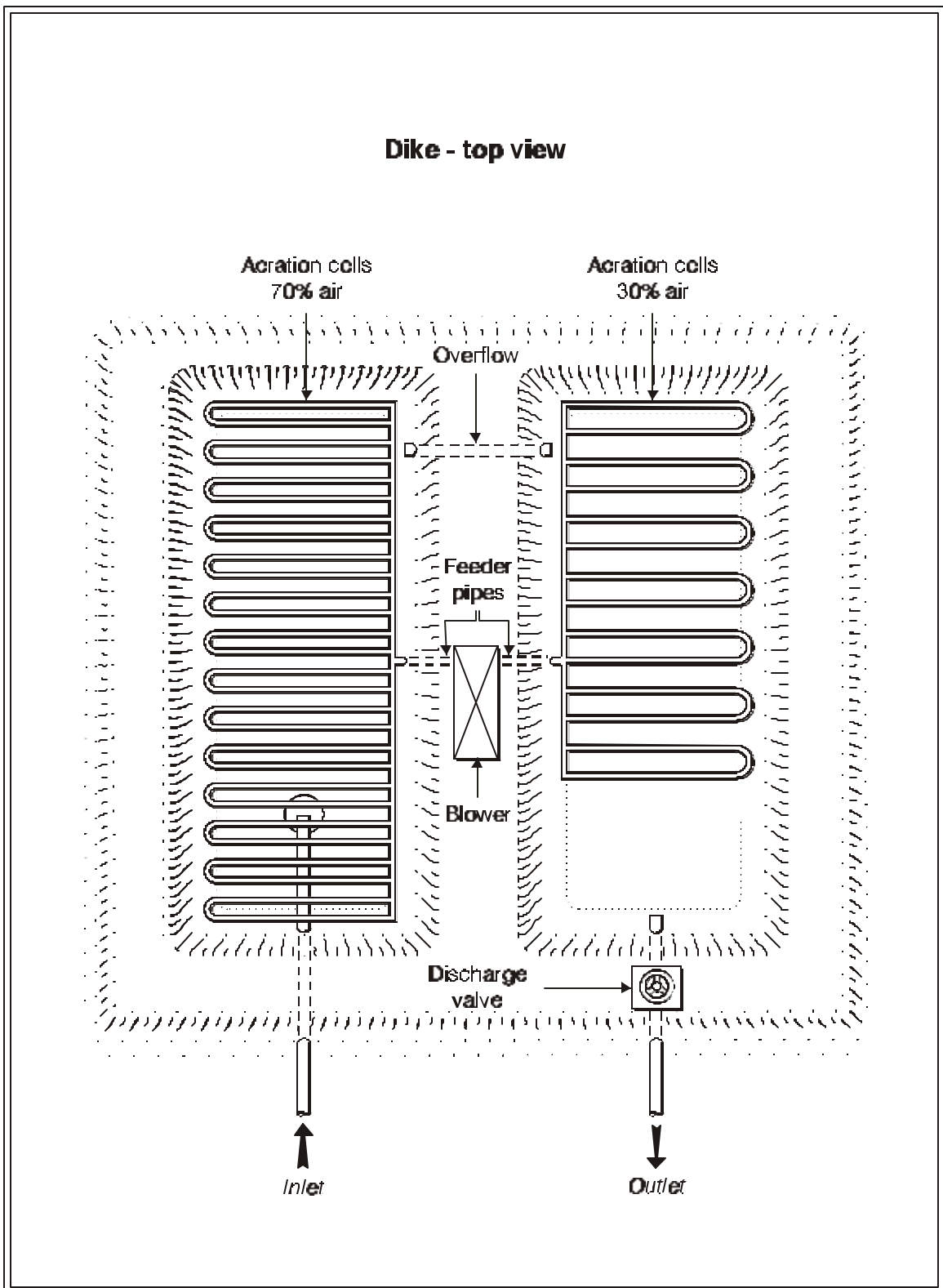


Figure 7: Aerated Lagoon.

4.3.2 Aerated Lagoon Sizing

In an aerated lagoon system, the ponds are typically sized on the basis of retention time. To treat normal domestic sewage, a retention period of 30 days is recommended. It has been shown that a good effluent quality can be achieved using this retention time. In extremely cold environments, however, a longer retention time may be required. Ordinarily, the liquid depth should be between 3 m and 4 m to allow the diffusers to function efficiently. In addition, a minimum additional freeboard of 1 m should be provided.

For an aerated lagoon system, there should be a minimum of two ponds consisting of a treatment pond and a polishing pond. The ponds should be of equal dimensions with approximately 70% of the air requirements assigned to the first lagoon. Air requirements are greater in the first pond to match the higher oxygen demand of raw wastewater.

With aerated lagoons, enough oxygen should be transferred to satisfy the applied Biochemical Oxygen Demand (BOD) loading of the wastewater and to provide sufficient mixing to maintain uniform dissolved oxygen levels throughout.

4.4 Operation and Maintenance Procedures

There should be adequate emphasis given to operation and maintenance procedures for the lagoon to operate properly. A lagoon requires regular maintenance and repairs to maintain its condition in proper order.

It is good practice to keep written records of all testing and work carried out on the lagoon. This would include any maintenance tasks performed. This not only provides a record of the last check or maintenance task but also enables the operator to detect any changes in the operating characteristics of the system.

4.5 Process Control

Final effluent quality tests should be performed as required by regulatory agencies. It is recommended that the operator of a lagoon system be given sufficient training in the operation and maintenance of this type of facility.

In certain regions, the “circuit rider” program is available to address these training needs. This is a practical hands-on training method that takes place at the operator’s facility.

Part 5: Mechanical Treatment Systems

5.1 General

Compared to sewage lagoons, mechanical treatment systems usually require much less land and can be continually discharged to a receiving body of water. In some instances, mechanical systems may be less costly to construct than lagoons.

Sewage treatment facilities, especially mechanical plants, should not be located upstream near a source of public water supply, a swimming area, or a sensitive fish habitat. This is to avoid unnecessary public health and environmental risks.

The mechanical treatment systems covered in this publication are:

- Rotating Biological Contactor (RBC)
- Trickling Filter
- Sequencing Batch Reactor (SBR)
- Extended Aeration Plant

5.2 Rotating Biological Contactor (RBC)

5.2.1 Process Description

The process usually consists of a flow equalization/solids settling chamber, RBC unit, and final settling tank (see Figure 8). The flow equalization/solids settling chamber is where removal of some settleable solids takes place and is installed upstream of the RBC.

The RBC is a shaft of rotating plastic discs set in an open tank filled with wastewater. The discs rotate slowly in the tank and as they pass through the wastewater, organics are removed by biological growth on the rotating discs. The buildup of biological growth on the discs increases in thickness, forming a slime layer. When the discs pass through the air, oxygen is absorbed, further promoting the growth of this slime layer. When the slime layer on the discs gets thick enough, some of it sloughs off and settles in the bottom of the RBC while the rest enters the final settling tank, where it is removed before the treated water is discharged. Settled solids in the RBC and the final settling tank are often pumped back to the equalization/sedimentation chamber, which precedes the RBC, for storage and digestion.

For maximum efficiency, the RBC system should consist of 4 to 6 stages with baffles between each stage. The diameter of each disc will depend upon the amount of media surface area required to treat the wastewater.

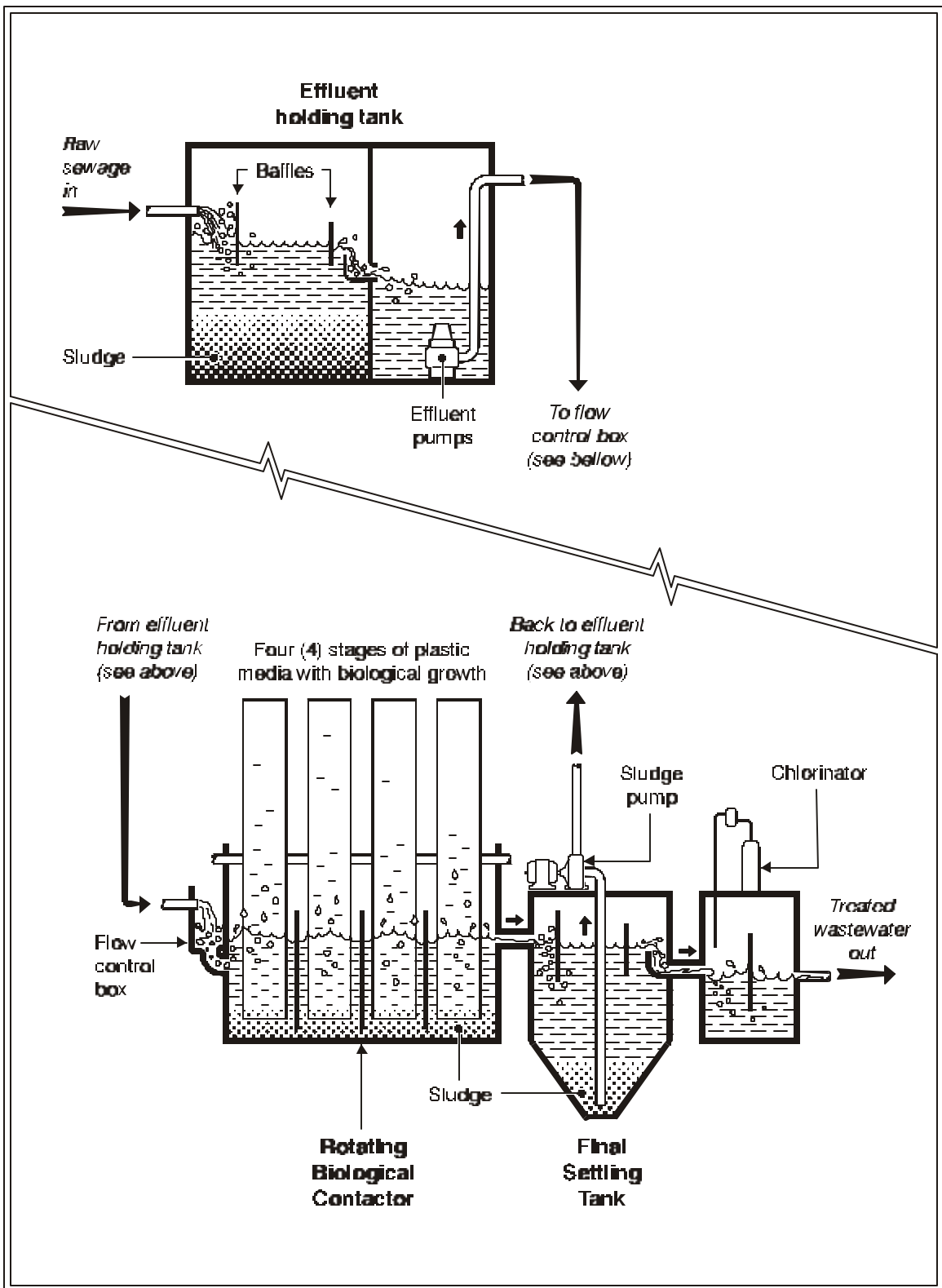


Figure 8: Rotating Biological Contactor (RBC).

5.2.2 Mechanical Equipment

As long as the shaft is rotating, the unit should be treating the waste. The shaft is rotated by drive equipment which usually consists of a motor, gear reducer, and chain drive. The main shaft is supported by two main bearings.

Since the RBC has few moving parts, it requires a relatively minor amount maintenance. Essentially, all that should be required is to keep the chain, reducer, shaft bearings, and motor well lubricated, and the chain and belt (if any) drive systems well aligned and under the proper amount of tension.

Maintenance procedures should be in accordance with the manufacturer's recommendations for maintenance and lubrication.

5.2.3 Settled Sludge

The material that settles to the bottom of settling tanks is known as sludge. Settled sludge should be pumped daily from the sludge hopper of the final settling tank.

Pumping of the settled sludge from the final settling tank can be readily accomplished by means of a timer. The clock should be designed to permit the operator to set the operating times of the pump as well as the duration of pump operation. The sludge should normally be pumped from the final settling tank to the primary flow equalization chamber for storage and ultimate disposal.

5.2.4 Enclosure

The RBC should be housed so as to protect the biological growth from freezing temperatures and avoid excessive loss of heat from the wastewater. The RBC, like most biological treatment systems, will show decreased treatment efficiency in cold temperatures.

In cold weather operation, the high humidity within the enclosure will result in condensation on the inside walls. To prevent this, and to minimize corrosion and increase operator comfort, the housing should be insulated and heated.

5.3 Trickling Filter

5.3.1 Process Description

A trickling filter consists of a bed of coarse material (such as rock, plastic, or other material) covered with biological growth. This is called the filter media. Wastewater is distributed over the top of the bed by a rotary distributor. As the wastewater trickles down through the openings of the media, organic matter is removed by contact with the micro-organisms. The treated wastewater is collected by an underdrain system prior to clarification in the final settling tank.

In the treatment of domestic wastewater, the trickling filter is usually preceded by a primary settling tank and followed by a final settling tank (see Figure 9).

The principal components of the trickling filter include:

- the distribution system which applies the wastewater to the filter media;
- the filter media which provides a surface area for the micro-organisms to grow; and
- the underdrain system which supports the media, collects the effluent and ventilates the filter providing oxygen for biological growth.

The trickling filter should be housed if used in cold climate areas. Trickling filters are generally only found in the southern parts of Canada.

5.3.2 Filter Media

The filter media should be hard, durable, and free from fine material. Heavy loads that may crush the medium should not be permitted on the filter. While stone has been used in the past, manufactured plastic media is more commonly used today.

5.3.3 Distribution System

For effective utilization of the filter unit, the wastewater should be uniformly distributed on the filter surface. Rotary distributors are used to achieve this.

Reaction-driven rotary distributors are used in most trickling filters. The rotary distributor consists of a central column to which horizontal pipe arms are attached. The arms rotate by the reaction of the wastewater discharging from the nozzles or by the mechanical action of an electric motor (see Figure 9).

Orifices and nozzles should be inspected daily, and clogged units should be cleaned. Scum and organic growth should be removed from the rotary distributors and the distribution system should be flushed periodically to remove any material that could cause clogging.

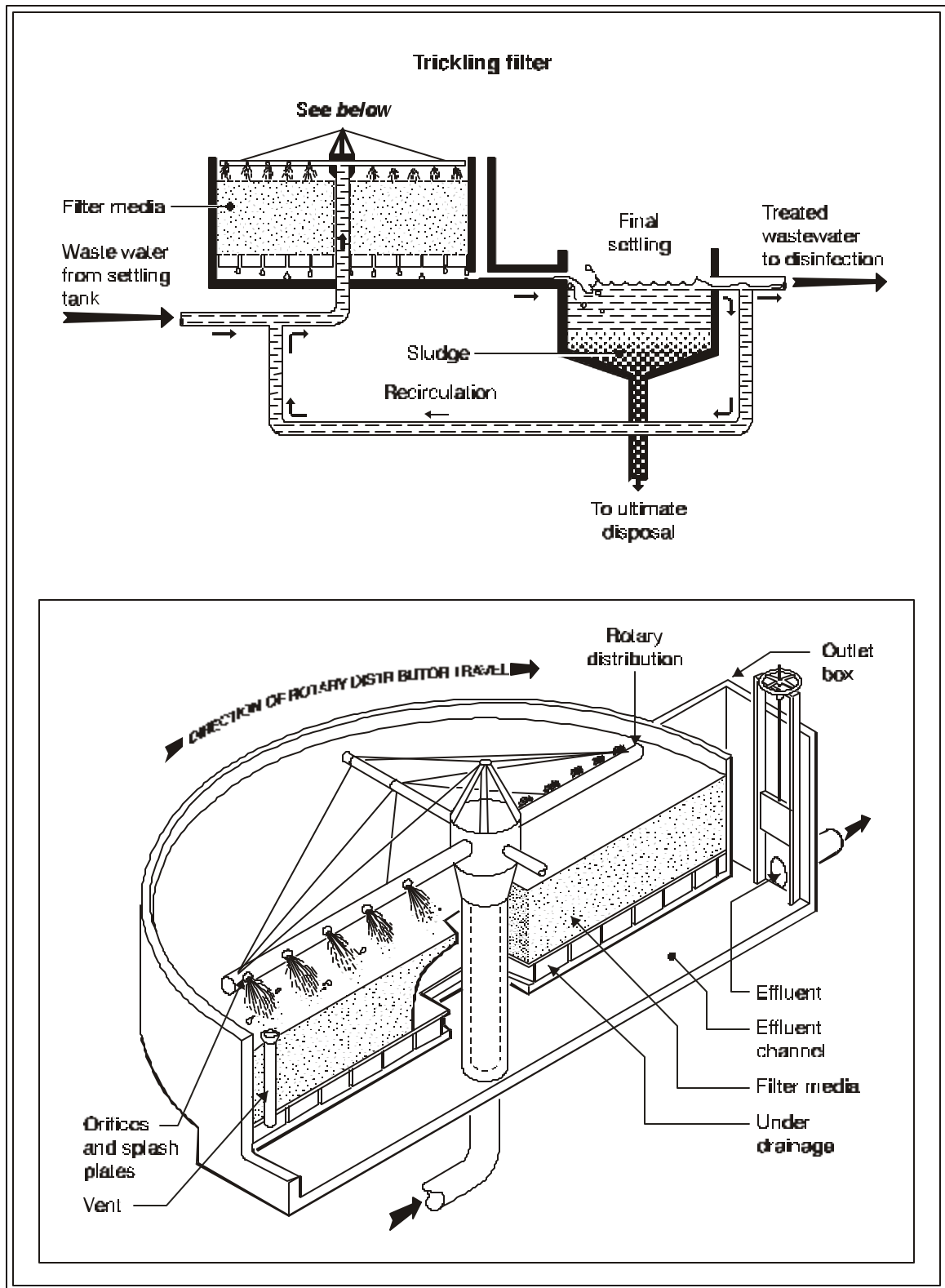


Figure 9: Tricking Filter System.

5.3.4 Underdrains

The base of the filter supports the underdrain system which in turn supports the filter media. The underdrain system is generally designed to flow one-third to one-half full to permit ventilation of the bed. If possible, the underdrains should be inspected periodically to make certain they are neither clogged nor surcharged. If the drains become clogged, they should be flushed with a hose stream.

5.3.5 Final Settling Tank

The efficiency of treatment attained by trickling filter plants is greatly affected by the operation of the final settling tank. The material that settles to the bottom of the settling tank is known as sludge. It is essential that sludge be removed from the final settling tank before it rises to the surface and is carried out with the final effluent. Sludge from the final settling tank can be pumped back to the primary settling tank or directly to sludge-handling facilities.

5.4 Sequencing Batch Reactor (SBR)

5.4.1 Process Description

The unique feature of a sequencing batch reactor is that all of the treatment operations take place in the same tank (see Figures 10 & 11). A sequencing batch reactor has five basic periods of operation, the sum of which constitute one complete cycle. They include:

- Fill - the receiving of the raw wastewater, during which time some reactions may already start to occur (can involve mixing and/or aeration);
- React - the reactor is full (thereby receiving no more wastewater), and the reactions started in Fill continue (mixing and aeration);
- Settle - a motionless period during which reactor contents are allowed to settle under gravity;
- Draw - the clarified supernatant in the reactor is drawn off and discharged without disturbing the settled solids blanket;
- Idle - the period between the end of Draw and the beginning of Fill (no aeration or mixing).

Each of the five periods performs a specific function in the reaction process. The efficiency with which these functions are performed depends to a large extent on the length of the particular period and the amount of aeration and/or mixing supplied to the system during that period. These functions can be adjusted and optimized to reflect the requirements of the treatment problem. A primary settling tank should also be provided for pretreatment to ensure that large solids do not enter the reactor.

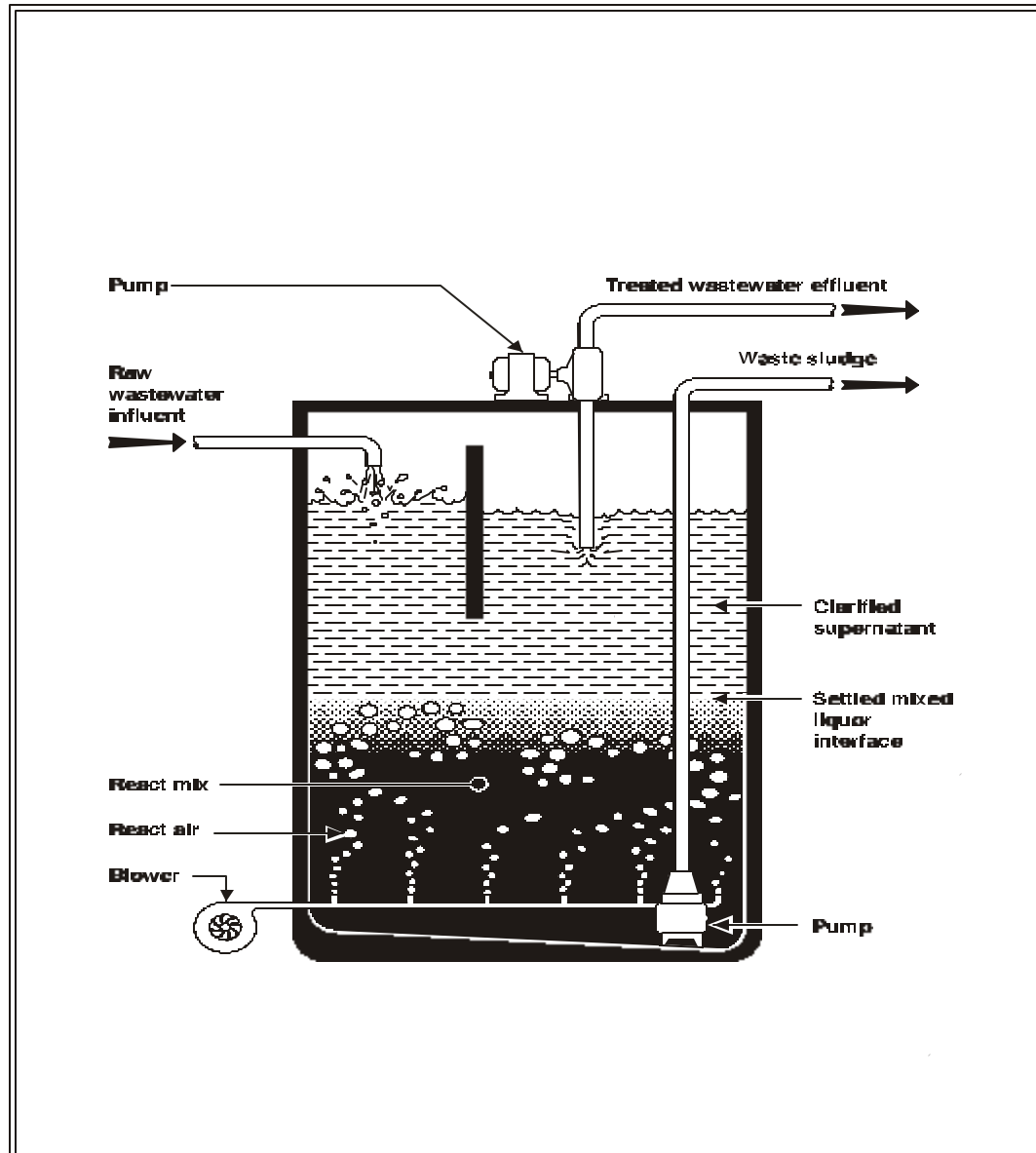


Figure 10: Sequencing Batch Reactor (SBR).

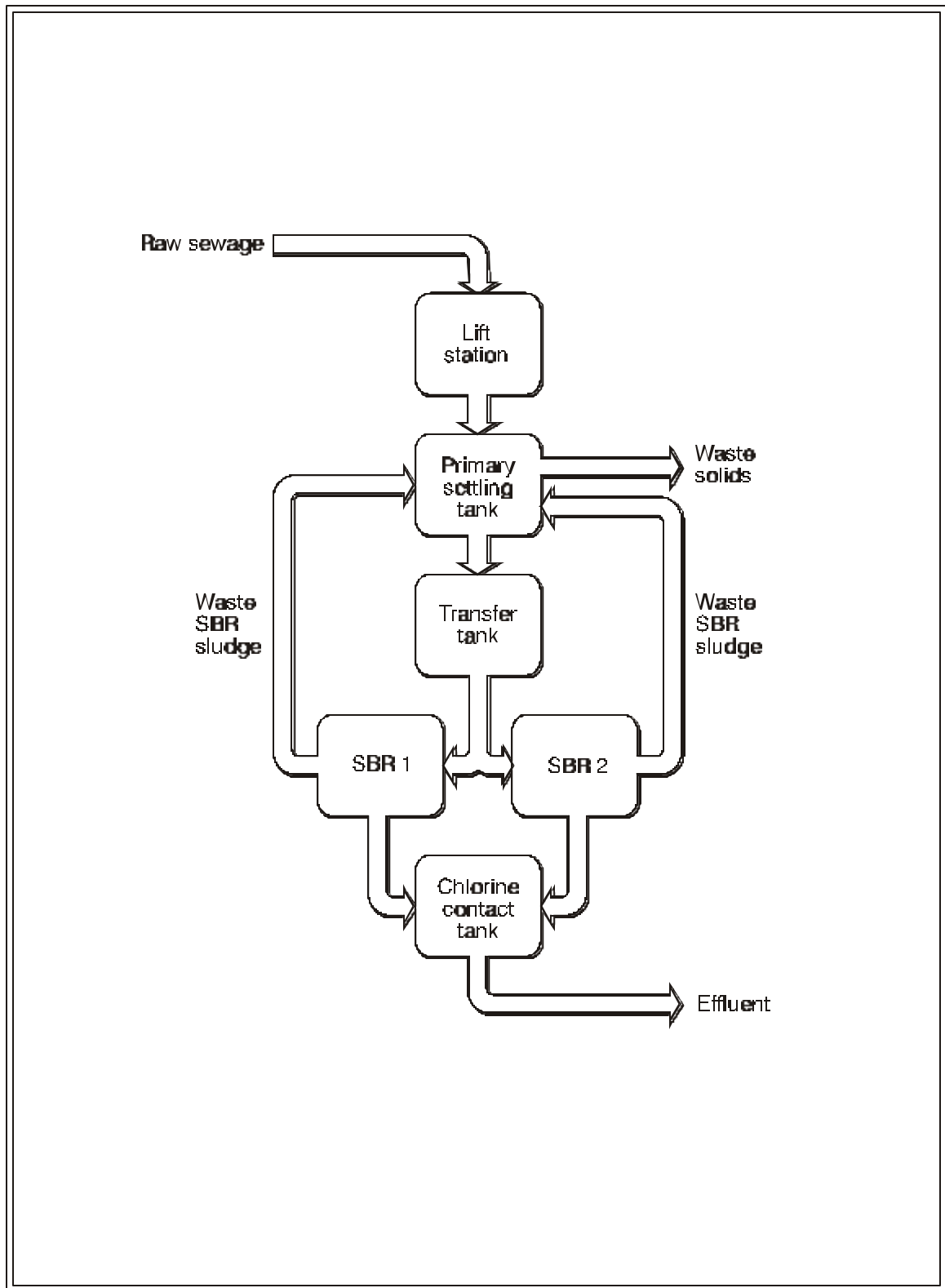


Figure 11: SBR Process Schematic.

5.4.2 Process Control Mechanisms

Process control is required in a sequencing batch reactor system. The entire five period cycle involves some form of time control to regulate the length of each period. Mechanisms are also necessary to control wastewater inflows and outflows through either pumps or switches as well as to regulate sludge wasting.

Process control can be achieved through time-clock control or through microprocessor regulation. Regardless of the control system used, service contracts with the manufacturer are desirable if not necessary.

The complexity of the SBR process controls will depend on the number of tanks in the system. For small communities, a one-tank or two-tank arrangement is usually sufficient; however, the operation of each of these systems is significantly different.

A one-tank reactor is suitable for non-continuous flow situations, such as work camps or very small groups of buildings, and for very low flow conditions where the use of two tanks is not warranted.

A two-tank arrangement provides the capacity for continuous wastewater inflow since either one of the tanks is always accepting the incoming waste.

5.4.3 SBR Maintenance

The amount of maintenance required and the associated costs depend to a large extent on the number of mechanical elements in the system. The expenses involved in running a SBR system are dependent on the costs to physically maintain the system as well as the energy costs. Unless the incoming wastewater and outgoing effluent are flowing by gravity, pumps will be required to fill up and discharge the reactor.

In short, all mechanical inputs will require regular maintenance. Failing this, regular repair and replacement will be necessary. It should be emphasized that all maintenance procedures should be in accordance with manufacturer's recommendations. Where entry into a reactor tank is required, strict safety procedures must be followed.

5.5 Extended Aeration Plant

5.5.1 Process Description

The main components of the extended aeration system are aeration tanks, a final settling tank, and sludge re-circulation (see figure 5). Where required, flow equalization should be provided upstream of the extended aeration plant.

Screened or shredded sewage flows directly into the aeration tank which generally provides a 24-hour retention. The sewage is mixed with re-circulated sludge from the final settling tank and aerated. Once the aeration period is complete the liquid passes into the final settling tank where separation of the heavier material occurs. The settled water flows out of the tank for disinfection and final disposal. The settled sludge in the bottom of the settling tank is drawn off and returned to the aeration tank. Some of the settled sludge is periodically directed into a holding tank where it is stabilized and thickened prior to final disposal.

5.5.2 Aeration Tank

Aeration of the tank contents serves three functions:

- Mixing the return sludge with incoming sewage;
- Maintaining the liquid in suspension; and
- Providing the necessary oxygen for biological treatment.

Air is generally introduced into the tank through a diffused air system. Air is blown from compressors through various types of porous material located at the bottom of the tank. The operator should maintain the dissolved oxygen content in the aeration tank at the level which results in adequate treatment.

Periodically, diffusers become clogged and should be cleaned. Indications of clogging are an increase of blower pressure or poor air transfer. Manufacturer's recommendations should be followed for detailed instructions on cleaning the diffusers. Where entry into the reactor tank is required, strict safety procedures must be followed.

5.5.3 Sludge Content

Normal plant operation typically requires the continuous return of sludge from the final clarifier to the aeration tank. Sludge is returned at a rate that yields the best plant effluent as determined by the plant operator.

A return air lift pump is used to pump sludge from the bottom of the settling tank to the aeration tank inlet. Periodic clogging of the air lift pump may occur. When clogging occurs, the pump is cleared by backflushing with air or water.

The quantity of sludge to be wasted is determined by experience. Sludge should be wasted to a sludge holding tank or, in small systems, to a sludge haulage truck.

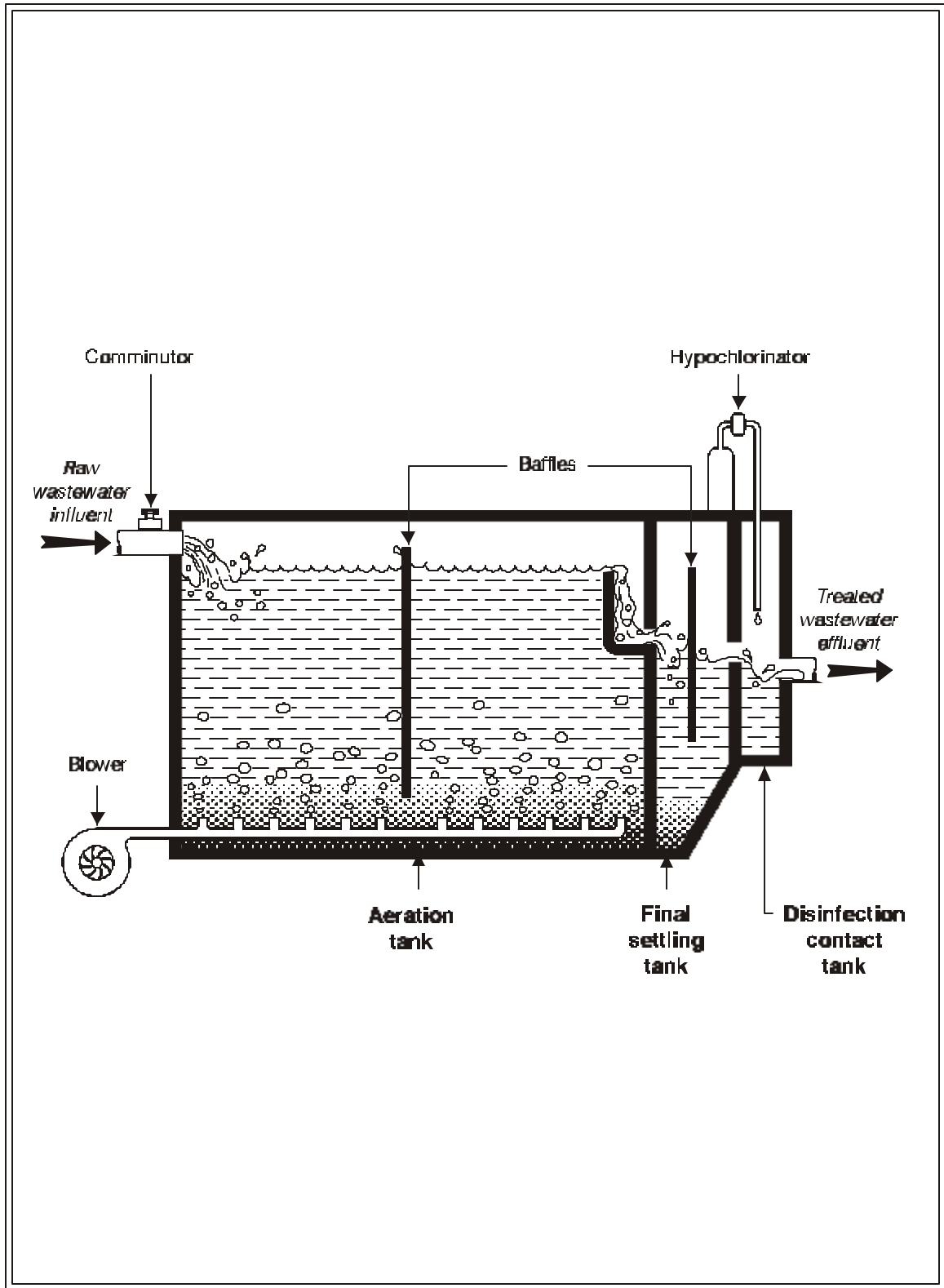


Figure 12: Extended Aeration Plant.

5.6 Disinfection

One additional step is to disinfect the wastewater. This ensures that any harmful bacteria are destroyed before wastewater is released from the plant. A common method for disinfecting treated wastewater for small treatment plants is hypochlorination. This means that chlorine is mixed with water and then added to the wastewater. Chlorine has the added advantage of providing residual disinfection of the wastewater. This is because the chlorine residual that remains in the wastewater after chlorination continues to provide protection from the possibility of re-contamination by bacteria.

An alternate means of disinfecting wastewater is to use ultraviolet (UV) disinfection. UV disinfection relies on the high energy contained in UV light to destroy the ability of bacteria and other microorganisms to reproduce, thereby, effectively killing them. In wastewater treatment, UV lamps are typically installed in a shallow contact channel so that, as the wastewater passes through the channel, UV light is shone through the water. The UV lamps can either be suspended above the wastewater in the channel or submerged in the wastewater itself. Where submerged UV lamps are used, they must be encased in quartz tubes to prevent excessive cooling and protected from breakage by a metal grid.

UV disinfection has been proven to be very effective in destroying bacteria in drinking water and some wastewaters. However, because the UV light must reach the bacteria in wastewater in order to be effective, wastewater must be relatively clear and free of turbidity (ie. have few suspended solid particles that give the wastewater a cloudy appearance). In turbid or very cloudy wastewater, the suspended solid particles will reflect and scatter much of the UV light, shielding some bacteria in the wastewater from the light and leaving them unharmed. This will result in inadequate disinfection. For this reason, UV light should not be used as the sole disinfectant on wastewaters with high suspended solids concentrations. It should also be noted that, unlike chlorination, UV disinfection provides no residual disinfection of wastewater. Since wastewater can easily become re-contaminated, it should not be stored for a significant length of time before its release from the treatment facility back into receiving waters.

Reference should be made to regulatory authorities for effluent quality requirements for disinfection of treated wastewater.

5.7 Other Treatment Technologies

It is not possible to cover all types of treatment processes in this type of publication. However, it should be noted that there are various other options available for both mechanical treatment systems as well as natural wastewater treatment systems (constructed wetlands, peat systems etc.).

For the application of any alternative treatment system, it is important to establish the adequacy of proposed processes and unit parameters for the treatment of the specific wastewater under consideration. The vendor should demonstrate that the alternative system meets existing design standards and guidelines and that the system has been proven in other communities under similar conditions. Where two or more solutions exist for providing wastewater treatment, each of which is feasible and practicable, the options should be analyzed and financial considerations (capital and operation and maintenance costs) assessed. All treatment system designs should satisfy the requirements of the provincial and federal regulatory authorities. Selection of the treatment system should be made in consultation with a qualified professional engineer registered in the province where the project is located.

5.8 Operation and Maintenance Procedures

Appropriate emphasis should be given to operation and maintenance for any mechanical treatment plant to operate properly. A qualified operator should always be available in order to make the necessary treatment adjustments. A treatment plant requires regular maintenance, repairs, and process control changes to maintain its condition in proper order. The operator should follow the manufacturer's recommendations on maintenance and lubrication. The name, address, and phone number of the service representative should be kept on file at the site.

Copies of the operation and maintenance manuals and applicable drawings should be available for use as required.

It is good practice to keep written records of all testing and work carried out on the treatment plant. This would include any maintenance tasks performed. This not only provides a record of the last check or maintenance task but also enables the operator to detect any changes in the operating characteristics of the plant.

In addition, a spare parts inventory should be kept so that in case a critical part breaks down, there is a replacement available. This is especially important in remote sites where the breakdown of a key part can result in the treatment plant being out of operation for an extended period of time while a replacement part is obtained.

5.9 Process Control

In order to make appropriate adjustments to the treatment plant, the operator should be able to perform certain tests that are required to monitor and control treatment processes depending on the type of treatment plant that is serving the community. Final effluent quality tests should be performed as required by regulatory agencies. It is recommended that the operator of a mechanical treatment plant be given sufficient training in the operation and maintenance of this type of facility. In certain regions, the “circuit rider” program is available to address these training needs. This is a practical hands-on training method that takes place at the operator’s facility.

5.10 Safety

Safety is one of the most important aspects of wastewater operation. Safety equipment should be used as directed, and all safety procedures should be stringently followed. Good housekeeping is important. The operator and other personnel must be protected from hazards.

Safety procedures should include the following:

- enclose the treatment facility site with a fence to discourage the entrance of unauthorized persons or animals;
- install handrails and guards where necessary;
- provide first-aid equipment;
- provide protective clothing and equipment such as hard hats, rubber gloves, boots, goggles, and vapour/dust mask,;
- provide safety equipment and tools for maintenance and operation emergencies, such as portable generators, portable gas-driven pumps, portable hoisting equipment, etc.; and
- provide appropriate safety training, including confined space entry training, to the operator and all other personnel.

Glossary

| | |
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| Aerobic | A condition characterized by the presence of dissolved oxygen in the aquatic environment. |
| Algae | Primitive aquatic plants that maintain their growth through the process of photosynthesis. |
| Bacteria | A group of microscopic organisms which consist of a single cell; most use organic nutrients as a food source. |
| Baffles | Deflector guides, gratings or similar devices placed in flowing wastewater to produce a more uniform distribution of flows in the plant. |
| Biochemical Oxygen Demand (BOD) | This is a common measurement of the amount of oxygen required by bacteria to stabilize wastewater. |
| Coliforms | A group of bacteria that inhabit the intestinal tract of humans and animals. |
| Effluent | A liquid flowing out of a chamber, treatment unit or basin. |
| Hydraulic loading | The volume of flow per day per unit of area (or volume). |
| Influent | The liquid entering a process unit or operation. |
| Inorganic matter | Chemical substances of mineral origin. |
| Organic loading | The amount of BOD per unit area (or volume) per unit of time; usually expressed as [kg/m ² /day] or [kg/m ³ /day]. |
| Pathogenic | Disease-causing. |
| pH | Expresses the intensity of acidity or alkalinity of a liquid. |
| Settleable solids | Those solids which will settle out in a prescribed time when a sample of sewage is allowed to stand undisturbed. |
| Sewer main | The sewer to which service connections are made from individual residences. |
| Suspended solids (SS) | The concentration of insoluble materials suspended or dispersed in wastewater. Usually determined by filtration methods. |