Foreword

The formulation of this national standard was initiated by the Agricultural Machinery Testing and Evaluation Center (AMTEC) under the project entitled "Enhancing the Implementation of the AFMA Through Improved Agricultural Engineering Standards" which was funded by the Bureau of Agricultural Research (BAR) of the Department of Agriculture (DA).

This standard has been technically prepared in accordance with PNS 01-4:1998 (ISO/IEC Directives Part 3:1997 – Rules for the Structure and Drafting of International Standards. It specifies the general requirements for waste management structures: agricultural liquid waste.

The word "shall" is used to indicate requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted.

The word "should" is used to indicate that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required.

In the preparation of this standard, the following references were considered:

Agricultural Waste Management Field Handbook. United States Department of Agriculture. July 1996.

ASAE EP403, Design of Anaerobic Lagoons for Animals Waste Management, ASAE Standard, 1986.

ASAE EP403.2, Design of Anaerobic Lagoons for Animals Waste Management, ASAE Standard, 1993.

ASAE R345.1, Design of Farm Waste Storage Tanks, ASAE Standard, 1975.

Constructed Wetlands and Aquatic Plant Systems for Municipal Wastewater Treatment, Design Manual. U.S. Environmental Protection Agency. Center for Environmental Research Information. Cincinnati, September 1998.

Crites, R. and G. Tchobanoglous. Small and Decentralized Wastewater Management Systems. WCB McGraw-Hill, 1998.

Hammer, M.J and M.J. Hammer, Jr. Water and Waste Water Technology, 3rd Edition. Prentice Hall, Inc. New Jersey, 1996.

Livestock Waste Facilities Handbook, MWPS-18.

Lustria, Ulyses M., Animal Waste Management and Recycling. Animal Husbandry and Agricultural Journal, March 1996.

1 Scope

This standard specifies the minimum requirements for design and construction of structures for the management of liquid component of agricultural waste. This standard excludes wastewater with chemicals and fertilizers.

2 Reference

The following normative document contains provisions which through reference in this text constitute provisions of this National Standard:

DENR A.O. No. 34, 1990	Revised Water Usage and Classification/Water Quality Criteria Amending Section Nos. 68 and 69, Chapter III of 1978 NPCC Rules and Regulations
DENR A.O. No. 35, 1990	Revised Effluent Regulations of 1990
PAES 413:2001	Agricultural Structures – Biogas Plant
PAES 414-2:2002	Agricultural Structures – Waste Management Structures: Part 2 – Agricultural Solid Waste - Composting
PD 1067	Water Code
PD 1152	Provisions of the Environmental Code on Solid and Liquid Waste Disposal

Rules and Regulations of National Pollution Commission, 1978

3 Definition

For the purpose of this standard, the following definitions shall apply:

3.1
aerobic
requires free oxygen

3.2
agricultural liquid waste
consist of liquid waste and slurry resulting from the production of livestock and poultry; and processing of crops, livestock and poultry

3.3
anaerobic
presence of free oxygen is not required

3.4
clean runoff
runoff not contaminated with manure such as runoff from roofs, grassed areas, drives and other areas which are not animal alleys

3.5
disinfection
process of killing all pathogenic microorganisms

3.6
dissolved solids
part of total solids passing through the filter in a filtration procedure

3.7
effluent
liquid waste, partially or completely treated, flowing out of a reservoir, basin, or wastewater treatment plant

3.8
facultative lagoons
lagoons that can function as aerobic or anaerobic depending on the environment

3.9
fixed solids
part of total solids remaining after volatile gases driven off at 600^{o}C

3.10
grit
non-biodegradable component of liquid waste composed of sand, gravel, cinders or other heavy solid materials

3.11
holding pond
storage where liquid waste is stored before final disposal

3.12
influent
liquid that flows into a containing space

3.13
lagoon
pit in the ground where liquid waste is stored to produce a higher quality effluent

3.14
liners
system of clay layers and/or geosynthetic membranes used to contain leachate and reduce or prevent contaminant flow to groundwater

3.15
lot runoff
rainfall containing animal manure

3.16
manure
accumulated moist animal excrement that does not undergo decomposition or drying; it include feces and urine which may be mixed with bedding material, spilled feed or soil

3.17
pathogenic microorganism
microorganism capable of causing diseases

3.18
primary treatment
treatment that causes substances in liquid waste to readily settle or float

3.19
secondary treatment
treatment used to convert dissolved or suspended materials into a form more readily separated from the liquid waste being treated

3.20
sludge
precipitate resulting from coagulation or sedimentation of liquid waste

3.21
slurry
watery mixture of insoluble solid

3.22
suspended solids
solids removed by filtration

3.23
total solids
residue remaining after water is removed from waste material by evaporation

3.24
volatile solids
part of total solids driven off as volatile gases when heated to 600^{o}C

3.25
5-day Bio-Chemical Oxygen Demand (BOD_5)
quantity of oxygen needed to satisfy biochemical oxidation of organic matter in waste sample in 5 days at 20^{o}C

4 Components and structures for liquid waste management

4.1 Collection

4.1.1 Alleys

4.1.1.1 Scrape alleys

4.1.1.2 Flush alleys

4.1.2 Gutters

4.1.2.1 Gravity drain gutters

4.1.2.2 Step-dam gutters

4.1.2.3 Scrape gutters

4.1.2.4 Flush gutters

4.2 Reception pit

4.3 Screening

4.4 Size-reduction

4.5 Solid-liquid separation

4.5.1 Grit chamber

4.5.1.1 Horizontal flow

4.5.1.2 Aerated grit

4.5.1.3 Vortex

4.5.2 Sedimentation tank

4.5.3 Settling channel

4.5.4 Screening

4.5.5 Evaporation

4.6 Oil and grease interceptor

4.7 Storage

4.7.1 Storage gutters

4.7.2 Storage tanks

4.7.3 Storage pond

4.8 Treatment

4.8.1 Anaerobic lagoons

4.8.2 Aerobic lagoons

4.8.3 Facultative lagoons

4.8.4 Mechanically aerated lagoons

4.8.5 Wetlands and aquatic treatment system

4.8.5.1 Free-water-surface constructed wetlands

4.8.5.2 Subsurface-flow constructed wetlands

4.8.5.3 Floating aquatic plant systems

4.8.5.3.1 Aerobic non-aerated

4.8.5.3.2 Aerobic aerated

4.8.5.4 Combination systems

4.9 Holding pond

4.10 Effluent treatment

4.11 Sludge treatment

4.12 Odor control

5 Typical processing diagrams for liquid waste

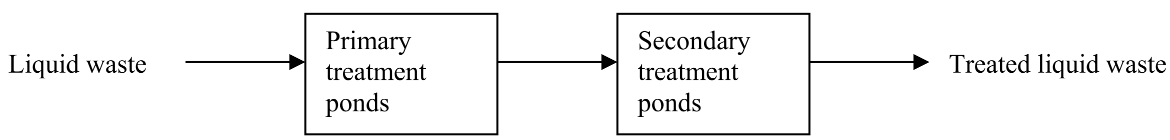


Figure 1 – Natural biological treatment in ponds

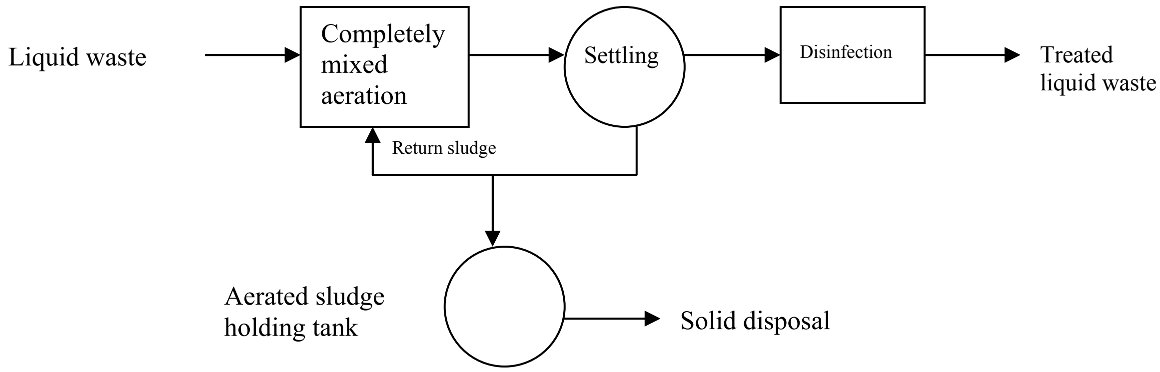


Figure 2 – Biological processing without primary sedimentation

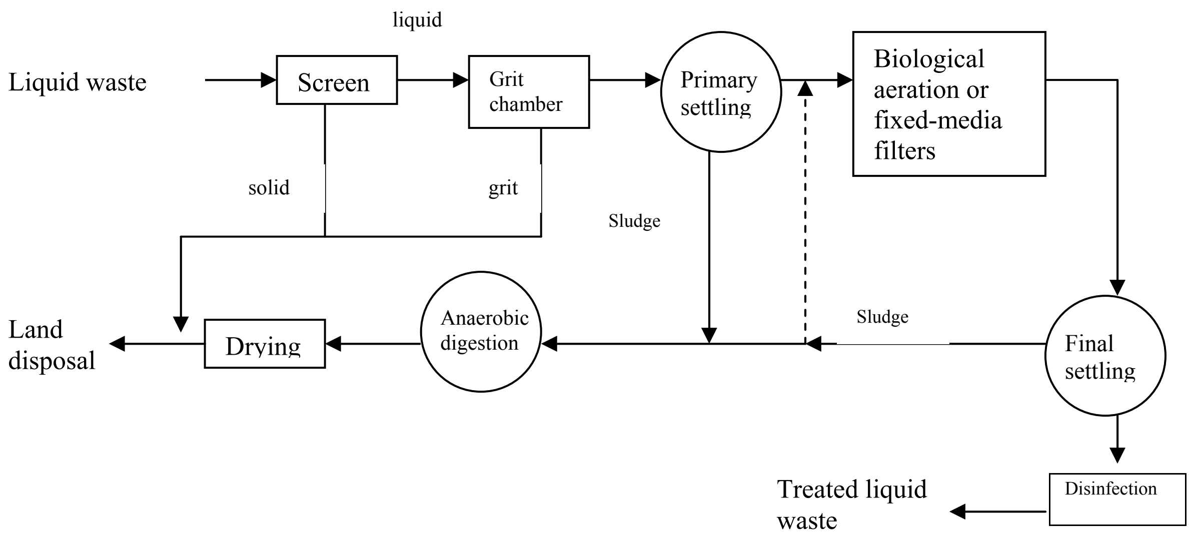


Figure 3 – Conventional liquid waste treatment plant

6 Location

6.1 The location of liquid waste facility shall conform with the existing zoning, land use standards, rules and regulations set by Department of Environment and Natural Resources (AO 34 and 35) and other national policies such as Water Code (PD 1067) and Environmental Code on Solid and Liquid Waste Disposal (PD 1152).

6.2 It shall be constructed on soils with at least 15% clay content. If constructed in other soil types, sealant shall be provided.

6.3 Liquid waste facility should be located so that the prevailing winds tend to disperse and transport the odor away from residences.

6.4 The site shall be provided with landscaping.

7 Functional requirements

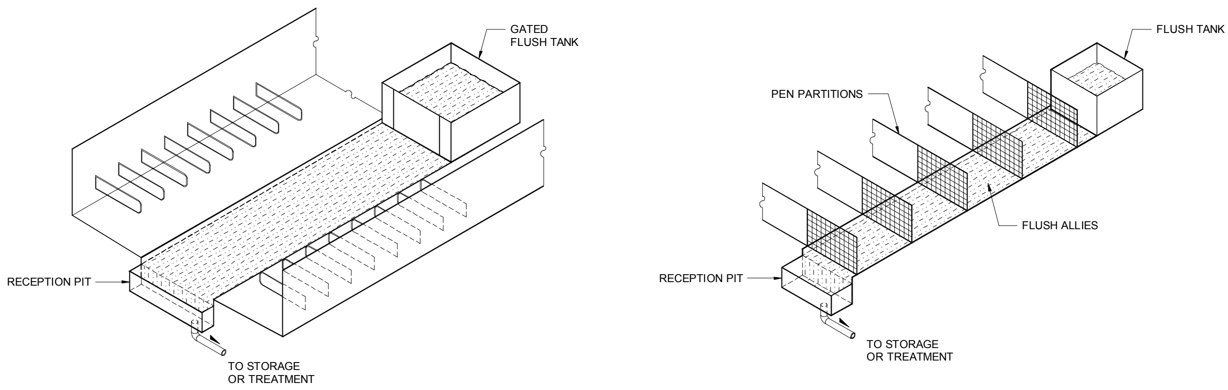
7.1 Waste collection

7.1.1 Alleys

7.1.1.1 Scrape alley shall be 2.5 m - 4 m wide for dairy and beef cattle and 1 m - 2.5 m wide for swine and poultry.

7.1.1.2 Flush alley shall be 1 m - 3 m depending on animal type. The initial flow depth should be 75 mm for underslat alley and 100 mm – 150 mm for open alleys. The grade of the alley should be 1.25% - 5%.

7.1.1.3 Flush alley shall be provided with cleaning mechanism such as water tanks and pumps. Figure 4 shows a typical dairy flush alley and swine flush alley.



a) DAIRY FLUSH ALLEY a) SWINE FLUSH ALLEY

Figure 4 – Typical flush alley

7.1.2 Gutters

7.1.2.1 Gravity drain gutter

For swine buildings, deep and narrow gutters (Figure 5) are recommended. The minimum depth shall be 760 mm and the width shall be 150 mm. The bottom slope shall be 1% towards the drain.

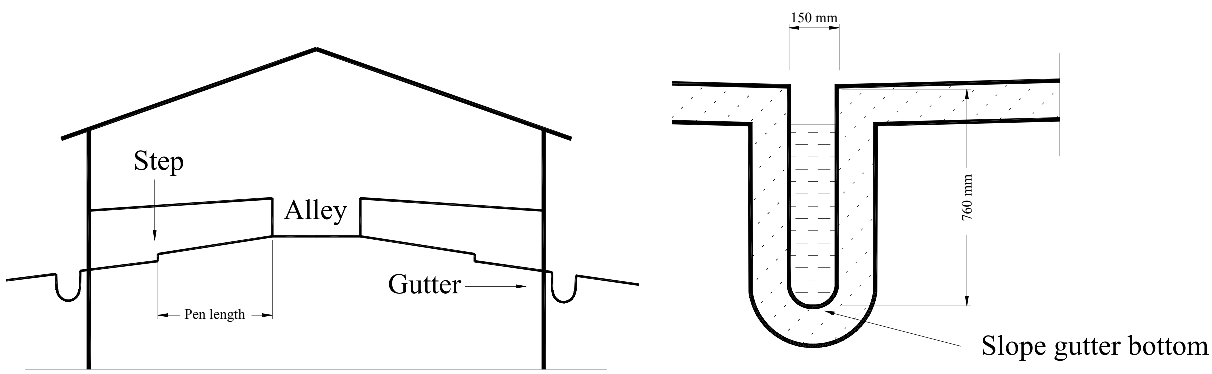


Figure 5 – Gravity drain gutter for swine manure

7.1.2.2 Step-dam gutters

Step-dam gutter is recommended for collecting cattle manure (Figure 6). A 150 mm high dam should be provided to hold back manure in a flat-bottomed channel. The gutter should be about 760 mm wide and should steps down to a deeper cross channel below the dam.

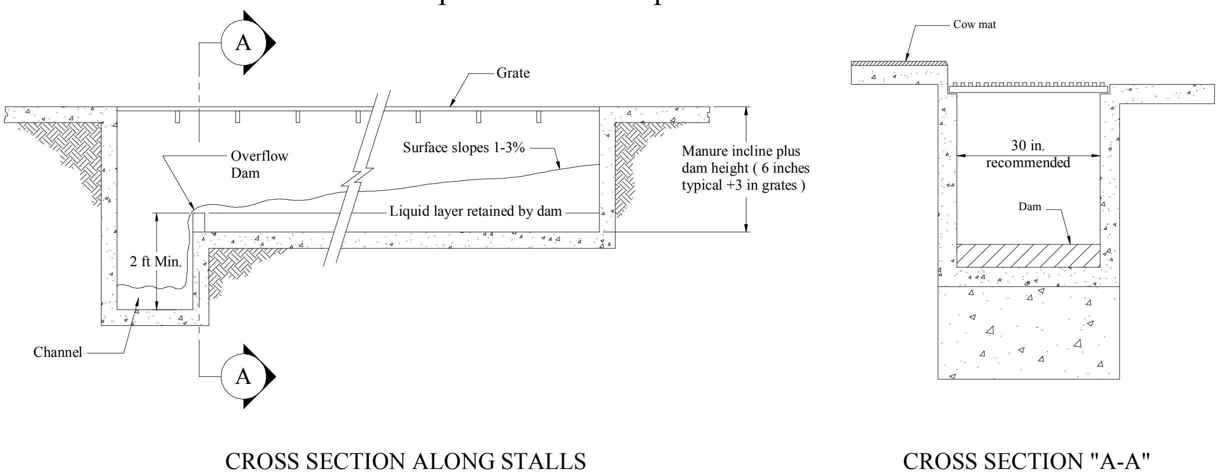


Figure 6 – Step-dam gutter for dairy manure

7.1.2.3 Scrape gutters

7.1.2.3.1 Scrape gutter is recommended for confined stall barns. Scrape gutters shall be 0.4 m - 0.6 m wide; 0.3 m - 0.4 m deep and generally does not have a bottom slope. It should be provided with paddles designed to move manure forward and down the gutter.

7.1.2.4 Flush gutters

Flush gutters shall have a minimum depth of 0.6 m on the shallow end. The depth should be either constant or increases as the length of the gutter increases. The bottom slope should be 0% - 5% depending on the storage requirements and clean out technique. It should be provided with flushing tanks or high volume pumps.

7.2 Runoff collection (Figure 7)

7.2.1 Clean runoff should be diverted away from the waste management system to reduce the amount of waste volume to be handled.

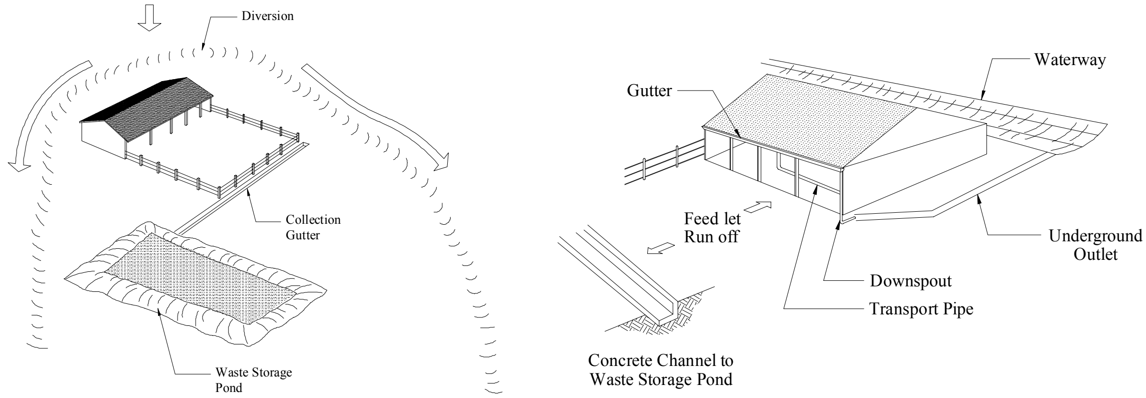


Figure 7 – Typical layout of collecting waste

7.2.2 To divert roof runoff away from waste control system, the roof gutter and the downspout should carry the water away from the site. Capacity of roof gutter and downspout is shown in Annex E and F.

7.2.3 If an open channel will not become polluted, eave gutters can be omitted, and roof water can fall to a surface channel with a minimum bottom slope of 0.5%.

7.2.4 Open concrete channels should be designed to carry the runoff. Element of channel section is shown in Annex D. Channels should be made of concrete or earth. Annex G and H shows the capacity of open concrete and earth channels.

7.2.5 Pipes and culverts used to transfer liquid wastes from storage gutters and pits to lagoons or storage should be selected based to the approximate pipe and culvert capacities (Annex I and J).

7.3 Reception pits

7.3.1 Slurry and liquid waste collected by scraping, gravity flow or flushing should be collected in a reception pit.

7.3.2 Reception pit should be designed to hold all the waste for several days.

7.3.3 It should be constructed of cast-in-place reinforced concrete or reinforced concrete block. Reinforcing steel should be added so that the walls can withstand internal and external loads.

7.3.4 Waste should be removed from the pit either by gravity or pumps.

7.4 Screening

7.4.1 Coarse screening

7.4.1.1 The screening element should consist of parallel bars, rods or wires. Details of screening devices are shown in Table 1.

Table 1 – Description of coarse screening devices used in liquid waste treatment

CLASSIFICATION OF SCREENING DEVICE	SIZE CLASSIFICATION	SCREEN OPENING mm	SCREEN MATERIAL	APPLICATION
Bar screen				
Manually cleaned	Coarse	25 – 50	Bars	Removal of coarse suspended solids and as pretreatment step for fine screening.
Mechanically cleaned	Coarse	15 - 75	Bars	
Fine bar or perforated coarse screen (mechanically cleaned)				
Fine bar	Fine coarse	3 – 12.5	Thin bars	Pretreatment
Perforated plate	Fine coarse	3 – 9.5	Perforated plate	Pretreatment
Rotary drum	Fine coarse	3 – 12.5	Stainless steel wedge wire	Pretreatment

7.4.1.2 The recommended specification for manually and mechanically cleaned bar racks is shown in Table 2.

Table 2 – Typical design specification for manually and mechanically cleaned bar racks

ITEM	UNIT	MANUALLY CLEANED	MECHANICALLY CLEANED
Bar size:			
Width	mm	5 – 15	5 – 15
Depth	mm	25 - 38	25 - 38
Clear spacing between bars	mm	25 - 50	15 - 75
Slope from vertical	%	58 - 100	0 - 58
Approach velocity	m/s	0.3 – 0.6	0.6 - 1
Allowable headloss	mm	152	152

7.4.2 Fine screening

Details of fine screening devices are shown in Table 3.

Table 3 – Description of fine screening devices used in liquid waste treatment

CLASSIFICATION OF SCREENING DEVICE	SIZE CLASSIFICATION	SCREEN OPENING mm	SCREEN MATERIAL	APPLICATION
Fine screen (mechanically cleaned)				
Fixed parabolic	Fine	0.25 – 3.2	Stainless steel wedge wire	Pretreatment
Rotary drum	Fine	0.25 – 3.2	Stainless steel wedge wire	Pretreatment
Rotary disk	Very fine	0.15 – 0.38	Stainless steel wedge wire	Primary treatment

7.4.3 Screenings should either feed to a shredder and returned to the liquid waste flow or be deposited in a portable receptacle for hauling and managed as solid waste (Refer to **PAES 414-2:2002** Waste Management Structures – Part 2: Agricultural Solid Waste - Composting).

7.5 Size reduction

7.5.1 Size reduction should be provided to cut solids in the liquid waste passing through the device to about 6 mm. It shall be installed after the screen.

7.5.2 Shredder or comminutor should be constructed with a bypass arrangement so that a manual bar rack is used in case flow rates exceed the capacity of the comminutor or in case there is a power or mechanical failure.

7.5.3 Headloss through the comminutor should range from 0.3 m – 0.9 m.

7.5.4 If comminutor precede grit removal facilities, rock traps in the channel upstream of the comminutor should be provided.

7.6 Solid-liquid separation

7.6.1 Grit chambers

7.6.1.1 Grit chamber should be designed to remove particles equivalent to fine sand (0.25 mm – 3.2 mm diameter with a specific gravity of 2.65).

7.6.1.2 Types of grit chambers:

7.6.1.2.1 Horizontal-flow grit chamber

Design data for horizontal-flow grit chamber is shown in Table 4.

Table 4 – Typical design information for horizontal-flow grit chambers

ITEM	UNIT	VALUE
Detention time	s	60
Horizontal velocity	m/s	0.3
Settling velocity for removal of:		
50-mesh material[a]	m/s	0.05
100-mesh material[a]	m/s	0.01
Headloss in a control section as percent of depth in channel	%	36[b]
Added length allowance for inlet and outlet turbulence	%	30

[a] If the specific gravity of the grit is significantly less than 2.65, lower velocities should be used.
[b] For Parshall flume control.

7.6.1.2.2 Aerated grit chambers

Design data for horizontal-flow grit chamber is shown in Table 5.

Table 5 – Typical design information for horizontal-flow grit chambers

ITEM	UNIT	VALUE
Detention time at peak flowrate	min	3
Dimensions:		
Depth	m	3
Length	m	12
Width	m	3.5
Width-depth ratio		1.5:1
Length-width ratio		4:1
Air supply per meter of length	$m^3/m\cdot min$	0.46
Grit quantities	$m^3/Mgal$	0.06

7.6.1.2.3 Vortex-type grit chambers

Design data for vortex-type grit chamber is shown in Table 6.

Table 6 – Typical design information for vortex-type grit chambers

ITEM	UNIT	VALUE
Detention time at peak flow rate	s	30
Diameter:		
Upper chamber	m	1.2 – 7.3
Lower chamber	m	0.9 – 1.8
Height	m	2.7 – 4.9
Removal rates:		
50 mesh material	%	92 – 98
70 mesh material	%	80 – 90
100 mesh material	%	60 - 70

7.6.1.3 There should be provision for washing grits to remove the organic materials and provision for proper disposal of screenings and grits.

7.6.2 Sedimentation tanks

7.6.2.1 Tanks should either be rectangular or circular. Length to width ratio of rectangular tanks should be 3:1 – 5:1. Table 7 shows the typical design information for rectangular and circular sedimentation tanks used for primary and secondary treatment of wastewater.

Table 7 – Typical design information for sedimentation tanks for primary and secondary treatment of liquid waste

ITEM	UNIT	VALUE	
		PRIMARY	SECONDARY
Rectangular:			
Depth	m	3 – 4.9	3 – 6.7
Length	m	15 – 90	15 – 90
Width	m	3 – 24	3 – 24
Flight speed	m/s	0.01 – 0.2	0.01 – 0.02
Circular:			
Depth	m	3 – 4.9	3 – 6.7
Diameter	m	3 – 60	3 – 60
Bottom slope	%	6 - 17	6 - 17
Flight travel speed	rev/min	0.02 – 0.05	0.02 – 0.05

7.6.2.2 Sedimentation tanks should be designed based on the detention time and surface overflow rates as shown in Table 8.

Table 8 – Typical detention time and overflow rates for primary sedimentation tanks

ITEM	UNIT	VALUE
Primary sedimentation tanks followed by secondary treatment		
Detention time	h	1.5 – 2.5
Overflow rate		
Average flow	$m^3/m^2 \cdot d$	30 – 50
Peak hourly flow	$m^3/m^2 \cdot d$	81 – 122
Weir loading	$m^3/m \cdot d$	124 - 497
Primary settling with waste activated sludge return		
Detention time	h	1.5 – 2.5
Overflow rate		
Average flow	$m^3/m^2 \cdot d$	24 - 33
Peak hourly flow	$m^3/m^2 \cdot d$	49 – 69
Weir loading	$m^3/m \cdot d$	124 - 497

7.6.3 Settling channel

7.6.3.1 Side slopes should be 3:1 or less and the bottom slopes should be 0.1 % - 0.3 % to maintain low velocities and rapid settling.

7.6.3.2 Side slopes should be 3:1 or less and the bottom slopes should be 0.1 % - 0.3 % to maintain low velocities and rapid settling.

7.6.3.3 For the first 15 m – 30 m section, 0.6 m/s velocity should be designed to settle out relatively large solids and debris. For the next 30 m – 91 m, the velocity should be as low as 0.15 m/s to settle out smaller solids.

7.6.4 Screening

The organic content of animal waste slurries can be reduced by filtering. Screened solids can be dried or composted (Refer to **PAES 414-2:2002**).

7.6.5 Evaporation

Dries or dehydrates solids in a pond or can be aided by supplemental heat in a dryer.

7.7 Oil and grease interceptor

7.7.1 The volume for interceptor tank should be 1 – 3 times the average daily flow rate.

7.7.2 Inlet should be situated below the water surface and the outlet should be placed closer to the bottom of the tank.

7.8 Storage

7.8.1 Storage gutters

Gutters should have a minimum depth of 760 mm and width of 150 mm with a bottom slope of 1%.

7.8.2 Storage tanks

7.8.2.1 Storage capacities should depend on the number and size of animals, amount of dilution by spilled and cleaning water, amount of runoff to be stored and the desired length of time between emptying.

7.8.2.2 Tank depth should be the sum of the depth for computed storage capacity plus freeboard above the lowest inlet opening and additional 0.2 m for the liquid always left in the tank.

7.8.2.3 Tanks should be designed to withstand all anticipated earth, hydrostatic, and live loads.

7.8.2.4 Sidewalls and partitions of the tank should be properly reinforced. For deep tanks, cast-in-place concrete should be used.

7.8.2.5 Storage tanks should be provided with a submerged centrifugal chopper pump.

7.8.2.6 Covers for tank opening should be non-floating and weigh at least 18 kg.

7.8.2.7 Provide a permanent ladder or steps below all openings with a minimum dimension of 381 mm.

7.8.2.8 Pit ventilation should be provided to reduce gasses and odors.

7.8.3 Storage pond

7.8.3.1 Liquid waste storage ponds and structures shall be sized to hold all of the manure, bedding, and liquid waste from animal housing, animal and crop processing plants, and contaminated runoff that can be expected during the storage period.

7.8.3.2 In addition to the waste volume, there shall be provision for the following depth adjustment to:

7.8.3.2.1 Account for a freeboard of 0.3 m.

7.8.3.2.2 Accommodate normal precipitation less evaporation on the pond surface accumulated during the storage period.

7.8.3.2.3 Accommodate precipitation less evaporation during the most critical storage period. If the pond does not have a watershed, the depth of the 25-year, 24-hour precipitation on the pond surface shall be included. For a pond with micro watershed, waste storage ponds shall be designed to include runoff from micro watersheds. The runoff volume shall be the 25-year, 24-hour storm.

7.9 Treatment

7.9.1 Anaerobic lagoons

7.9.1.1 Minimum lagoon volume requirement shall be the sum of waste volume, minimum treatment volume, and sludge volume for the treatment period (Figure 8).

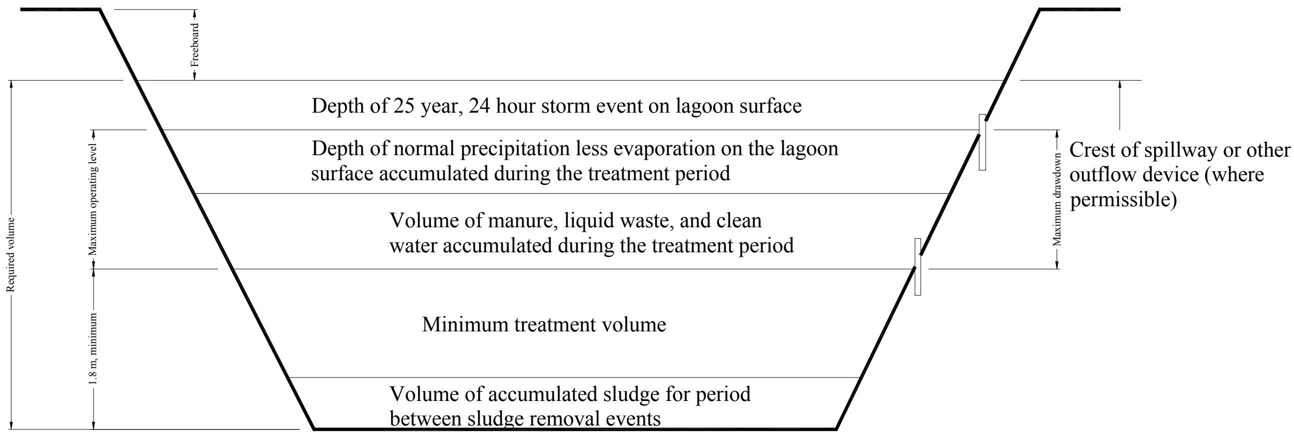


Figure 8 – Anaerobic lagoon cross-section

7.9.1.1.1 Waste volume (*WV*)

Waste volume shall reflect the actual volume of manure, liquid waste, flush water that will not be recycled, and clean dilution water added to the lagoon during the treatment period.

$$WV = VM_T + VWW_T + CW$$

where:
WV = Waste volume for treatment period, m^3
VM_T = Total volume of manure for treatment period, m^3
VWW_T = Total volume of wastewater for treatment period, m^3
CW = Clean water added during treatment period, m^3

7.9.1.1.2 Minimum treatment volume ($TV_{\min}$)

The minimum treatment volume shall be determined as follows:

$$TV_{\min} = \frac{VS_T}{VSLR}$$

where:
$TV_{\min}$ = Minimum treatment volume, m^3
VS_T = Total daily volatile solids loading (from all sources), kg/day
$VSLR$ = Volatile solids loading rate, kg/1,000 m^3/day

7.9.1.1.3 Sludge volume (*SV*)

Sludge volume (*SV*) shall be determined as follows:

$$SV = 365\,x\,AU\,x\,TS\,x\,SAR\,x\,T$$

where:
SV = Sludge volume (m^3)
AU = Number of animal units
T = Sludge accumulation time (years)
TS = Total solids production per animal unit per day (kg/AU/day)
SAR = Sludge accumulation ratio (m^3/kg TS), refer to Table 9

Table 9 – Sludge accumulation ratio (SAR)

Animals	SAR
Poultry	0.0295
Swine	0.0485
Cattle	0.0729

7.9.1.2 In addition to the minimum volume requirement, there shall be provision for the following depth adjustment to:

7.9.1.2.1 Account for a freeboard of 0.3 m.

7.9.1.2.2 Accommodate normal precipitation less evaporation on the pond surface accumulated during the storage period.

7.9.1.2.3 Accommodate precipitation less evaporation during the most critical storage period. If the pond does not have a watershed, the depth of the 25-year, 24-hour precipitation on the pond surface shall be included. For a pond with watershed, waste storage ponds shall be designed to include outside runoff from watersheds. The runoff volume shall be the 25-year, 24-hour storm.

NOTE The minimum acceptable depth for anaerobic lagoons shall be 1.8 m.

7.9.2 Aerobic lagoons

7.9.2.1 Minimum lagoon volume requirement shall be the sum of waste volume and sludge volume for the treatment period (Figure 9).

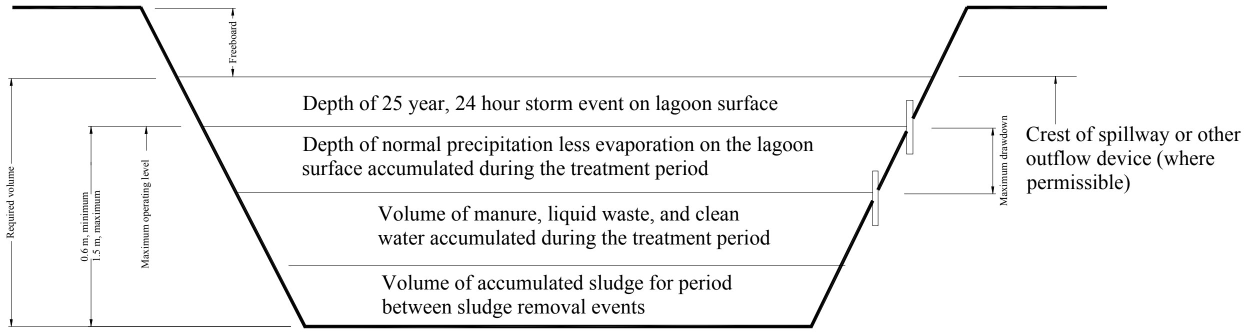


Figure 9 – Aerobic lagoon cross-section

7.9.2.1.1 Waste volume (*WV*)
For the computation of waste volume, refer to subclause **7.9.1.1.2.**

7.9.2.1.2 Sludge volume (*SV*)

For the computation of waste volume, refer to subclause **7.9.1.1.3.**

7.9.2.2 The minimum treatment surface area shall be computed based from BOD_5 of total daily production of waste and the selected BOD_5 loading rate of lagoon. It is computed as follows:

$$TSA_{\min} = \frac{BOD_T}{BOD_{LR}}$$

where:
$TSA_{\min}$ = Minimum treatment surface area
BOD_T = Total daily production of BOD_5 of manure and wastewater
BOD_{LR} = Selected lagoon BOD_5 loading rate

7.9.2.3 The depth shall be computed from the minimum lagoon volume requirement and from the minimum treatment surface area. The minimum operating depth shall be 0.6 m and the maximum level shall not exceed 1.5 m.

7.9.2.4 In addition to the minimum volume requirement, there shall be provision for the following depth adjustment to:

7.9.2.4.1 Account for a freeboard of 0.3 m.

7.9.2.4.2 Accommodate normal precipitation less evaporation on the pond surface accumulated during the storage period.

7.9.2.4.3 Accommodate precipitation less evaporation during the most critical storage period. If the pond does not have a watershed, the depth of the 25-year, 24-hour precipitation on the pond surface shall be included. For a pond with watershed, waste storage ponds shall be designed to include outside runoff from watersheds. The runoff volume shall be the 25-year, 24-hour storm.

7.9.3 Mechanically aerated lagoons

7.9.3.1 Mechanically aerated lagoons combine the small surface area feature of anaerobic lagoons with relative odor free operation of an aerobic lagoon.

7.9.3.2 The depth of aerated lagoons shall depend on the type of aerator used.

7.9.4 Construction of lagoons

7.9.4.1 Soil and foundation

7.9.4.1.1 Lagoons should be located on soil with at least 15% clay content. If the distance between the bottom of the pond and the water table is less than 1m, seal shall be used.

7.9.4.1.2 Soil should be properly compacted and the storage bottom should be at least 1 m above the water table.

7.9.4.1.3 The outside slope should be seeded with grass and mowed regularly to provide protection against erosion and provide stability.

7.9.4.2 Earth embankment

7.9.4.2.1 Lagoon embankments should be constructed for stability and should be protected against wave damage, erosion due to weather and burrowing by rodents.

7.9.4.2.2 Top width should be at least 2.5 m to allow access for tractors and pumps.

7.9.4.2.3 Inside slopes should be between1:2 and 1:4 while outside slope should be 1:5 to allow easy access with the pumping equipment and for maintenance.

7.9.4.2.4 Embankment elevation should be increased at least 5% during construction to allow for settling.

7.9.4.2.5 The top of the settled embankment should be at least 0.6 m above the maximum design surface level.

7.9.4.3 Inlet and outlet

7.9.4.3.1 Inlet devices should discharge into the lagoon at a point beyond the cut slope of the embankment. It should be either located above or below the lagoon surface.

7.9.4.3.2 Pipes or open channels should be used with a minimum dimension of 200 mm.

7.9.4.3.3 Access to the inlet should be provided for cleaning.

7.9.4.3.4 Outlet devices should be installed in a manner that allows effluent to be taken at a level 150 mm – 450 mm below the surface.

7.9.4.4 Overflow

7.9.4.4.1 Effluent from an anaerobic lagoon should not be discharged to streams, lakes or waterways. Lagoon should overflow to a subsequent storage or treatment cell.

7.9.4.4.2 Lagoon supernatant should be applied to the land without producing surface runoff, in such amounts that undesirable levels of nutrients or toxic materials do not accumulate in the soil, plants, soil water, groundwater or runoff.

7.9.4.5 Water supply

Adequate water should be available to establish and maintain the minimum operating level of the lagoon at 60% of the design depth.

7.9.4.6 Mixing

There should be provision for mixing the wastewater. It should be accomplished using hydraulic jumps in open channels, venturi flumes, pipelines, pumping, static mixers and mechanical mixers.

7.9.5 Wetlands and aquatic treatment system

7.9.5.1 Free-water-surface constructed wetlands

7.9.5.1.1 It should consist of channels or basins with natural or constructed impermeable barrier to prevent seepage.

7.9.5.1.2 The emergent vegetation should be flooded to a depth of 100 mm – 450 mm.

7.9.5.1.3 The basin should have a slope of 0.4 % - 0.5 %.

7.9.5.1.4 The inlet end of the wetland should be provided with gated pipe, weirs or drilled holes in the distribution pipelines.

7.9.5.1.5 Outlet structures should provided with adjustable weirs with stop logs and submerged outlet header pipes with control valves.

7.9.5.1.6 There should be provision to vary the water depth and to drain the basin.

7.9.5.1.7 There should be provision to recirculate partially or fully treated effluent back to the head end of the basin.

7.9.5.1.8 Detention time should range from 2 days – 5 days.

7.9.5.2 Subsurface-flow constructed wetlands

7.9.5.2.1 The wastewater should laterally flow through the porous medium. Medium should range from course gravel to sand.

7.9.5.2.2 The gravel size for the bed should range from 3 mm – 32 mm. For the inlet zone, gravel size should be 50 mm – 100 mm to minimize clogging.

7.9.5.2.3 If the soils are permeable (greater than 5 mm/h), a liner below the bed medium should be provided.

7.9.5.2.4 The depth of the bed should be 0.45 m – 1 m with a slope of 0 % - 0.5 %.

7.9.5.2.5 The water level should be kept 75 mm – 150 mm below the top of the medium.

7.9.5.2.6 Inlet should be provided with gated pipe, slotted pipe, or troughs with V-notch weirs. Outlet devices should consist of perforated pipes submerged to the bottom of the bed with valves or adjustable-level outlet pipes to control the water depth.

7.9.5.2.7 There should be provision to recirculate partially or fully treated effluent back to the head end of the basin.

7.9.5.2.8 Detention time should range from 3 days – 4 days.

7.9.5.3 Floating aquatic plant system

7.9.5.3.1 Water hyacinth

7.9.5.3.1.1 Design criteria for water hyacinth wastewater system is shown in Table 10.

Table 10 – Typical design criteria for water hyacinth wastewater treatment system

ITEM	UNITS	TYPE	
		AEROBIC NONAERATED	AEROBIC AERATED
Influent wastewater		Fine-screened or settled	Fine-screened or settled
Water depth	m	0.45 – 0.75	1.2 - 1.4
Detention time	days	10 -30	4 – 8
Aeration	m^3/min.Mgal	none	11.32– 12.03
Type of aerator		none	Fine bubble
Channel cross section		Trapezoidal	Trapezoidal
Channel top width	m	6 - 9	6 - 9
Channel side slopes		1:1	1:1
Channel lining		Geomembrane	Geomembrane
Liner thickness	mil	40 – 80	40 – 80
Pond geometry		Horseshoe shape	Horseshoe shape

7.9.5.3.1.2 Inlet structures should be either concrete weir or manifold pipes with multiple outlets.

7.9.5.3.1.3 A subsurface discharge is preferred for inlets, while interbasin and extrabasin transfer structures should either be surface or subsurface.

7.9.5.3.1.4 Outlet structures should be designed to remove effluent of various depths. It should remove effluent at a depth of 0.3 m below the shallowest operating depth.

7.9.5.3.2 Duckweed

7.9.5.3.2.1 Design criteria for duckweed wastewater system is shown in Table 11.

Table 11 – Typical design criteria for duckweed system

ITEM	UNIT	VALUE
Influent wastewater		Facultative pond influent
Detention time	days	20 – 30
Water depth	m	1.5 – 2.4

7.9.5.3.2.2 Duckweed ponds should be designed like water hyacinth basins. Floating baffles should be provided to reduce the effects of the wind.

7.9.5.3.2.3 Inlet structures should be either concrete weir or manifold pipes with multiple outlets.

7.9.5.3.2.4 A subsurface discharge is preferred for inlets, while interbasin and extrabasin transfer structures should either be surface or subsurface.

7.9.5.3.2.5 Outlet structures should be designed to remove effluent of various depths.

7.10 Holding pond

7.10.1 Capacity of the holding pond should depend on the duration of storage period, and volume of liquid waste during storage period.

7.10.2 The bottom and sides of the pond should be watertight to avoid possible ground-water contamination.

7.10.3 The bank of the pond should be not steeper than 2.5:1.

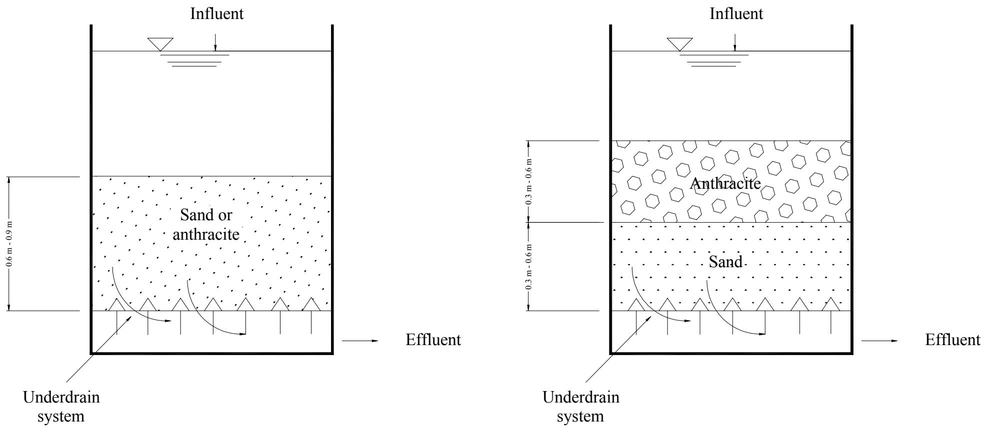
7.11 Effluent treatment

7.11.1 Filtration

7.11.1.1 The surface area required for filters should be based on the peak filtration and peak plant flow rates.

7.11.1.2 The width-to-length ratios for filter bed should 1:1 – 1:4.

7.11.1.3 Filter medium such as sand should have an effective diameter of at least 0.45 mm and shall have a minimum depth of 280 mm.



a b

Figure 10 – Typical granular-medium filter: a) conventional monomedium downflow filter, and b) conventional dual-medium downflow filter

7.11.1.4 There should be provision for backwashing to clean the material within the filter effectively. Backwashing should be achieved using waster backwash with auxiliary surface water-wash agitation, water backwash with auxiliary air scour, and combined air-water backwashing.

7.11.2 Disinfections

7.11.2.1 There should be provision for disinfection through the use either chemical agents, physical agents, mechanical means and radiation.

7.11.2.2 Disinfection shall be required if the treated wastewater will be irrigated for food crops unless the crops are processed commercially prior to use, disinfected effluent is acceptable.

7.11.3 The quality of the effluent before final disposal to the environment shall conform with water quality standards of the Department of Environment and Natural Resources (Refer to DAO No. 35, Series of 1990).

7.12 Sludge treatment

7.12.1 Biogas production

Refer to PAES 413:2001 Agricultural Structures – Biogas Plant.

7.12.2 Drying

7.12.2.1 The bed should consist of 300 mm fine sand underlaid by 200 mm – 460 mm of gravel.

7.12.2.2 The sand should have an effective size of 0.3 mm – 0.75 mm, free from fines and should have a maximum uniformity coefficient of 3.5. The gravel size should be 2.5 mm – 25 mm.

7.12.2.3 Underdrains should be 100 mm in diameter and should slope at 1%.

7.12.2.4 Beds should be divided every 3 m by 0.6 m partitions. The drying bed wall should be concrete.

7.12.2.5 Seepage collected in the underdrains should be returned to the treatment area with the raw wastewater.

7.12.3 Sludge lagoon

7.12.3.1 Sludge lagoon should either be designed for sludge drying, intermediate storage in conjunction with land application and long-term storage.

7.12.3.2 Sludge drying lagoon should have a sludge depth of 0.62 m – 1.25 m. Storage lagoon should have a depth of 3 m – 5 m and should be provided with mechanical aerator.

7.13 Odor control

7.13.1 Odor control methods to treat foul air should either with the use of chemical scrubbers, activated carbon and bulk medium biofilters.

7.13.2 Bulk medium biofilters such as soil, peat and compost should have sufficient porosity, near-uniform particle size and pH-buffering capacities.

7.13.3 Figure 11 shows the typical configurations for bulk medium odor control facilities and Table 12 shows the design considerations.

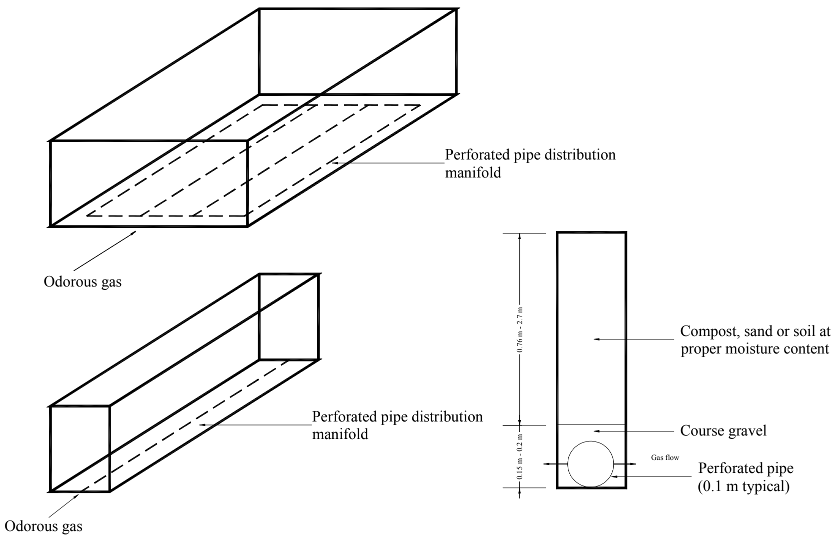


Figure 11– Typical configurations for bulk medium odor control facilities

Table 12 – Design considerations for bulk medium biofilters

ITEM	UNITS	VALUE
Oxygen concentration	Parts oxygen/parts oxidizable gas	100
Moisture Compost filter Soil filter	 % %	 40 – 50 10 - 25
Temperature, optimum	°C	37
pH of medium		6 – 8
Gas residence	s	30 - 60
Depth of medium	m	0.9 – 1.5
Loading rate	m^3/m^2.min	0.46 – 0.91
Back pressure, maximum	mm of Hg	15

8 Operation, maintenance and safety

8.1.1 Collection function operation

The collection function involves the initial capture and gathering of waste from the point of origin or deposition to a collection point. Frequency of collection should be dependent on the type of operation.

8.1.2 Storage function operation

Storage function components include waste storage ponds and structures. Storage structures include tanks and stacking facilities. Monitoring storage levels in relationship to the storage period is of prime importance in the operation of storage components. Storage facility should be provided with staff gauge.

8.1.3 Treatment function operation

Proper operation of waste treatment lagoons includes maintaining proper liquid levels and assuring that the maximum loading rates are not exceeded. The rate of filling should not exceed the design rate.

8.2 Maintenance

8.2.1 Production function maintenance

8.2.1.1 Roof gutters and downspouts

Maintenance items should include cleaning debris from the gutters, unplugging outlets, repair of leaks, repair or replacement of damaged sections of gutters and downspouts, repair of gutter hangers and downspout straps, and repair of protective coatings.

8.2.1.2 Diversions

Maintenance of diversions includes, as appropriate to the type of construction, mowing vegetation, eliminating weeds, repair of eroded sections, removal of debris and siltation deposits, and repair of concrete. Inspections should be made on a regularly scheduled basis and after major storm events.

8.2.1.3 Collection

Maintenance requirements for the collection function are primarily directed at mechanical equipment. Regularly scheduled lubrication and other preventive maintenance must be performed on electric motors, sprockets, and idle pulleys according to the manufacturer's recommendations.

8.2.1.4 Storage

8.2.1.4.1 Ponds

Regularly scheduled inspections and timely maintenance are required for waste storage ponds. Inspections should focus on leaks, slope failures, excessive embankment settlement, eroded banks, and burrowing animals. Earthen waste storage ponds should be inspected carefully during and after they are emptied.

8.2.1.4.2 Tanks

Inspection and maintenance of waste storage tanks should be regularly scheduled for checking cracks, degradation of the concrete and any sudden or unexpected drop or rise in the liquid level.

8.2.1.4.3 Stacking facilities

Concrete should be inspected for cracks and premature degradation. If any problems are found with the concrete, appropriate repairs should be made.

Lumber should be inspected for damage either by natural deterioration or from man, animal, or weather event causes. Damaged lumber should be replaced. Roofs should be inspected regularly for leaks and damaged trusses, and repairs made promptly.

8.2.1.4.4 Constructed wetlands

There should be provision for mosquito control such as mosquitofish stocking, vegetation management, application of chemical and biological control agents. Harvesting of the emergent vegetation should be practiced to maintain hydraulic capacity, promote active growth and avoid mosquito growth.

8.3 Safety

8.3.1 Gases

8.3.1.1 There should be provisions that allow for maintenance of equipment outside the space or for equipment parts that can be easily retracted for maintenance.

8.3.1.2 Safety equipment such as air packs, face masks, safety harness, first-aid kits, safety signs and hazardous atmospheres testing kits or monitor should be provided.

8.3.1.3 If feasible, lids for manure tanks or pits should be constructed and access covers should be kept in place.

8.3.1.4 There should be provision for ventilation systems that provide for both a supply of fresh air and exhaust of accumulated gases.

8.3.2 Impoundments

8.3.2.1 Sturdy guard rails should be built to prevent people and equipment from falling into waste impoundments.

8.3.2.2 Fence around the impoundment should be provided and should be provided with warning signs.

8.3.2.3 Loading ramps and walkways should be constructed with a traction surface to minimize slipping.

8.3.3 Tanks

8.3.3.1 Safety features should be provided such as warning signs, grates and lids for openings, fences, barriers, and rescue equipment. Grates, lids, and gates should be secured in place when left unattended.

8.3.3.2 A ladder hinged to the tank cover that can be pulled down with a rope to allow escape should be provided.

8.3.3.3 Perches installed on the tank floor or wall that a person can stand on to attain fresh air and call for help should be constructed.

8.3.4 Equipment operation

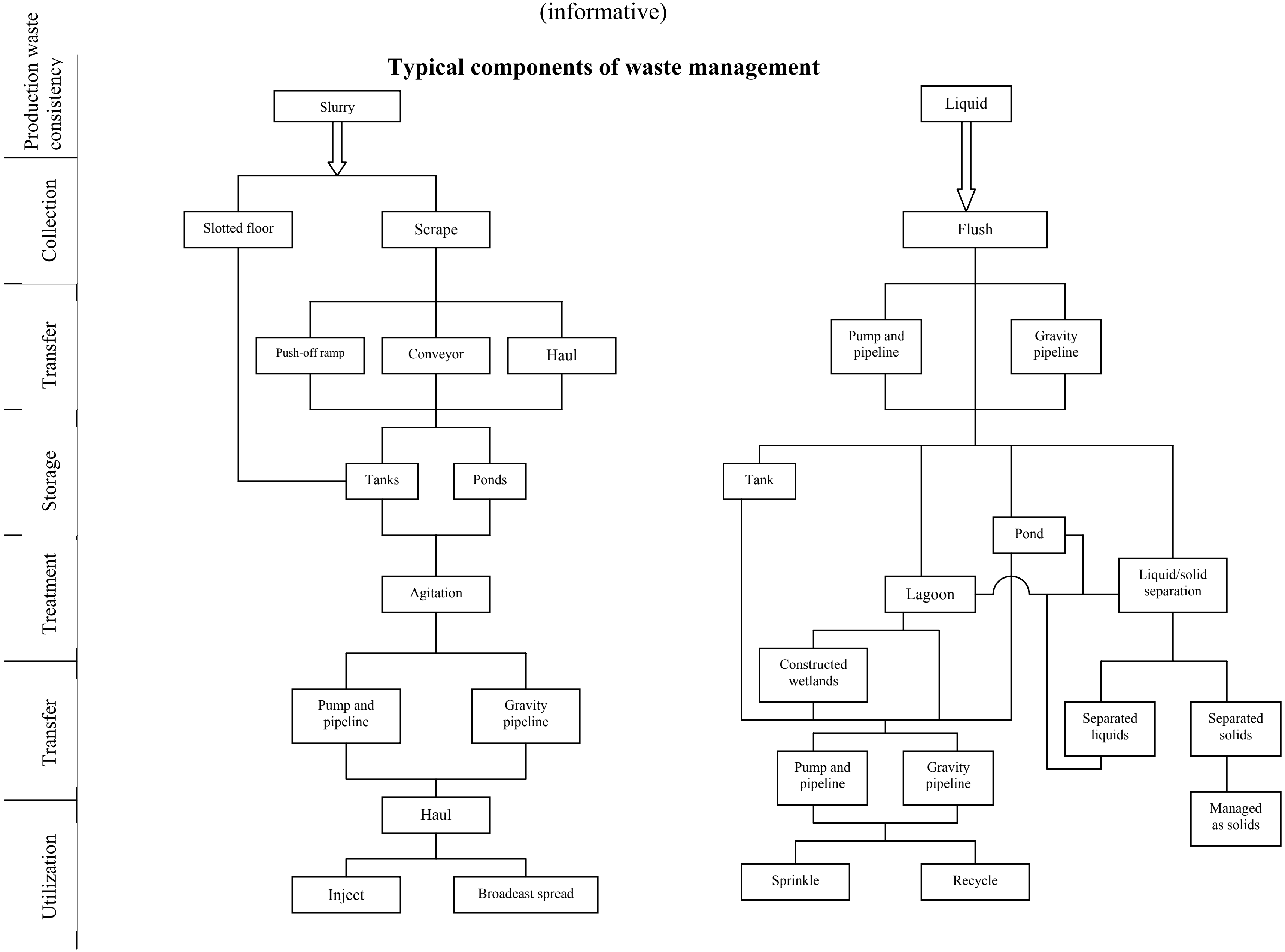
8.3.4.1 Moving parts that would expose an operator to injury should be properly guarded.

8.3.4.2 Backup signals on equipment should be used.

8.3.4.3 Electrical equipment should be properly maintained and should be properly grounded.

Annex A
(informative)

Typical components of waste management



Annex B
(informative)

Waste characteristics

B.1 Animal manure

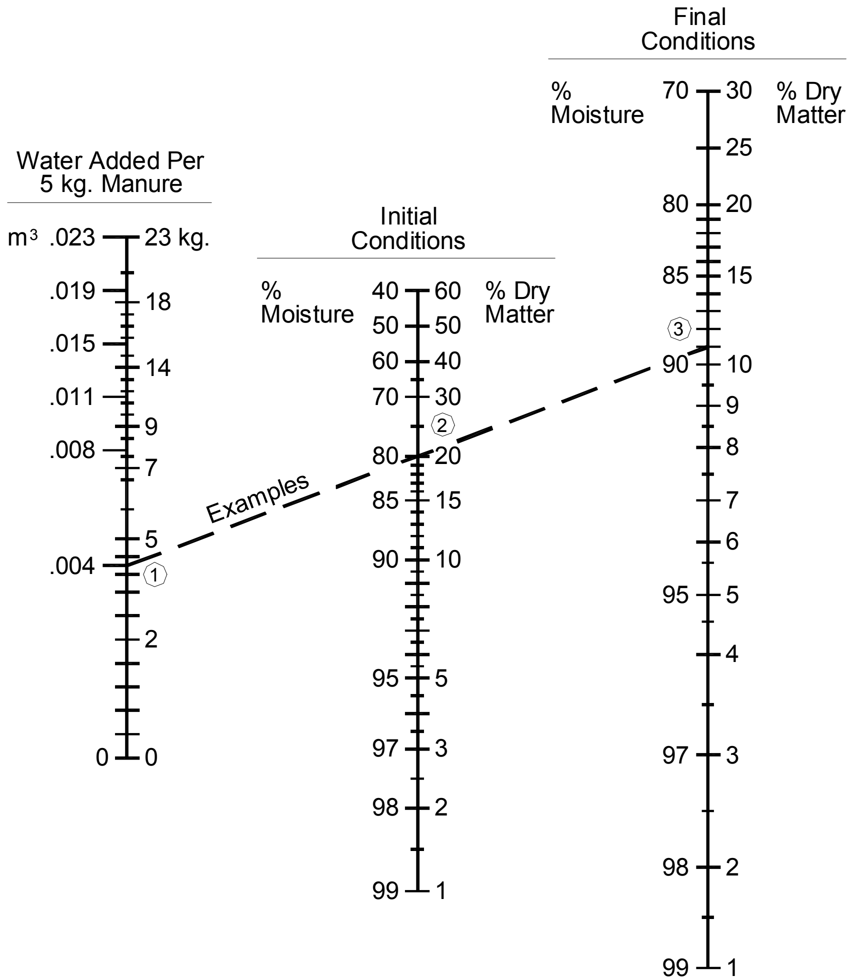
Animal	Size	Total manure production			Water	Density	TS	VS	BOD_5
	kg	kg/day	m^3/day	L/day	%	kg/m^3	kg/day	kg/day	kg/day
Dairy cattle	66.96	5.36	0.01	5.68	87.30	977.46	0.71	0.58	0.12
	111.61	8.93	0.01	9.08	87.30	977.46	1.16	0.94	0.19
	223.21	18.30	0.02	18.93	87.30	977.46	2.32	1.92	0.38
	446.43	36.61	0.04	37.48	87.30	977.46	4.64	3.84	0.76
	625.00	51.34	0.05	52.62	87.30	977.46	6.52	5.36	1.06
Beef cattle	223.21	13.39	0.01	14.38	88.40	945.93	1.56	1.34	0.36
	334.82	20.09	0.02	21.20	88.40	945.93	2.32	1.96	0.54
	446.43	26.79	0.03	28.39	88.40	945.93	3.08	2.68	0.71
	558.04	33.48	0.03	35.58	88.40	945.93	3.88	3.30	0.89
Swine									
Nursery pig	15.63	1.03	0.001	1.02	90.80	945.93	0.09	0.08	0.03
Growing pig	29.02	1.88	0.002	1.82	90.80	945.93	0.17	0.14	0.06
Finishing pig	66.96	4.38	0.005	4.28	90.80	945.93	0.40	0.32	0.13
	89.29	5.80	0.006	5.68	90.80	945.93	0.54	0.43	0.17
Gestate sow	122.77	3.97	0.004	4.16	90.80	945.93	0.37	0.29	0.12
Sow and litter	167.41	14.73	0.015	15.14	90.80	945.93	1.34	1.07	0.45
Boar	156.25	4.91	0.005	5.30	90.80	945.93	0.45	0.38	0.16
Sheep	44.64	1.79	0.002	1.74	75.00	1024.76	0.45	0.38	0.04
Poultry									
Layers	1.79	0.09	0.0001	0.10	74.80	945.93	0.02	0.02	0.01
Broilers	0.89	0.06	0.00087	0.07	74.80	945.93	0.02	0.01	0.00
Horse	446.43	20.09	0.021	21.31	79.50	945.93	4.20	3.35	-

B.2 Fruit and vegetable

Fruit/vegetable	Moisture content	TS	VS	FS
Banana, fresh	84.0	16.0	13.9	2.1
Broccoli, leaf	86.5	13.5		
Cabbage, leaf	90.4	9.6	8.6	1.0
Cabbage core	89.7	10.3		
Carrot, top	84.0	16.0	13.6	2.4
Carrot root	87.4	12.6	11.3	1.3
Cassava, root	67.6	32.4	31.1	1.3
Corn, sweet, top	79.8	20.2	19.0	1.2
Lettuce, top	94.6	5.4	4.5	0.9
Onion, top, mature	8.6	91.4	84.7	6.7
Orange, flesh	87.2	12.8	12.2	0.6
Orange pulp	84.0	16.0	15.0	1.0
Potato, top, mature	12.8	87.2	71.5	15.7
Squash	91.3	8.7	7.9	0.8
Tomato, fresh	94.2	5.8	5.2	0.6
Tomato solid waste	88.9	11.1	10.2	0.9

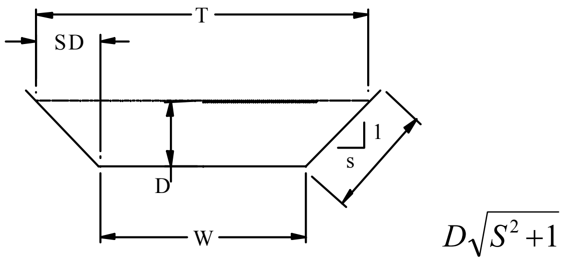
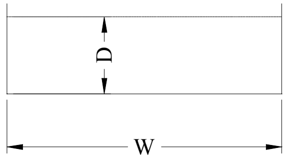
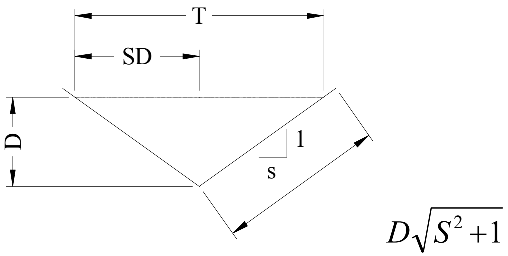
Annex C
(informative)

Moisture content of diluted manure



Annex D
(informative)

Elements of Channel Sections

Section	Area A	Wetted perimeter P	Hydraulic perimeter R	Top width T
 Trapezoid	$WD + SD^2$	$W+2D\sqrt{S^2+1}$	$\frac{WD+SD^2}{W+2D\sqrt{S^2+1}}$	$W+2SD$
 Rectangle	WD	$W+2D$	$\frac{WD}{W+2D}$	W
 Triangle	SD^2	$2D\sqrt{S^2+1}$	$\frac{SD}{2\sqrt{S^2+1}}$	$2SD$

Annex E
(informative)

Capacity of Roof and Concrete Gutter

Gutter depth mm	**Capacity**, m^3/min						
	Gutter width, mm						
	152.4	**203.2**	**254**	**304.8**	**355.6**	**406.4**	**457.2**
50.8	0.27	0.39	0.51	0.63	0.75	0.88	1.00
101.6	0.70	1.02	1.36	1.73	2.11	2.48	2.85
152.4	1.16	1.73	2.34	3.01	3.69	4.38	5.10
203.2	1.63	2.48	3.40	4.38	5.42	6.49	7.58
254	2.11	3.23	4.49	5.81	7.22	8.70	10.19
304.8	2.55	4.08	5.61	7.31	9.17	11.04	12.91
355.6	3.06	4.76	6.80	8.83	11.04	13.25	15.80
406.4	3.57	5.61	7.82	10.36	12.91	15.63	18.52
457.2	4.08	6.46	9.00	11.89	14.95	18.18	21.58
508	4.59	7.14	10.19	13.42	16.82	20.56	24.47

Annex F
(informative)

Cross sectional area of downspout

Gutter depth mm	**Cross sectional area of downspout,** m^2						
	Gutter width, mm						
	152.4	**203.2**	**254**	**304.8**	**355.6**	**406.4**	**457.2**
50.8	0.007	0.010	0.014	0.017	0.020	0.023	0.027
101.6	0.013	0.019	0.026	0.033	0.039	0.046	0.054
152.4	0.017	0.027	0.036	0.046	0.057	0.068	0.079
203.2	0.022	0.033	0.045	0.059	0.072	0.086	0.101
254	0.025	0.039	0.054	0.070	0.086	0.104	0.122
304.8	0.028	0.044	0.061	0.079	0.099	0.120	0.141
355.6	0.031	0.048	0.068	0.088	0.111	0.134	0.159
406.4	0.034	0.053	0.074	0.097	0.122	0.148	0.175
457.2	0.036	0.057	0.080	0.105	0.132	0.161	0.192
508	0.039	0.061	0.085	0.113	0.143	0.174	0.206

Annex G
(informative)

Capacity of open concrete channels

Depth mm	**Capacity,** m^3/min							
	Width, m							
	0.61	**1.22**	**1.83**	**2.44**	**3.05**	**3.66**	**4.27**	**4.88**
50.8	1.02	2.38	3.57	4.76	5.95	7.14	8.50	9.68
101.6	3.23	6.97	10.87	14.78	18.69	22.43	26.33	30.24
152.4	5.78	13.25	20.73	28.20	35.85	43.49	51.14	58.79
203.2	8.83	20.39	32.45	44.51	56.75	68.98	81.38	93.62
254	11.89	28.88	45.87	62.86	81.55	98.54	115.53	134.22
304.8	15.29	37.38	59.47	83.25	107.04	130.82	154.61	180.10
355.6	18.69	45.87	76.46	105.34	135.92	166.50	198.78	229.37
406.4	22.09	56.07	91.75	129.12	168.20	205.58	244.66	283.73
457.2	25.49	66.26	108.74	154.61	200.48	246.36	293.93	339.80
508	28.88	76.46	127.43	180.10	234.46	290.53	339.80	407.76
558.8	33.98	86.65	146.11	207.28	270.14	334.71	390.77	458.73
609.6	37.38	96.84	164.80	234.46	307.52	373.78	458.73	526.69

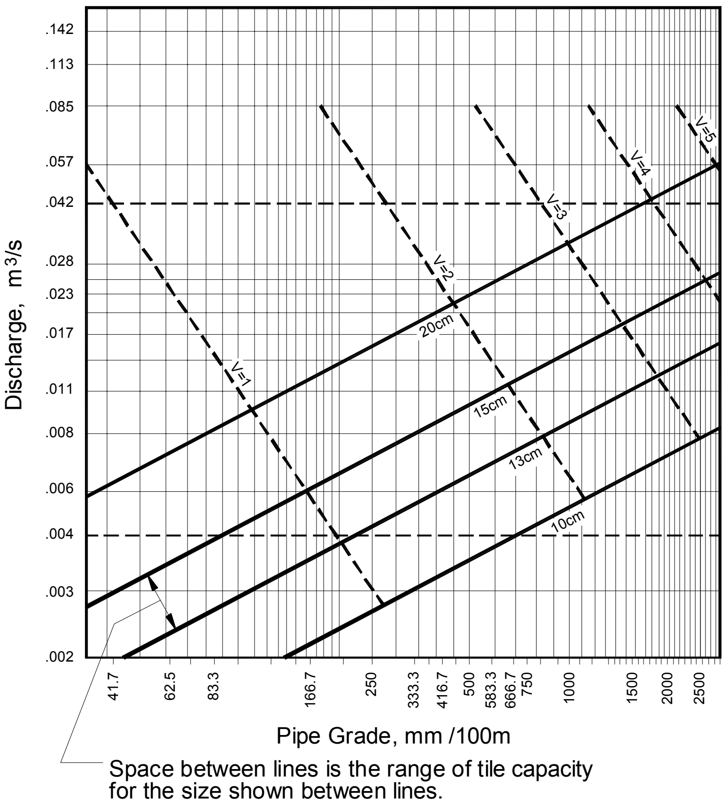
Annex H
(informative)

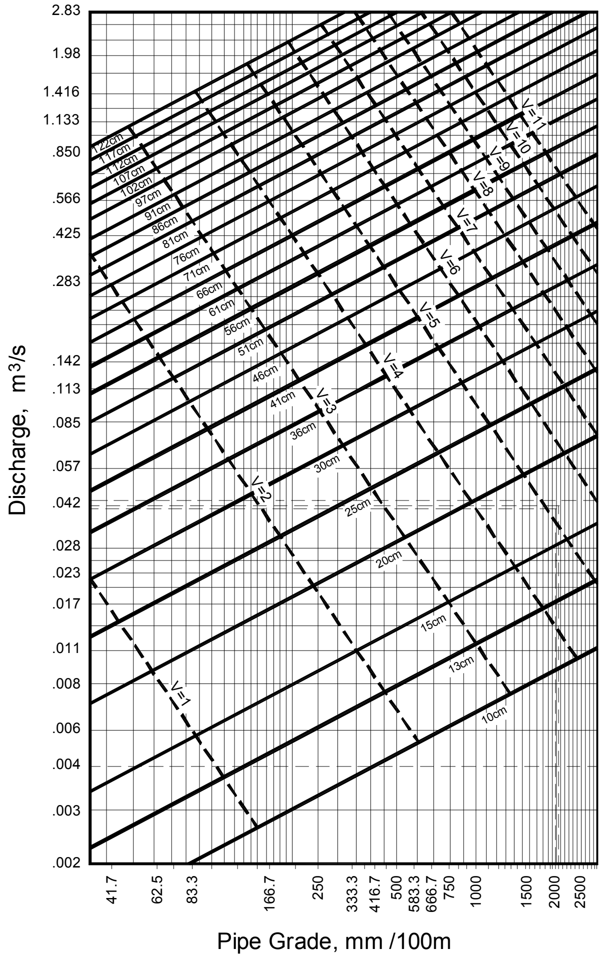
Capacity of earth channels

Depth m	Unit	Width, m						
		0.30	**0.61**	**1.22**	**1.83**	**2.44**	**3.05**	**3.66**
A. Longitudinal slope = 1%								
0.15	m/s	0.43	0.55	0.58	0.61	0.64	0.64	0.64
	m^3/s	0.04	0.10	0.16	0.23	0.29	0.36	0.42
0.30	m/s	0.07	0.07	0.08	0.08	0.08	0.09	0.09
	m^3/s	0.26	0.44	0.63	0.83	1.03	1.24	1.44
0.46	m/s	0.08	0.09	0.10	0.10	0.11	0.11	0.11
	m^3/s	0.77	1.12	1.49	1.87	2.26	2.65	3.05
0.61	m/s	0.10	0.11	0.12	0.12	0.13	0.13	0.13
	m^3/s	1.65	2.22	2.81	3.42	4.04	4.66	5.30
0.76	m/s	0.12	0.13	0.13	0.14	0.14	0.15	0.15
	m^3/s	3.00	3.82	4.67	5.54	6.43	7.33	8.23
0.91	m/s	0.14	0.14	0.15	0.15	0.16	0.16	0.16
	m^3/s	4.88	5.99	7.14	8.31	9.50	10.70	11.92
B. Longitudinal slope = 2%								
0.15	m/s	0.61	0.76	0.82	0.85	0.88	0.91	0.91
	m^3/s	0.06	0.14	0.23	0.32	0.41	0.50	0.60
0.30	m/s	0.09	0.10	0.11	0.12	0.12	0.12	0.13
	m^3/s	0.37	0.63	0.90	1.18	1.46	1.75	2.04
0.46	m/s	0.12	0.13	0.14	0.15	0.15	0.16	0.16
	m^3/s	1.08	1.59	2.11	2.65	3.20	3.75	4.31
0.61	m/s	0.15	0.16	0.17	0.17	0.18	0.18	0.19
	m^3/s	2.34	3.14	3.98	4.84	5.71	6.59	7.49
0.76	m/s	0.17	0.18	0.19	0.20	0.20	0.21	0.21
	m^3/s	4.24	5.41	6.61	7.84	9.09	10.36	11.64
0.91	m/s	0.19	0.20	0.21	0.22	0.22	0.23	0.24
	m^3/s	6.90	8.48	10.10	11.75	13.43	15.14	16.86
C. Longitudinal slope = 3%								
0.15	m/s	0.76	0.91	1.01	1.07	1.10	1.10	1.13
	m^3/s	0.07	0.17	0.28	0.39	0.50	0.62	0.73
0.30	m/s	0.11	0.13	0.14	0.14	0.15	0.15	0.16
	m^3/s	0.45	0.76	1.10	1.44	1.79	2.14	2.50
0.46	m/s	0.15	0.16	0.17	0.18	0.19	0.19	0.20
	m^3/s	1.33	1.94	2.59	3.25	3.92	4.60	5.28
0.61	m/s	0.18	0.19	0.20	0.21	0.22	0.22	0.23
	m^3/s	2.87	3.85	4.87	5.92	6.99	8.08	9.17
0.76	m/s	0.21	0.22	0.23	0.24	0.25	0.25	0.26
	m^3/s	5.20	6.62	8.10	9.60	11.13	12.69	14.26
0.91	m/s	0.24	0.25	0.26	0.27	0.27	0.28	0.29
	m^3/s	8.46	10.38	12.37	14.39	16.45	18.54	20.65

Annex I
(informative)

Capacity of tile and corrugated pipe





Annex J
(informative)

Capacity of culverts