ENVIRONMENTAL HEALTH HANDBOOK

3rd Edition, 2020

Kansas Department of Health and Environment

Pollution Prevention Institute

PREFACE

The Environmental Health Handbook (EHH) has been a valuable resource for professionals, service providers, and technicians who work with private wastewater and water systems. Users have relied on it for wastewater and water system guidance since the first edition was published in August 1992. Many county sanitary codes revised since it was published refer to the handbook as a reference and as a source of information to supplement their code.

Within a few years after the first edition of the handbook was published, the Kansas Department of Health and Environment (KDHE) updated and made substantial changes to Bulletin 4-2. With the EHH first edition as the starting point, a new KDHE, Bulletin 4-2 *Minimum Standards for Design and Construction of Onsite Wastewater Systems* was developed and adopted in mid-1997.

Onsite wastewater system research, products, and technology have all advanced since the first edition of the EHH was published. The second edition addressed additional topics, incorporated minor improvements, and was expanded to include additional alternative systems. It corrected discrepancies created by the revised Bulletin 4-2 adopted by KDHE. Members of the Kansas Association of Sanitarians (KAS) were the primary authors of both the first and second editions of the EHH. KAS members are field and subject matter experts and their work on the EHH was invaluable.

The private water well section of the handbook, added in 1998, is regarded as satisfying the KDHE requirement for Bulletin 4-1 *A Manual of Recommended Standards for Locating, Constructing, and Equipping Private Water Wells*.

KDHE and the Kansas State University Pollution Prevention Institute (PPI) have updated this third edition of the EHH with a number of changes. First and foremost, the entirety of the manual was converted into a Microsoft Word format from the original PDF files. This change will allow more efficient updating and editing in the future and truly creates a “living document” approach to the EHH. Structurally, all chapters have also been annotated and captioned to take advantage of the built-in Table of Contents tool in Word which allows the reader to have easier access to specific information. Chapters 7, 9, 10, and 11 were reviewed for technical accuracy, and the updates to these four chapters include revisions to the text, redrawn and colorized figures, and the creation of a new and separate bulletin for subsurface drip dispersal information. Subsequent updates and editions of the EHH will continue to be managed by KDHE.

Significant changes continue in the onsite industry with new research, technology development, strengthened state and local regulations, and many new products. For the EHH to meet its primary purpose as a resource manual there is an ongoing need for review and improvement to keep it current with the latest research information and products. Another purpose, as a training manual, requires that the handbook be reviewed and updated on a continuing basis as new information becomes available and shortcomings are identified. KDHE is committed to providing ongoing coordination for needed corrections, improvements, and updates. Users are encouraged to provide feedback about errors, needed additions, and improvements by contacting the Watershed Management Section of the KDHE Bureau of Environmental Field Services. The more specific your recommendations the greater will be their value in providing input for changes.

ENVIRONMENTAL HEALTH HANDBOOK
TABLE OF CONTENTS

Chapter I

PRIVATE WATER WELLS

TABLES

FIGURES

INTRODUCTION

A reliable and safe water supply is important to every household, business, church, and institution. While public supplies are regulated by KDHE to ensure that they meet safe drinking water standards, the quality of private supplies is the sole responsibility of the owner and/or water user. There is no federal or Kansas law that regulates drinking water quality from private water wells. This chapter of the Environmental Health Handbook discusses in detail the basic principles for a reliable and safe water supply and includes an inspection protocol for new or existing wells.

The 1990 Census data showed Kansas has more than 109,000 private water supplies (mostly wells), which supply about 11 percent of the total housing units in the state. The most populous counties tend to have more private wells. Conversely, twenty-nine Kansas counties each have more than 1,000 private wells. Twenty-eight counties, mostly in sparsely populated areas of the state, have fewer than 500 private drinking water wells each. In eastern Kansas, rural water districts cover much of the rural area, especially where there is no principal groundwater aquifer. Table I-1 summarizes private and public water supplies for each Kansas County.

Obtaining safe water from a private well should be relatively simple, but it requires carefully following some basic principles. Simply stated, safe water is most reliably obtained from a safe well. A safe well is one that meets the following conditions:

- Located away from potential contamination sources and out of possible pollutant pathways from both surface and groundwater flows.
- Meets current KDHE well construction standards.
- Annual check of condition and for damage, and complete the maintenance schedule.
- Well protection written plan has been prepared, is reviewed, and is followed.

WELL LOCATION

The well should be located in an area not subject to flooding, on a well-drained site, and as far removed and as far up-slope as practical from possible sources of contamination.

Microorganism Protection

A continuous blanket of moderate to well-drained soil in the area around the well generally provides good protection from microbiological contamination sources such as septic systems and animal wastes. The soil layers act as a good mechanical filter. Microbes in an aerated soil, aided by slow percolation through the soil, give reduction and die-off of microbiological pathogen contaminants. Thus, a 50-foot horizontal separation from a bacterial pollution source (K.A.R. 28-30-8) has usually been considered adequate to insure removal of pathogenic bacteria, viruses, protozoa, and cysts. However, additional separation will further reduce the risks of contamination.

When the total horizontal separation from pollution sources and the vertical separation distance to the groundwater aquifer is greater than 100 feet, additional protection is provided. The thickness of soil cover and depth to groundwater are usually greater in western Kansas. This greater travel distance, combined with lower rainfall and higher evaporation rates, produces much longer travel times for water that supplies the well. Thus, protection of groundwater from microbial contamination is usually substantially greater in western than in eastern Kansas for the same horizontal separation unless there is poor well construction. When the soil blanket is thin, poorly- drained, shallow to rock, very coarse, or combinations of these conditions occur, more rapid groundwater recharge rates are likely. The more quickly water moves through the soil to groundwater, the greater the risk of microbes being carried to the aquifer. These conditions more commonly occur in eastern Kansas, meaning that greater separation distances are needed to provide the same measure of protection as in western Kansas. Additionally, groundwater movement through joints, cracks, and solution channels of rock aquifers in eastern Kansas is much more rapid. This also reduces the protection provided by horizontal separation.

Table I-1. Public and Private Water Systems in Kansas

		UNITS WITH PUBLIC WATER SYSTEM OR PRIVATE COMPANY		UNITS WITH PRIVATE WATER SUPPLIES	
County	**Total Housing Units**	**Number**	**Percent**	**Number**	**Percent**
Allen	6,454	6,047	93.7	407	6.3
Anderson	3,514	3,127	89.0	387	11.0
Atchison	6,691	6,015	89.9	676	10.1
Barber	3,120	2,452	78.6	668	21.4
Barton	13,144	10,699	81.4	2,445	18.6
Bourbon	6,920	6,490	93.8	430	6.2
Brown	4,890	3,711	75.9	1,179	24.1
Butler	20,072	15,937	79.4	4,135	20.6
Chase	1,547	934	60.4	613	39.6
Chautauqua	2,249	1,711	76.1	538	23.9
Cherokee	9,428	8,390	89.0	1,038	11.0
Cheyenne	1,687	1,104	65.5	583	34.5
Clark	1,327	975	73.5	352	26.5
Clay	4,138	3,331	80.5	807	19.5
Cloud	5,198	4,371	84.1	827	15.9
Coffey	3,712	3,166	85.3	546	14.7
Comanche	1,256	889	70.8	367	29.2
Cowley	15,569	14,012	90.0	1,557	10.0
Crawford	16,526	16,311	98.7	215	1.3
Decatur	2,063	1,369	66.4	694	33.6
Dickinson	8,415	6,521	77.5	1,894	22.5
Doniphan	3,337	2,582	77.4	755	22.6
Douglas	31,782	30,574	96.2	1,208	3.8
Edwards	1,867	1,381	74.0	486	26.0
Elk	1,743	1,394	80.0	349	20.0
Ellis	11,115	9,725	87.5	1,390	12.5
Ellsworth	3,317	2,368	71.4	949	28.6
Finney	11,696	9,543	81.6	2,153	18.4
Ford	10,842	9,118	84.1	1,724	15.9
Franklin	8,926	7,792	87.3	1,134	12.7
Geary	11,952	11,007	92.1	945	7.9
Gove	1,494	984	65.9	510	34.1
Graham	1,753	1,153	65.8	600	34.2
Grant	2,599	1,941	74.7	658	25.3
Gray	2,114	1,401	66.3	713	33.7
Greeley	801	511	63.8	290	36.2
Greenwood	4,243	3,665	86.4	588	13.6
Hamilton	1,214	942	77.6	272	22.4
Harper	3,481	2,920	83.9	561	16.1
Harvey	12,290	10,655	86.7	1,635	13.3
Haskell	1,586	1,057	66.7	529	33.3
Hodgeman	1,022	531	52.0	491	48.0
Jackson	4,564	3,705	81.2	859	18.8
Jefferson	6,314	5,335	84.5	979	15.5
Jewell	2,409	1,845	76.6	564	23.4
Johnson	144,155	143,434	99.5	721	0.5
Kearny	1,561	1,145	73.4	416	26.6
Kingman	3,645	2,219	60.9	1,426	39.1
Kiowa	1,738	1,306	75.2	432	24.8
Labette	10,641	10,204	95.9	437	4.1
Lane	1,117	770	69.0	347	31.0
Leavenworth	21,264	19,328	90.9	1,936	9.1
Lincoln	1,864	1,258	67.5	606	32.5

***Table I-1. Public and Private Water Systems in Kansas** (cont.)*

		UNITS WITH PUBLIC WATER SYSTEM / PRIVATE COMPANY		UNITS WITH PRIVATE WATER SUPPLIES	
County	**Total Housing Units**	**Number**	**Percent**	**Number**	**Percent**
Linn	4,811	4,209	87.5	602	12.5
Logan	1,466	1,090	74.4	376	25.6
Lyon	14,346	13,413	93.5	933	6.5
Marion	5,659	4,051	71.6	1,608	28.4
Marshall	5,269	4,394	83.4	875	16.6
McPherson	10,941	8,982	82.1	1,959	17.9
Meade	2,049	1,518	74.1	531	25.9
Miami	8,971	7,912	88.2	1,059	11.8
Mitchell	3,359	3,100	92.3	259	7.7
Montgomery	17,920	16,534	94.5	986	5.5
Morris	3,149	1,602	50.9	1,547	49.1
Morton	1,515	1,151	76.0	364	24.0
Nemaha	4,319	3,602	83.4	717	16.6
Neosho	7,726	7,362	95.3	364	4.7
Ness	2,048	1,464	71.5	584	28.5
Norton	2,798	2,048	73.2	750	26.8
Osage	6,324	5,843	92.4	481	7.6
Osborne	2,496	1,981	79.4	654	20.6
Ottawa	2,591	1,842	71.1	749	28.9
Pawnee	3,412	2,599	76.2	813	23.8
Phillips	3,264	2,421	74.2	843	25.8
Pottawatomie	6,472	4,756	73.5	1,716	26.5
Pratt	4,620	3,520	76.2	1,100	23.8
Rawlins	1,744	994	57.0	750	43.0
Reno	26,607	19,981	75.1	6,626	24.9
Republic	3,283	2,652	80.8	631	19.2
Rice	4,868	3,748	77.0	1,120	23.0
Riley	22,868	20,695	90.5	2,173	9.5
Rooks	2,979	2,356	79.1	623	20.9
Rush	1,999	1,525	76.3	474	23.7
Russell	4,079	3,789	92.9	290	7.1
Saline	21,129	20,114	95.2	1,015	4.8
Scott	2,305	1,701	73.8	604	26.2
Sedgwick	170,159	155,355	91.3	14,804	8.7
Seward	7,572	6,875	90.8	697	9.2
Shawnee	68,991	67,749	98.2	1,242	1.8
Sheridan	1,324	752	56.8	572	43.2
Sherman	3,177	2,532	79.7	645	20.3
Smith	2,615	1,903	72.8	712	27.2
Stafford	2,666	1,583	59.4	1,083	40.6
Stanton	956	634	66.4	322	33.6
Stevens	2,116	1,606	75.9	510	24.1
Sumner	10,769	8,410	78.1	2,359	21.9
Thomas	3,534	2,611	73.9	923	26.1
Trego	1,851	1,258	68.0	593	32.0
Wabaunsee	2,853	1,640	57.5	1,213	42.5
Wallace	840	566	67.4	274	32.6
Washington	3,355	2,449	73.0	906	27.0
Wichita	1,190	767	64.5	423	35.5
Wilson	5,091	4,592	90.2	499	9.8
Woodson	2,199	1,794	81.6	405	18.4
Wyandotte	69,102	68,825	99.6	277	0.4
State Totals	1,044,112	934,205	89.5	109,656	10.5

Source: US Census Bureau 1990 Housing Census

Minimum separation distances regulated by K.A.R. 28-30-8 and K.A.R. 28-5-2 are presented in Table I-2. The plan view in Figure I-1 shows the well location as well as the required and recommended separation distances from sources of contamination. These distances should be adequate to protect from microorganism contamination, however greater distances provide added protection. Much greater separation distances are necessary to protect from other pollution sources (inorganic and organic chemicals).

A sanitarian, extension agent or other qualified person should be called upon to assist in siting a new well location. A protocol to evaluate a new well site or existing well and a report form to assist in collecting the necessary data is included at the end of this chapter.

TABLE I-2. Minimum and Recommended Separation Distances from Private Wells

POTENTIAL SOURCE OF POLLUTION	SEPARATION DISTANCES (in feet)	
	Min. Required[1]	Recommended[2]
Sealed sewer line (cast iron, tight line, etc.)	10	50
Unsealed sewer lines	50	> 400
Septic tanks (watertight)	50	> 100
Lateral lines and septic absorption field	50	> 400
Pit privies	50	> 400
Stables, livestock pens, lagoons and manure piles	50	> 400
Streams, lakes and ponds	50	> 100
Fertilizer and fuel storage (above or below ground)	50	> 400
Seepage pits (prohibited after May, 1996)	50	> 400
All other wastewater systems	50	> 100
Property line	25	> 50
Public water supply sources (i. e., wells) 3	100	> 100
Building/structure (termite treatment) 4	50	> 100
Pesticide storage, mixing and disposal repeated use areas	50	> 400

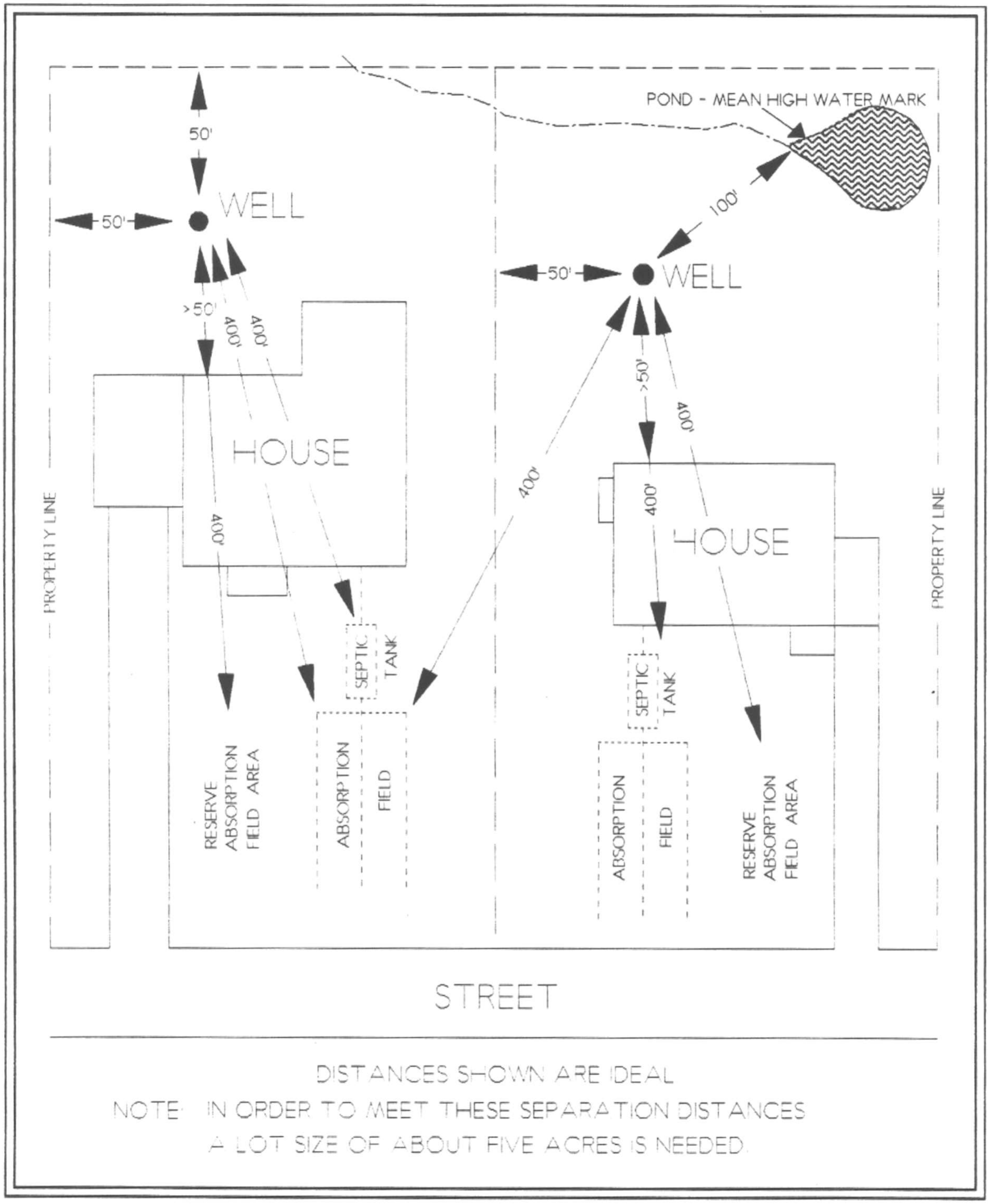
1 *Required by K.A.R. 28-30-8.*

2 *Separation distances that help assure more adequate protection from contaminants other than bacteria.*

3 *From Policies, General Consideration and Design Requirements for Public Water Supply Systems in Kansas.*

4 *Required when injecting liquid pesticide, see manufacturers label. These distances do not assure contamination will not reach well*

Figure I-1. Site Features Showing Minimum and Recommended Separation Distances



Protection from Other Contaminants

Protecting wells from contaminants other than microorganisms involves management at the surface and separation distances greater than 50 feet. The Farmstead Well Study, conducted by the Kansas State University and Kansas Department of Health and Environment in 1986-87, found 28 percent of the wells with nitrate levels above the safe drinking water standard of 10 mg/L. Other inorganic chemicals above the standard were found in an additional 10 percent of wells. Pesticides were detected in 8 percent of the wells but were above the EPA drinking water standard in only 1 percent of wells.

Protection of well water from sources of contamination other than microorganisms requires much more careful planning. For instance, nitrate, like most negatively charged inorganic constituents (known as anions) moves freely through the soil. It is dissolved in water and is carried along as the water percolates through the soil to the groundwater and moves in the aquifer. The most active removal mechanisms for nitrate are: a) careful management of nitrogen sources at the surface, b) removal by plants as water percolates through the root zone, and c) denitrification in shallow, poorly aerated layers. Once nitrate reaches groundwater, there is virtually no mechanism for removal except lateral movement with groundwater to a well or reappearance at the surface through springs.

Some organic and inorganic chemicals, both natural and man-made, are adsorbed by the exchange capacity of clay and organic matter in the soil. However, excessive repeated applications, dumping, and spills can exceed the soil's capacity to remove these contaminants. Because most organics are at least partly dissolved in water, if they are not removed they can be carried to groundwater.

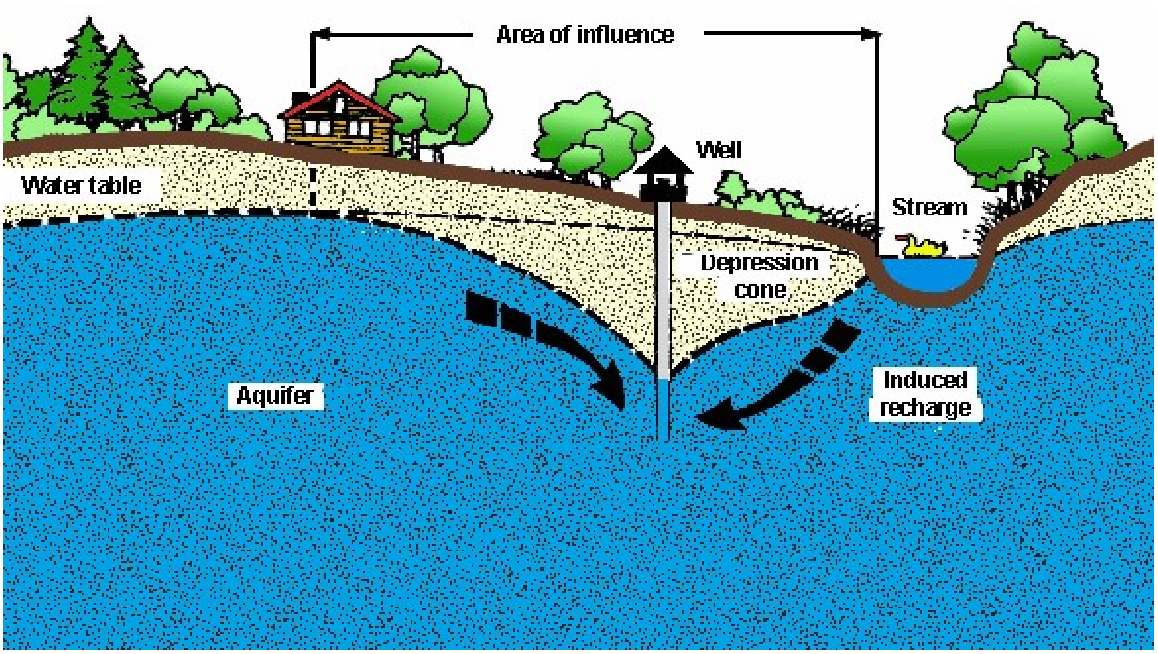
The effluent from a properly designed and operated wastewater system still contains large amounts of dissolved nutrients, some of which eventually may reach groundwater. The effluent also contains some chemical contaminants and viruses which are capable of traveling long distances when they reach groundwater, especially in jointed and channeled rock. The required minimum separation distance for wastewater systems is 50 feet from private water supplies and 100 feet from public water supplies. However, to minimize possible health hazards and pollution potential of wastewater systems it is good policy to locate them as far as possible from drinking water supplies and surface water.

The type and number of wastewater systems and other sources of pollution in the vicinity of a well gives an indication of the potential for contamination of the groundwater supplying that well. The well construction, volume of water pumped, and the well draw-down are also extremely important as they determine the distance and speed with which pollution may travel. Usually pollution will be minimized with increased separation distance and groundwater travel time.

Cone of Depression

A well in regular use causes groundwater to flow towards the pumping well. The withdrawal of water from the well by pumping causes the water level in the well to be lower than the static, nonpumping, water table. This lowers the pressure (creates a vacuum) in the area surrounding the well which in turn causes the groundwater level to decline around the well. This drop in the level of the water table around the well is called the cone of depression. The distance away from the well that the cone of depression extends is the radius of influence. Any source of contamination that reaches the groundwater within the radius of influence can be drawn toward the well. See diagram of cone of depression for a pumping well in Figure I-2.

Figure I-2. Cone of Depression for a Pumping Well



Example of cone of depression. The elevation at the well is 1,200 feet, the original water table is 1,080 feet, the water level is 1,050 feet when the well is pumped, and the radius of influence is 400 feet. A pollution source located 350 feet from the well can potentially contaminate the well if the contamination moves down to groundwater, elevation about 1,078 feet, within the cone of depression. Thus, the protection of a well from pollution sources is not just a matter of surface separation distance. Rather it is a combination of surface separation, elevation of the pollution sources and well, radius of influence (cone of depression) of the pumping well, and groundwater flow direction and gradient.

Wells, in areas of fractured limestone formations near the ground surface or where solution channels are known to exist in the rock formations, should be separated by much greater distances from pollution sources. Special precautions should be taken to prevent shallow subsurface seepage from entering the well. The surface ground slope should be away from the well. Local sanitary and environmental codes may require more stringent standards than state regulations and should always be consulted before sitting a new well.

When factors that might influence well contamination were evaluated in Phase 2 of the *Farmstead Well Study*, separation distance was the strongest contributor to contamination. The greater the distance of the source of contamination from the well, the less chance there is of contamination affecting water produced by the well. Based on this study, a minimum 200 foot separation distance from sources of contamination is recommended to provide adequate protection of wells for both inorganic and organic contaminants

Locating a New Well

Careful evaluation of all potential sources of contamination is essential when siting the location of a well. Many potential sources are shown in Figure I-1 for a modern farmstead. Contamination sources include fertilizer and pesticide handling, storage, mixing and clean-up areas; above and below ground fuel storage tanks; and mechanic/maintenance shop areas where solvents and degreasers are used.

A good approach to safely locate a well is to draw a 200 foot radius circle around each of the potential sources of contamination and then locate the well outside of all circles. Be sure the well is located up-gradient in groundwater flow direction from these sources. Figure I-3 illustrates a typical rural development with the preferred location of pollution sources associated with house, yard, and septic system in relation to the location of the well.

A study during 1994-1995 sponsored by the Centers for Disease Control found total coliform bacteria present in 51 percent of private drinking water wells in Kansas. E. coli was present in 18 percent of these wells. Approximately 80 percent of the wells included in this study did not meet either location guidelines or current construction standards.

See *Protocol: Well Evaluation for a New Site or Existing Private Well* at the end of this chapter.

WELL CONSTRUCTION

To supply good water, the well construction must prevent the entrance of all surface water and shallow or deep groundwater seepage into the well except at screened sections. Approved grout must restore the seal around the casing at the surface and through all confining layers.

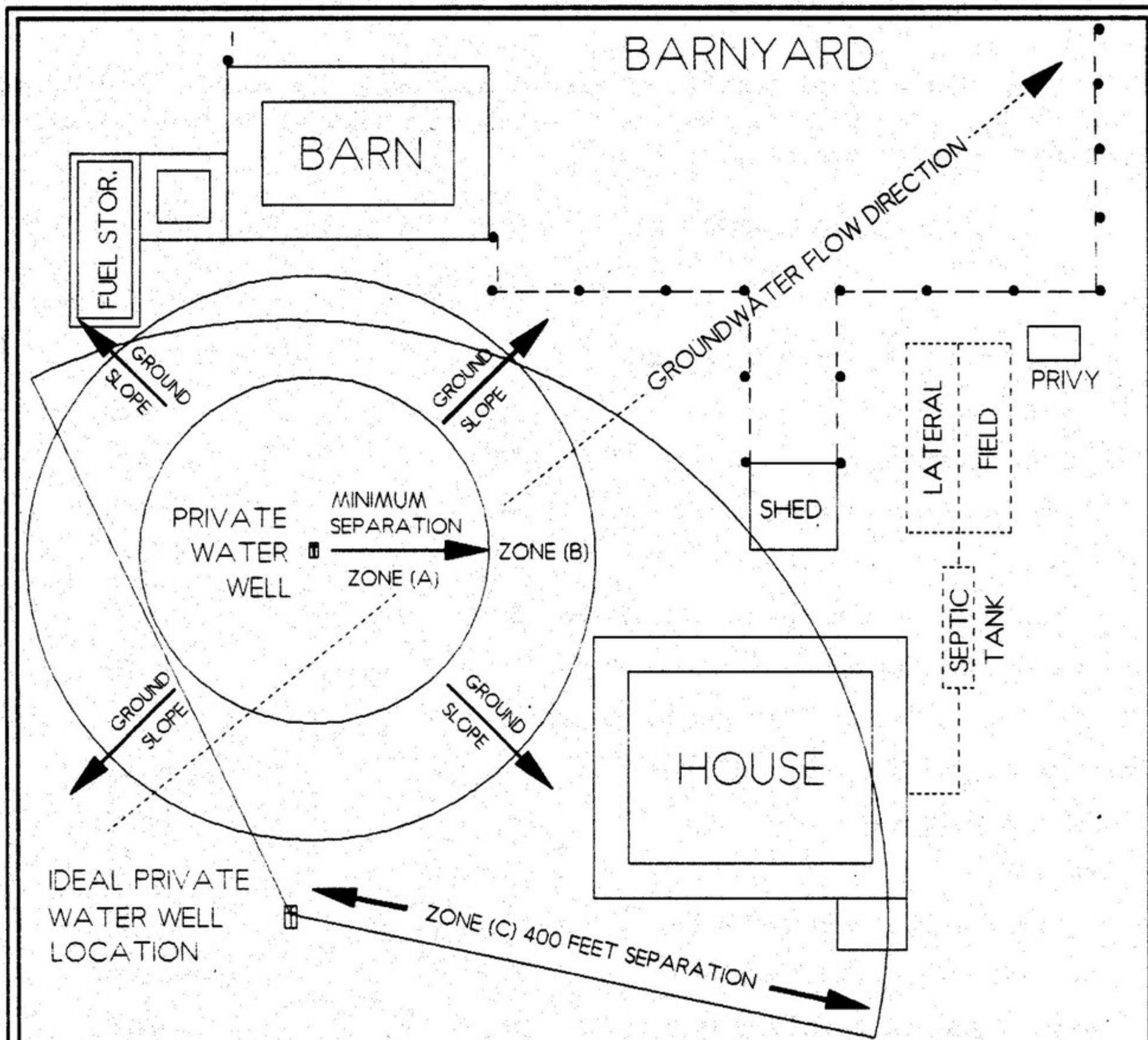
The Kansas Groundwater Exploration and Protection Act, also called the *Water Well Construction Act,* K.S.A. 82a-1201 et seq., and the implemented regulations, K.A.R. 28-30-1 et seq., specify how wells are to be constructed, reconstructed, and plugged. They set minimum standards for well construction and reconstruction, and specify materials used in constructing or reconstructing water wells.

Well construction and reconstruction requires a licensed Kansas Water Well Contractor.

However, landowners may construct new wells, modify existing wells, and plug wells located on their own property without being licensed by KDHE. Landowners must comply with all requirements of the law and regulations including the filing of a Water Well Record (form WWC-5) with KDHE as mandated by law.

Numerous methods have been developed for construction of water wells. These include digging, driving, boring, and drilling. In recent decades, practically all new wells in Kansas are drilled or driven. Recommendations and requirements for using these two methods as well as procedures for reconstructing or upgrading dug wells are briefly discussed here.

Figure I-3. Good Well Location and Separation Distances for a Farmstead



ZONE (A): REQUIRED SEPARATION AT LEAST 50 FT. FROM SEWERS, SEPTIC TANK SYSTEMS, PRIVIES, BARNYARDS, FUEL, FERTILIZER STORAGE, BUILDINGS, ETC. NOT LESS THAN 25' FROM PROPERTY LINE (50' OR MORE RECOMMENDED) ALL SURFACE DRAINAGE MUST BE AWAY FROM THE WELL.

ZONE (B): RECOMMENDED 100 FT. (OR MORE) SEPARATION FROM SOURCES OF CONTAMINATION. (SEE TABLE 2)

ZONE (C): IDEAL PRIVATE WATER WELL LOCATION 400 FEET OR MORE FROM SOURCES OF CONTAMINATION. (SEE TABLE 2)

Wastewater flow for sizing a lagoon is based on average flow rather than peak flow, which is used for sizing an inground wastewater system. Lagoons easily handle temporary high flows with a rise in water level which results in an increase in losses. Conversely, inground systems must be able to handle these peak flows to avoid a malfunction or failure.

Drilled Wells

A drilled well is constructed with a drilling machine using rotary, percussion, or jetting tools. The hole is drilled into or through the water-bearing formation(s) and a casing and screen are inserted into the bore hole. New PVC, wrought iron, steel or other KDHE approved materials, in clean and serviceable condition, shall be used to case the well.

Construction details for unconsolidated (sand and gravel) and consolidated (rock) drilled wells are shown in Figures I-4 and I-5. For purposes of illustration different grout materials are shown.

Driven Wells

Driven well construction is limited to areas of unconsolidated aquifers and where the water-bearing strata lie at comparatively shallow depths. Driven wells are most often used only where the water table is less than 20 feet below ground surface. Driven wells can not be used where there are intervening formations of rock, hard and dense layers, or boulders that would interfere with the driving of the pipe.

Driven wells are properly constructed by drilling and casing at least the upper 10 feet of the well or to the water table if more than 10 feet. This provides for easy placement of the required protective grout around the outer casing placed in the bore hole. The outer well casing must meet the casing requirements of K.A.R. 28-30-1, et seq. The well is completed by driving a water-tight pipe (normally steel) that is fitted with a drive point and a well screen into the water-bearing formation below the water table to the desired depth, sufficient for continuous pumping.

Construction details for a driven well are shown in Figure I-6

Dug Wells

Construction of dug wells has been illegal since the Well Construction Act was passed in 1975. Existing dug wells should be abandoned and properly plugged or reconstructed to meet the requirements of this act and accompanying regulations. Reconstruction of dug wells to meet current well construction standards and thus reduce potential of contamination is generally not cost effective.

Well Casing

To insure adequate protection of the aquifer(s) supplying the well, the casing must exclude surface water and water from undesirable subsurface strata. All wells must have durable, watertight casing from at least one foot above finished ground surface (recommend at least one foot above the elevation of the 100-year flood) to the top of the producing zone(s) of the aquifer. The watertight casing shall extend at least at least 5 feet into the first clay or shale layer or a minimum of 20 feet below the finished ground surface. The casing shall be clean and serviceable and of a type to assure that it remains watertight for the useful life of the well (usually at least 40 years). Used, reclaimed, rejected, or contaminated pipe shall not be used for casing any well.

Groundwater producing zones that are known or suspected to contain natural or man-made pollutants must also be cased and sealed off during construction of the well to prevent the movement of the polluted or undesirable groundwater to either overlying or underlying fresh groundwater zones.

Figure I-4. Construction of A Drilled Well in an Unconsolidated Formation

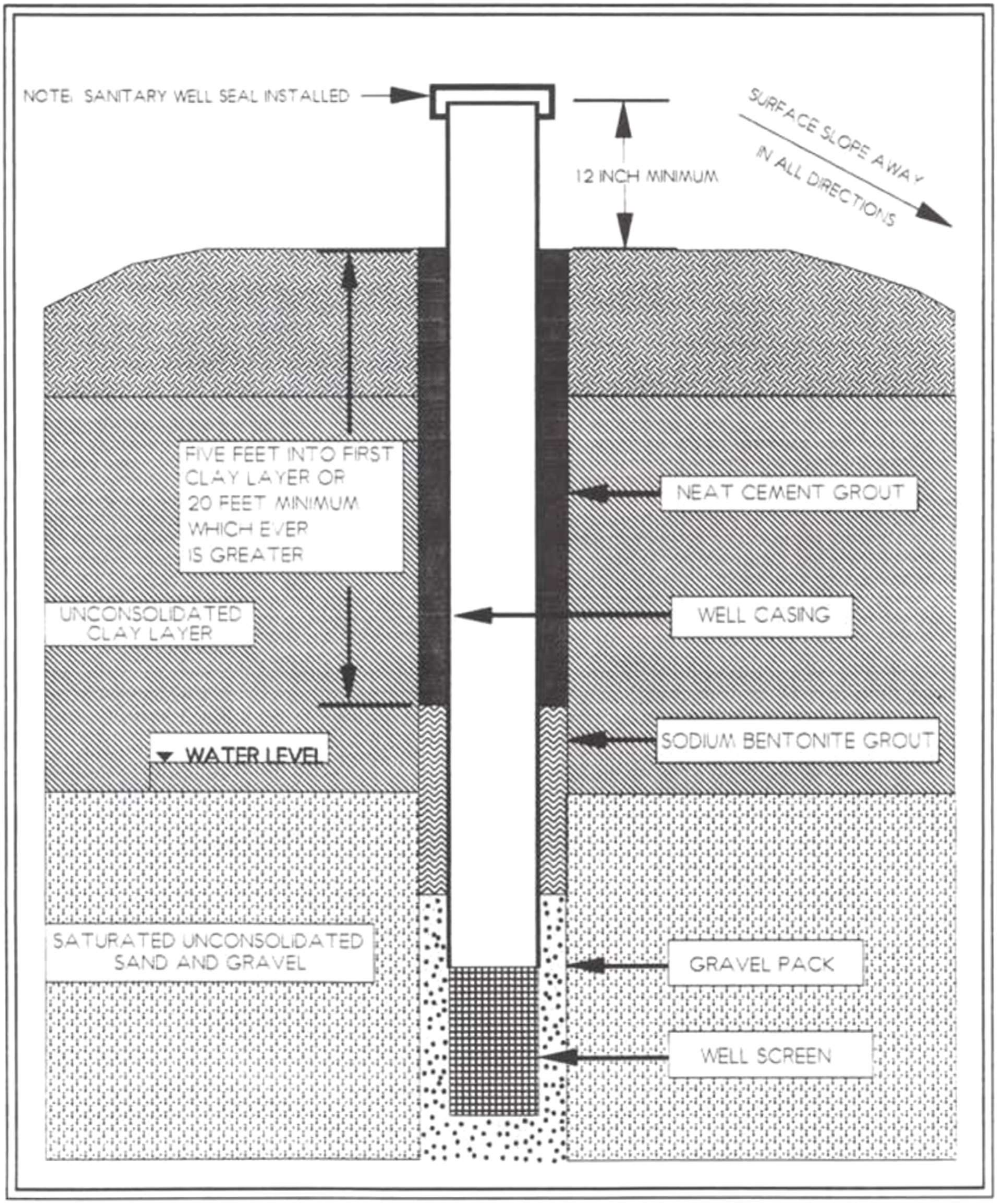


Figure I-5. Construction of A Drilled Well in a Consolidated Rock Formation

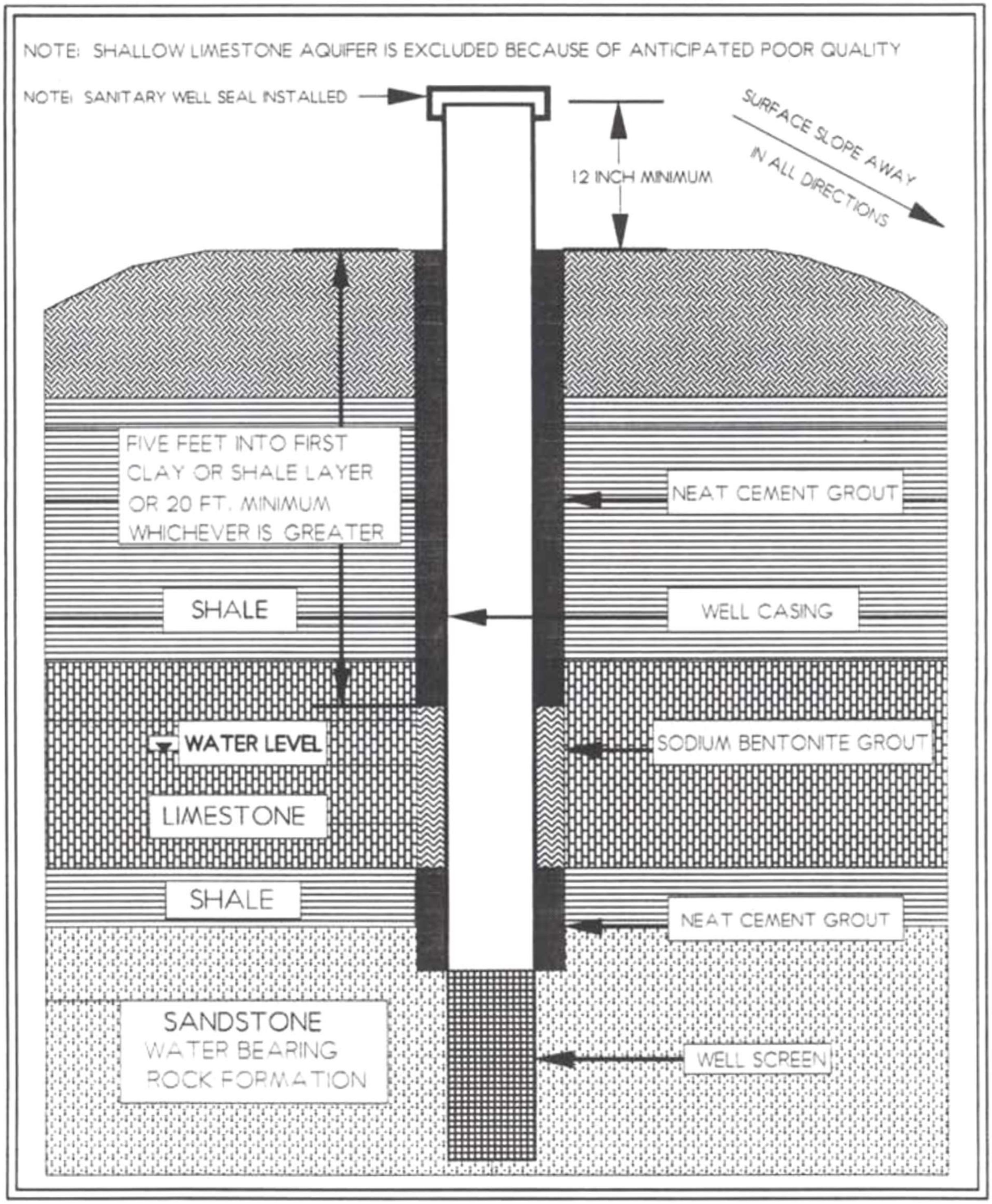
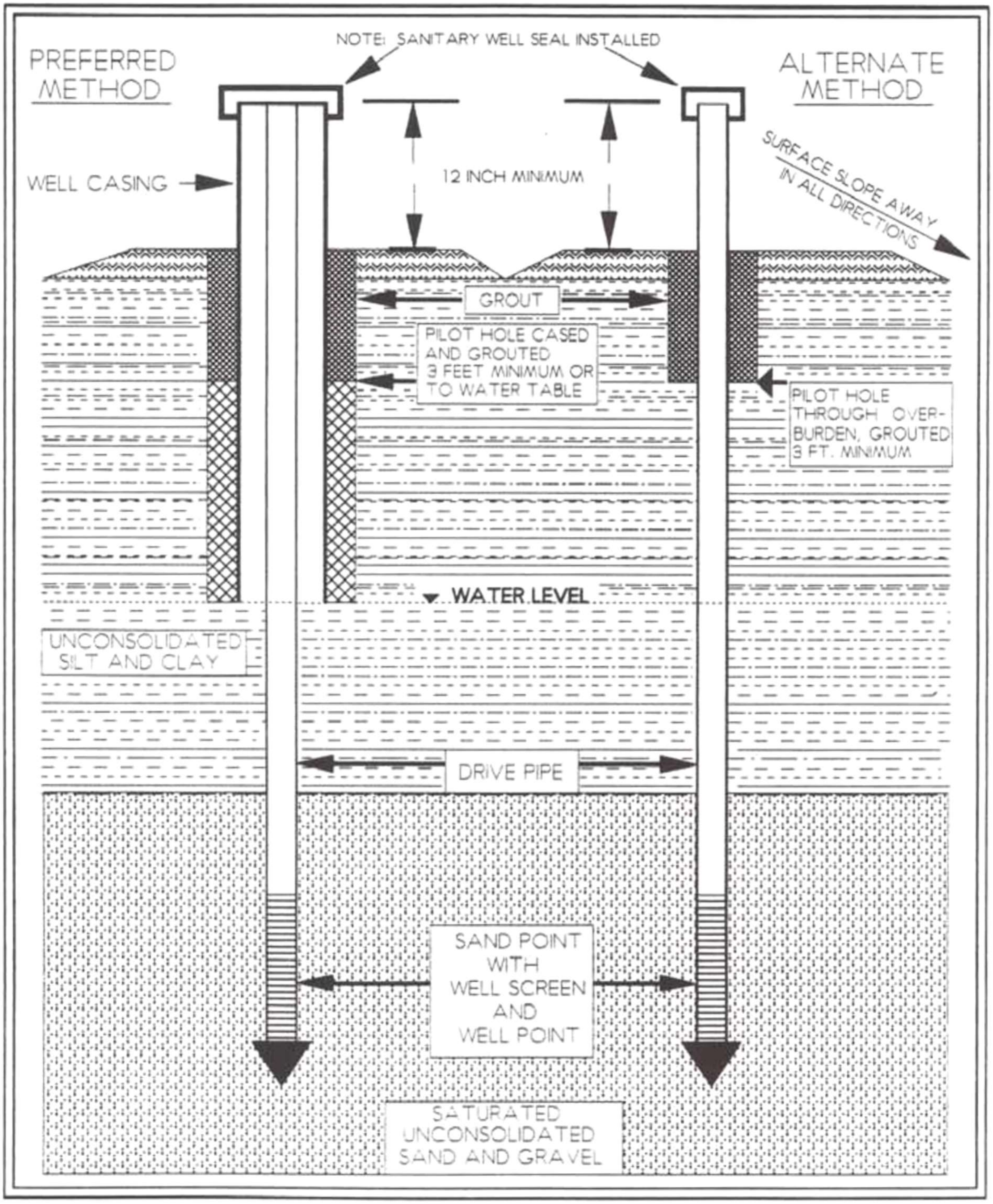


Figure I-6. Construction of A Driven Well



All water well casing must be approved by KDHE. Plastic pipe must meet standards of the National Sanitation Foundation (NSF) or American Society for Testing and Materials (ASTM) and bear the stamp of approval PW (potable water), DW (drinking water) or WELL CASING. It is important that all connections (joints) be watertight where two sections of well casing are joined. Concrete pipe, vitrified clay tile, and similar type materials are not approved for well casing unless special permission is granted by KDHE as provided in the Appeals Clause in K.A.R. 28-30-9.

The casing must be of sufficient inside diameter (ID) to easily accommodate the maximum outside diameter (OD) of the pumping equipment to be installed in the well. Most small drilled wells serving farmsteads, homes, and businesses are cased with five-inch ID casing or larger.

Casing of this diameter will accommodate most submersible turbine pumps, deep well jet pumps, reciprocating pumps, and numerous other types of shallow well pumps in sizes commonly used to supply water for household purposes.

The well casing must be watertight from the screened intake to at least twelve inches above finished ground surface. No casing shall be cut off below the ground surface except to install a pitless well unit. No holes shall penetrate the watertight well casing except to install a pitless adapter and this penetration must be finished watertight.

Well Grouting

The space between the casing and the bore hole must be grouted to restore aquifer separation by preventing water movement through this space. The diameter of the bore hole must be at least three inches greater than the maximum outside diameter of the well casing to facilitate the placement of grout around the casing throughout the required intervals. Adequately grouted wells protect the well and aquifer from contamination by preventing the mixing of surface water or water from different aquifer layers through the bore hole.

All well casing must be grouted to a depth of 20 feet or more below the finished ground surface. When the first clay or shale layer is deeper than 20 feet from ground surface, then the grouted interval must extend at least five feet into the clay or shale layer. The grouting requirement may be modified to meet local conditions (i.e. groundwater is encountered at less than the 20-foot minimum depth) when prior approval is obtained from KDHE.

For example, while drilling the bore hole a clay layer is found at 34 feet below the ground surface. At 57 feet the clay layer changes to sand and gravel that contains potable groundwater. The placement of the well casing would be then from the top of the aquifer (57 feet) to at least one foot above finished ground surface. The well casing is grouted into the bore hole from the 34-foot depth to finished ground surface or to a depth just below the deepest frost line if a pitless adapter or pitless unit is installed. The construction of a concrete slab around the well casing is optional and may also help provide a good seal around the casing in addition to providing a strong clean work platform for servicing the well.

It is common for wells that penetrate multiple water bearing layers to be designed to obtain groundwater from two or more separate aquifers. In such wells, the casing interval between the aquifers must be grouted into the bore hole to maintain aquifer separation within the borehole even though two or more aquifers are communicating through the well's screens. This requirement is mandated to assure that if one of the aquifers becomes unusable it can be blocked off from the other aquifer with packers or sealed off with a blank casing liner or abandoned and plugged to protect the usable aquifer from the undesirable aquifer.

Well Screen and Gravel Pack

The well screen should be factory slotted and installed as designed to prevent gavel pack or aquifer materials from entering the well. Well screens should be made of corrosion-resistant materials. In most cases, screens that are fabricated from an alloy of copper, tin, silicon, and manganese are satisfactory. In waters containing large amounts of sulfate or detectable hydrogen sulfide, a stainless steel or polyvinyl chloride (PVC) plastic screen should be used to enhance corrosion protection. The choice of the well screen slot size (mesh size) is dependent on the particle size of the aquifer material and the gravel pack used. By examining samples of the aquifer materials collected when the well is drilled, most well screen manufacturers can determine the screen slot size and gravel pack design needed to prevent fines from entering.

Fine, silty sand cannot normally be prevented from entering the well by use of a well screen alone. In this case, a specific gravel pack design is critical to control the continuing entrance of fines into the well. Washed, graded gravel pack disinfected with at least 200 parts per million (ppm) chlorine solution is placed around the well screen to prevent entrance of undesirable fine material. This chlorine concentration is produced by 51 ounces of 5¼ percent chlorine bleach, 27 ounces of 10 percent liquid chlorine bleach, or 4 ounces of dry 65 percent dry chlorine per 100 gallons of water.

When the aquifer contains large quantities of fine material such as very fine sand or silt, in addition to good well screen and gravel pack design, thorough development of the well is essential. Development helps retard the movement of very fine sand and silt into the well. Sand and silt accelerate wear on the pump and can accumulate in the bottom of the well which may prevent proper cooling of the pump motor and eventual motor failure. Sediment can accumulate in plumbing, pressure tank, and water heater and also cause turbidity in the water.

Well Development

Well development is a specialized part of well construction and should be done by a Kansas Licensed Water Well Contractor who has the necessary equipment. It is recommended that all newly constructed or reconstructed wells be developed by one of the procedures discussed here. Think of development as dislodging and washing fine material out of the aquifer adjacent to the well. Some of these fines are introduced during well drilling.

Well development is accomplished by using a bailer, high pressure jetting, over-pumping (a rate exceeding the well capacity to deliver water), and other methods that physically force the well water back and forth through the well screen and gravel pack. The action of water moving in and out of the well screen, gravel pack, and adjacent aquifer removes the majority of the very fine sand and silt in the aquifer within the immediate vicinity of the well bore. The larger particles of the aquifer are left in place, next to the gravel pack, which effectively helps hold back the very fine sand and silt that is farther away from the gravel pack.

A bailer (a hollow open top cylinder pipe from 5 to 20 feet long with an opening and flapper valve in the bottom) is lowered into the well. The flapper valve opens when the bailer is lowered into the well and then close when it reaches the bottom. Repeatedly lowering and raising the bailer surges the well, pushes and pulls water in and out of the well screen, gravel pack, and adjacent aquifer. The very fine sand and silt is dislodged, suspended, and flushed into the casing. The bailer is drawn to the surface with flapper valve closed and its contents, water with sediment, is discharged to waste. Well development by bailing is continued until the water withdrawn is mostly clear of sediment.

The over-pumping development method involves placing a high capacity pump (without the normal check valve) and pump column pipe near the bottom of the well. When the pump is turned on, the water is lifted and discharged at the surface to waste. After the pump has been discharged for a period of time, it is turned off and the water inside the pump column is forced by gravity into the well and back through screen. This washes or "back-flushes" the fine materials from around the well screen. This cycle is repeated many times, with the length of the discharge time increased each time. Pumping continues until the water discharged to waste is clear.

High pressure jetting development involves using a tool with nozzles that drives high pressure water into the screen while the tool is lowered, raised, and rotated throughout the well screen area. Water that meets drinking water standards and that has been disinfected is delivered by pump to the nozzle jets. After jetting, the tool is removed and a bailer or pump is used to remove the dislodged sediments. Alternate jetting followed by sediment removal is repeated in sequence until the well water becomes clear.

Sanitary Well Seal

The top of every well casing must be fitted with a KDHE approved, water-tight sanitary seal to prevent entry of contaminants including water, animals, insects, or other pollutants. If the pump is not installed immediately, a permanent cap can be installed on the casing. This seal or cap prevents any contamination from accidentally entering the well and minimizes chances of vandalism. The sanitary seal is available for use with a variety of pumps, piping, and well casing diameters. Examples are illustrated in Figure I-7.

See *Protocol: Well Evaluation for a New Site or Existing Private Well* at the end of this chapter.

DISINFECTION OF WELL

The well casing, pump, wiring, and piping system should be thoroughly disinfected following well construction, development, repairs, pump installation, and annually as part of a preventive maintenance program.

When wells are constructed or reconstructed and pumps and piping are installed or repaired, microbiological contamination often results. All wells used for human consumption or food processing must be thoroughly disinfected before its first use in compliance with K.A.R. 28-30-10. An effective and economical method for disinfecting water wells is through the use of a high strength chlorine solution. Common laundry bleach contains a 5¼ or 6 percent solution of sodium hypochlorite is readily available and suitable to make the chlorine solution.

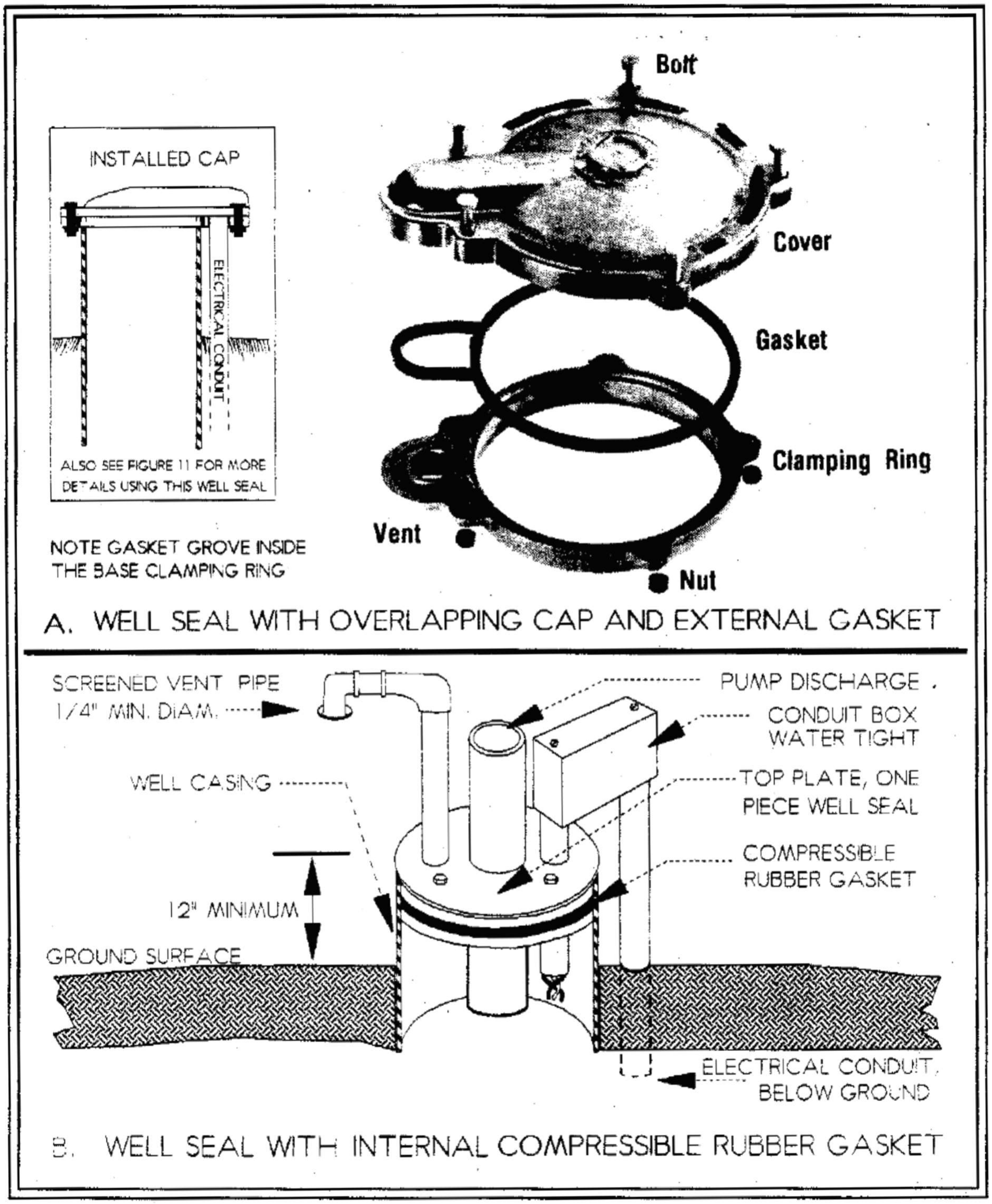
The recommended chlorine dosage for disinfection of existing wells, reconstructed wells, pump replacement or pump or well repairs is 500 mg/L or ppm (a gallon of laundry bleach for each 100 gallons of water) in the well and plumbing system. For disinfection of new wells, a dosage of 100 mg/L or ppm (one gallon of laundry bleach for each 500 gallons of water) is recommended. The recommended procedure for disinfecting water wells is found in Appendix A and in K-State Research and Extension publication Shock Chlorination for Private Water Systems, MF-911.

Following disinfection of the well and its appurtenances (plumbing), a sample of water should be collected after 7 days for bacteriological analysis. Prior to sampling the water, a test for free chlorine should be made. If chlorine is present, bacterial analysis should be postponed until the water is free of chlorine. If the bacteriological analysis indicates the water is still contaminated, the disinfection procedure should be repeated.

In rare cases, after careful investigation fails to reveal any defects in location or construction of the well and total coliform bacteria continue to be present, installation of equipment that provides continuous disinfection many be necessary.

Note: continuous disinfection is not a reliable replacement for proper well location and construction.

Figure I-7. Sanitary Well Seals



WELL PUMPS

The well should be provided with a pump selected for the application. The pressure and volume relationship that defines the pump curve is the primary factor in choosing the correct pump for the application. The pump should be installed in a manner that will prevent contamination from entering the well. A wide variety of pump equipment is available for lifting and pressurizing water from wells. The two most common devices, power pumps and hand pumps, are discussed in the following sections:

Power Pumps

Two types of power pumping equipment are commonly installed today on private water supply wells; the submersible turbine type pump and the jet type pump. Examples of power pump equipment and the important sanitary features governing their installation are shown in Figures I-8 and I-9. For more information on pumps refer to the EPA Manual of Individual and Non-Public Water Supply Systems or the Midwest Plan Service Private Water Systems Handbook. See references for complete citations.

Figure I-8. Submersible Pump Components

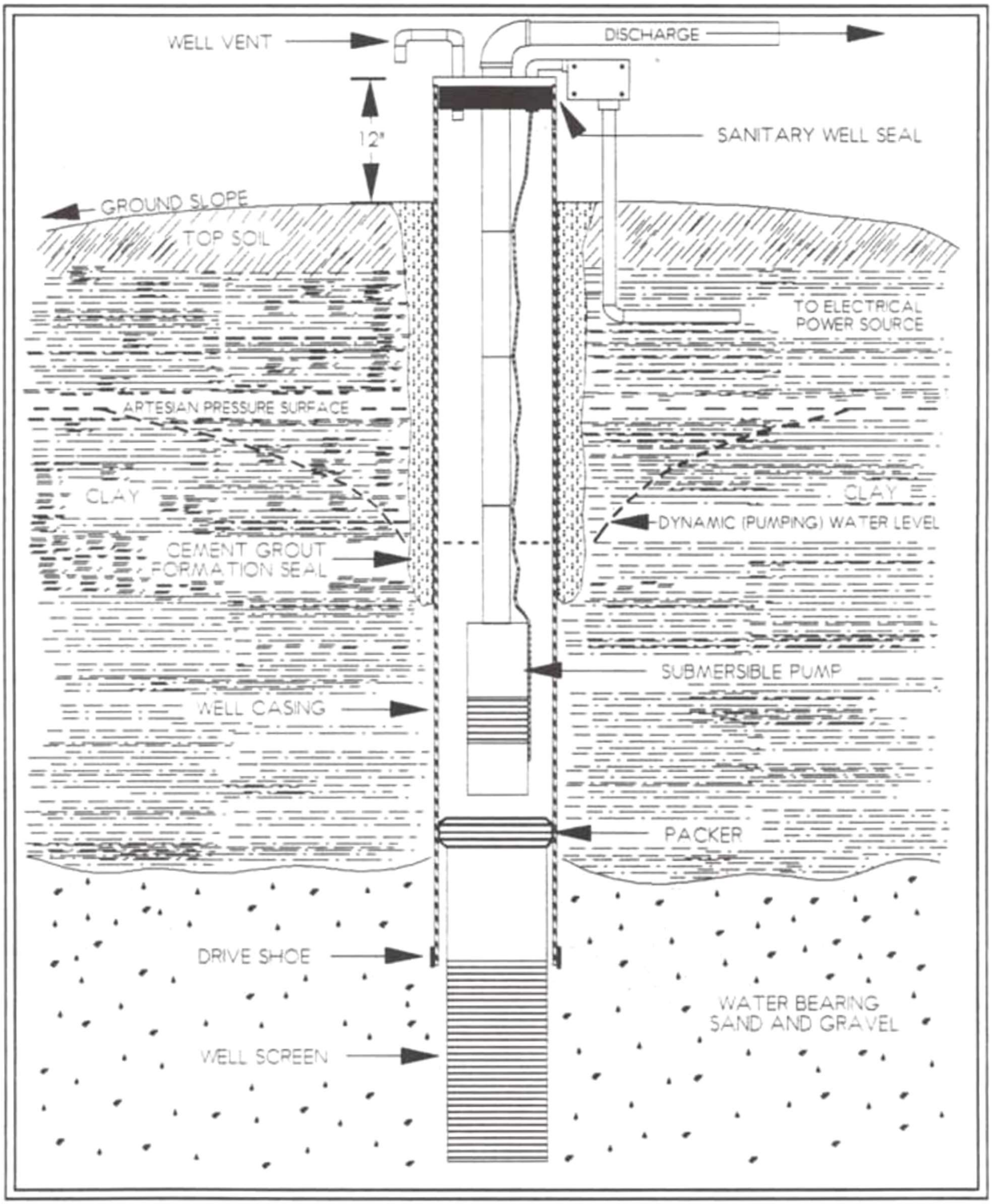


Figure I-9. Twin Tube Jet Pump Components for Deep Well

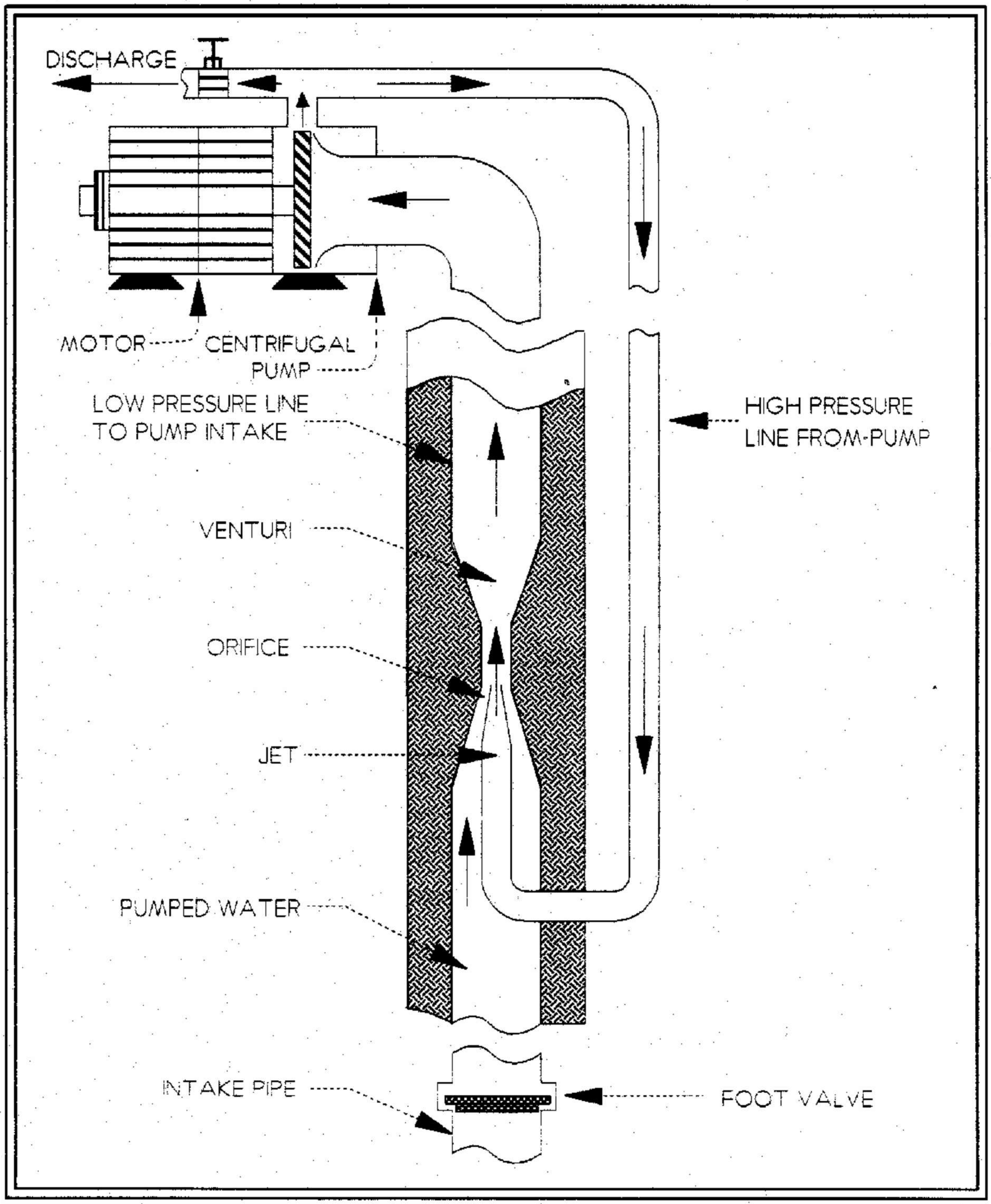
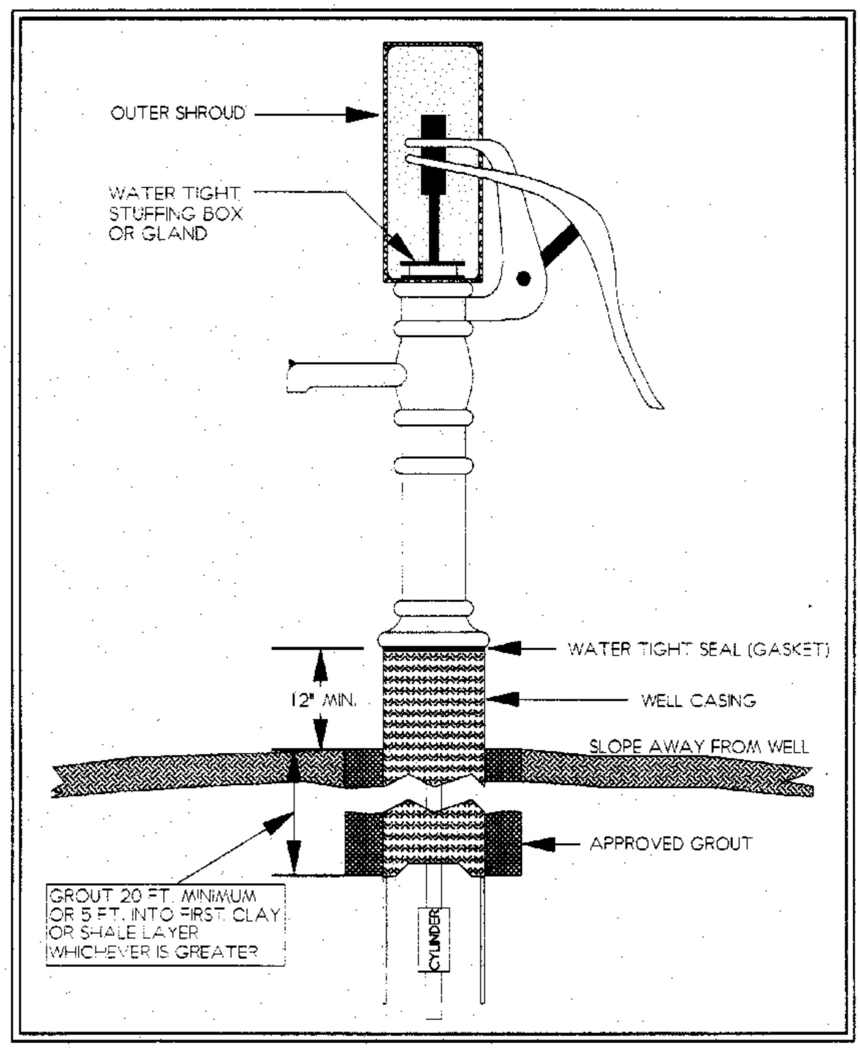


Figure I-10. Sanitary Hand Pump Components



Hand Pumps

The basic sanitary requirements for hand pumps are:

1) A solid, one piece, recessed type cast iron pump base, cast or threaded to the pump column, must be provided.

2) The top of the pump must be provided with a stuffing box or gland that forms a seal for the pump sucker rod.

3) The pump spout must be closed and directed downward.

4) A flange and gasket must be provided for attaching the pump base to the well casing.

5) The pump cylinder should be located below the static water level in the well so that priming of the pump is not necessary.

6) Adequate overhead clearance is essential to permit removal of pump rods, pump column pipe and pump cylinder for maintenance, repairs or replacement.

The recommended design for a hand pump installation is shown in Figure I-10.

FREEZE PROTECTION

Well installations require freeze protection for the piping and in some cases also the pump and pressure tank. Two feasible freeze protection options are pitless installations with the pump located in an area not subject to freezing, such as a basement or well pit at least 2 feet from the well, or an insulated pump house with supplemental heat. A submersible pump installed in the well is the most common pump type except for shallow wells. In the past, wells were often put in pits, basements, garages, and crawl spaces, or buried beneath the ground surface for freeze protection. These techniques and locations are all prohibited by state regulation K.A.R. 28-30-6(o) implemented in 1975 because of the high potential for contamination.

Well Pump House

A pump house is a structure built over well on a concrete floor to protect equipment from freezing and damage. The size of the pump house depends on how much equipment, the size of the equipment and how much space is needed to remove, replace or repair the equipment placed there. Allow adequate room to work comfortably while repairing or replacing. If you plan to install a pump, pressure tank, and disinfection equipment, the building will need to be larger than if only the pump will be housed there. Dimensions of a small pump house would be four feet long by four feet wide by seven feet tall. A larger pump house could be eight feet wide by eight feet long by seven feet tall. The roof should always be built so it can easily be removed or have a hatch that can be opened to enable removal of the pump column. The complete structure should be watertight, vermin and insect proof, and insulated to retain heat in the winter. A well work-over pulling unit is often used to pull pump rods, pump column pipe, submersible pumps, and other lengthy equipment placed inside the well.

In order to install as much insulation as practical, R30 if possible, the walls and ceiling should be 10 inches thick for fiberglass and 5½ inches thick for rigid foam. All walls should be solid on the interior and exterior and trimmed or sealed where they meet. All vents should be fine mesh screened to reduce the likelihood of insect entry. The door should be well insulated, weather stripped, and lockable. The pump house floor should be constructed of reinforced concrete at least four inches thick and sloped away in all directions from the well casing or suction pipe. Because the danger of electrical shock is greater with a wet floor, care should be exercised when installing electrical equipment in the pump house to be sure that the floor is well-drained and dry.

Supplemental heat can be provided by installing a thermostatically controlled heater, usually electric heat tape near the floor around piping, or an alternate heat source. A ground fault circuit interrupter (GFCI) should be used for all circuits in areas of water. All electrical wiring should be placed in vermin proof conduit.

Continuous chlorination of private well supplies is not normally required but provisions for installation of such equipment should be included in the pump house design. Figure I-11 shows recommended construction for the pump house. The pump house should not be used to store any material that could contaminate water including pesticides, paint, products that contain petrochemicals, or other chemicals or products.

Pitless Installations

Figure I-12 illustrates a typical pitless well device installation. The device (called a pitless well adapter or pitless unit) is often used in conjunction with a submersible pump to assure freeze protection for water lines. A basement may be a suitable option for locating the pump and pressure tank. A 50-foot separation distance of the well from buildings is required because of potential contamination from termite treatment. This separation of the well applies when the pump and pressure tank are located in the basement. The design of a pitless well unit and a pitless well adapter are shown in Figure I-13. A well in a pit has been illegal for new construction since the Well Construction Act was adopted in 1975. A pump pit can still be used but must be located at least 2 feet away from the water well.

Figure I-11. Typical Pump House Components

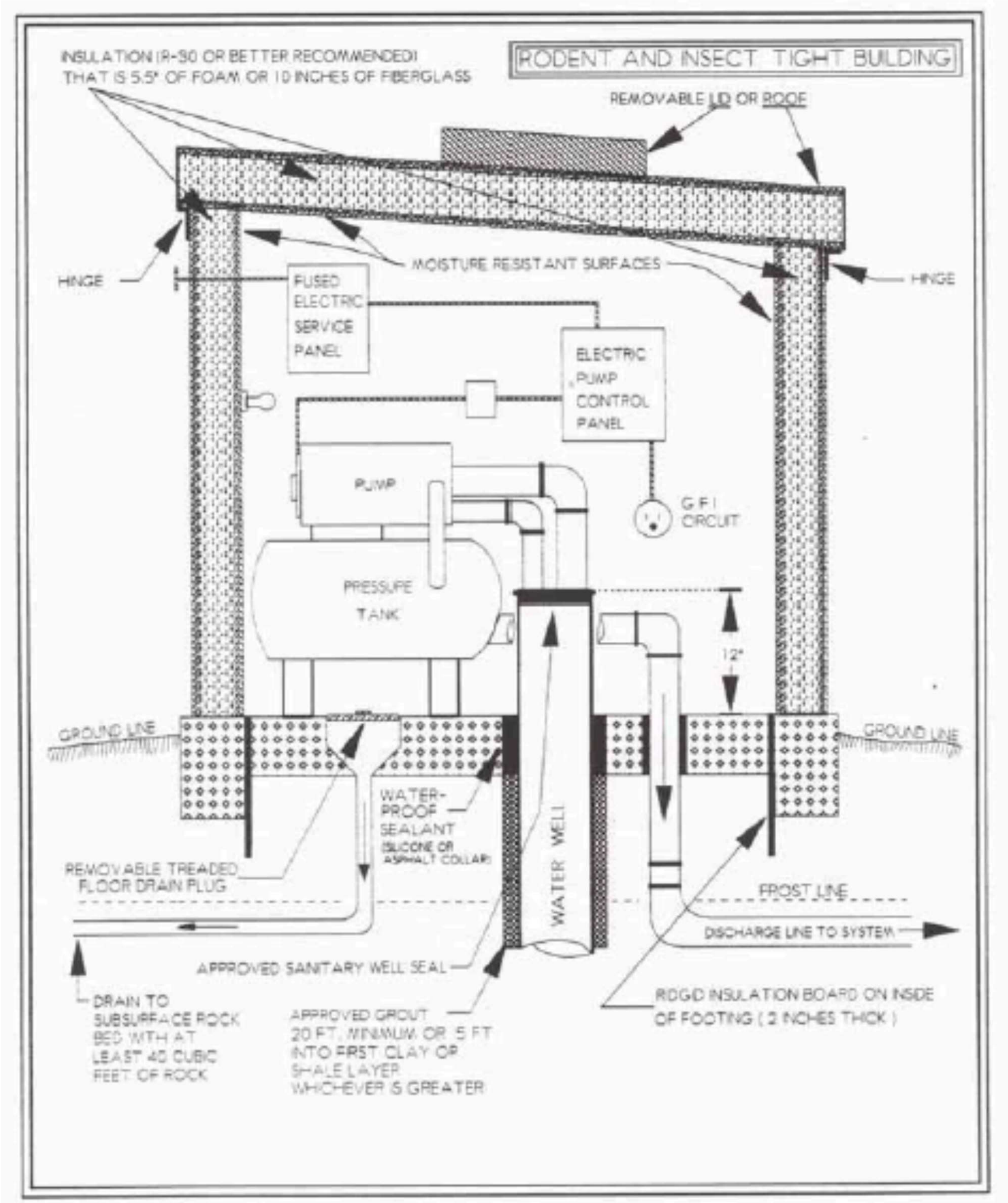


Figure I-12. Typical Pitless Well Device

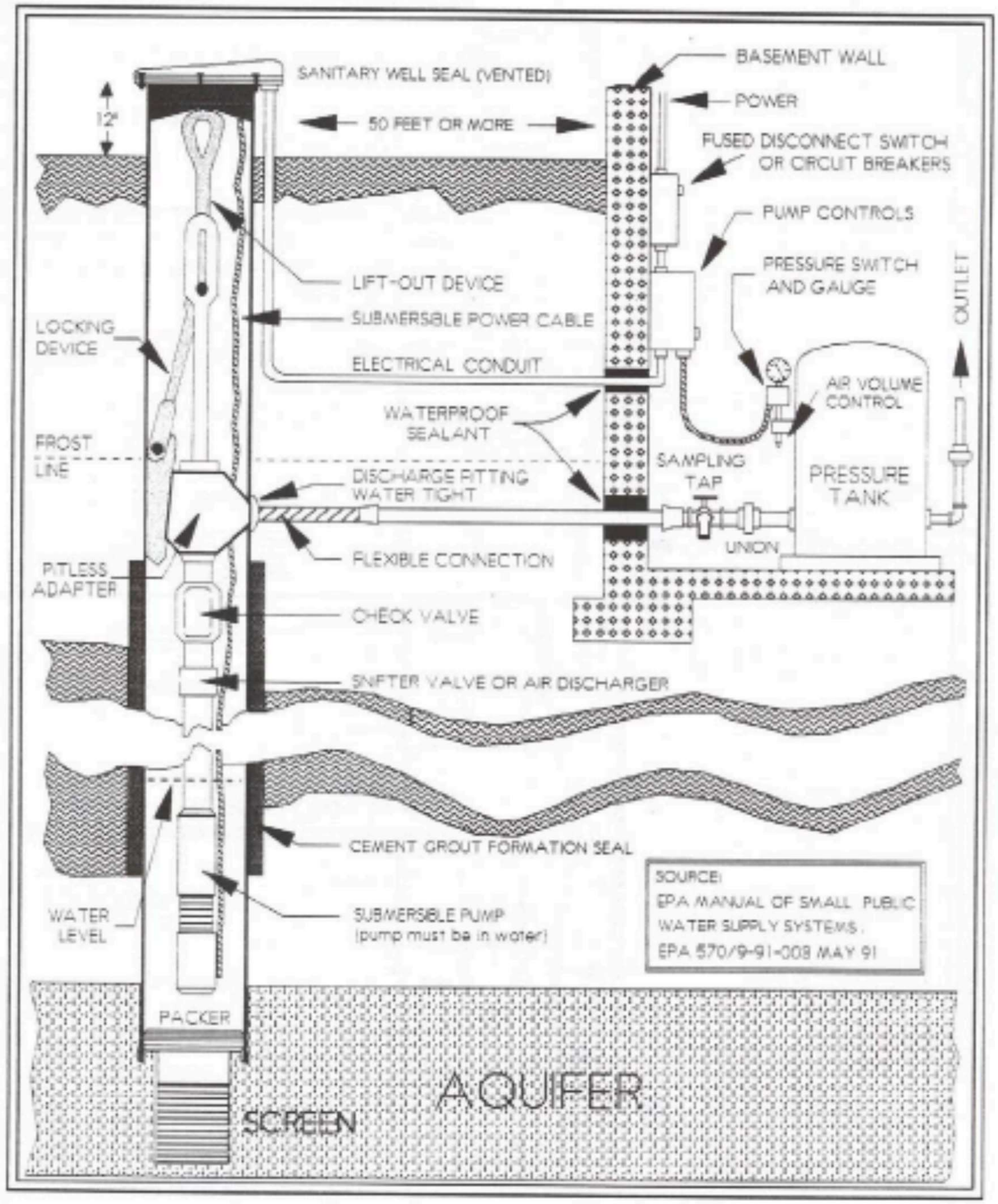
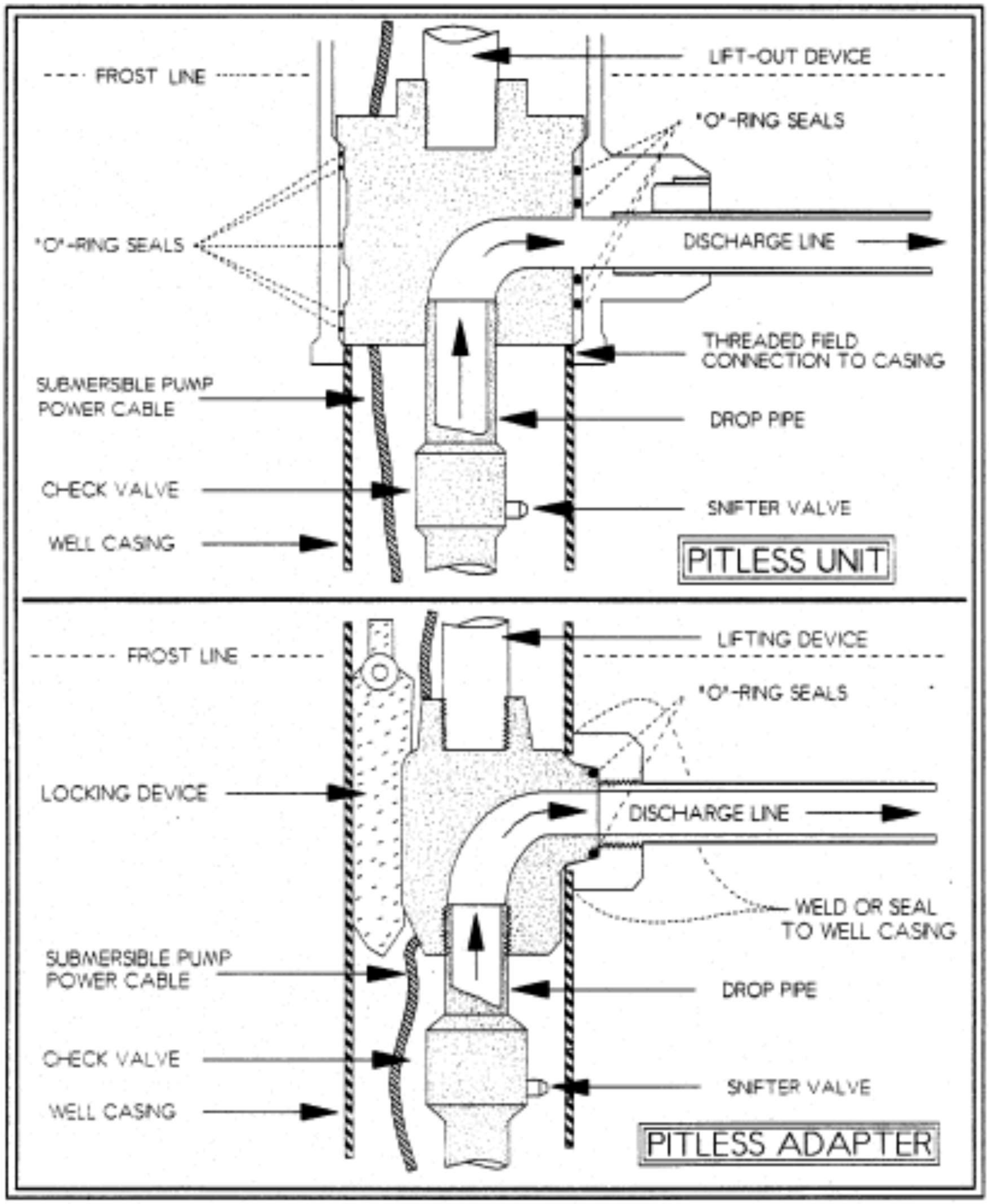


Figure I-13. Design of Typical Pitless Unit and Pitless Adapter



WELL MAINTENANCE

The first concern is always that the location meets recommended separation distances between the well and sources of contamination as shown in Table I-2. Location is the most important factor for protection of water quality. Second is the quality of well construction which is of concern primarily when the well is initially drilled. However, well components deteriorate over time, can be damaged, or may be removed and not correctly reinstalled that means the well may no longer meet the construction standards and thus would be unsafe. Well maintenance is the important action needed to help assure that wells continue to be safe for supplying safe water.

In addition to good well location and construction that meets current well standards, regular maintenance helps ensure that the well continues to be a safe source of drinking water. A well that is not maintained can not be expected to reliably produce safe water. Recommended annual well maintenance includes: checking the well casing for leaks, checking for a secure and watertight well seal, assuring that the ground surface slopes away from the well, disinfection of the well and water system, and a verifying water test is free of coliform bacteria. A checklist, recommended for an annual well maintenance procedure is presented in Table I-3. *Note: See Extension bulletins in references at the end of the chapter for additional information*

Table I-3. Private Well 12-Point Maintenance Check

Do each year:

- Check that the well casing is free of cracks or other leaks from the water table to at least 1 foot above the ground surface or highest flood level whichever is greater.
- Check that the sanitary seal is a KDHE-approved type and is secure and watertight.
- Make sure the ground slopes away from the well for at least 15 feet in all directions.
- Shock chlorinate the well and water system.
- Test coliform bacteria, nitrate, pH, and total dissolved solids and file the results with other records and information about the well.

Always do:

- Have a licensed water well contractor do all work on the well and casing and be sure well meets all current KDHE minimum construction standards.
- Find and fix the cause of any change in water color, odor, or taste. Disinfect the well and water system following any service on the system.
- Maintain 50 ft. (100 ft. preferred) of open space between the well and any buildings, waste system, parked vehicle, equipment, compost, or other possible contamination source.
- Store chemicals such as fertilizer, pesticides, oil, fuel or paint at least 100 ft. down slope.
- Prevent backflow and backsiphonage by maintaining an air gap above the container you are filling, or by using an adequate backflow prevention device.
- Disinfect the well after any service work on the pump, well, or water system.
- Plug all abandoned wells and wells not used in the last 2 years following state regulations or upgrade them to current standards. Plug all unused cesspools, septic tanks, and other holes.

Finally, every well needs a wellhead protection plan to assure continuing protection of water quality, especially for those wells being used for drinking water. The wellhead protection plan indicates site vulnerability to groundwater contamination and rates the risk of activities within 500 feet of the well. For the plan to have any benefit, it must be followed and updated by the landowner or user. With many problems of poor private well water quality in Kansas, it is in the owners' interest to take steps to protect their own wells so they can have safe water.

Water Testing

Remember: No Federal or Kansas law regulates the quality of drinking water from private water supplies. The owner or user is responsible for the quality of water from a private well.

After the annual maintenance check is done, a water test is recommended for coliform bacteria, nitrate, pH, and total dissolved solids concentration. Water testing confirms the water safety after all efforts have been made to be sure the well is safe. When coliform bacteria is used as an indicator of safe drinking water, a monthly test is recommended (a minimum is a quarterly, 4 per year, test). Frequent testing can assist in identifying problems and alerting the need for action.

Additional testing is advised following an event which could jeopardize water safety, such as:

- Flooding or spills that could cause contamination
- Any evidence that water quality may have changed (taste, odor, color, turbidity, etc.)
- Frequent or unexplained illness of people or animals
- Poor livestock or animal performance (weight gain, litter size, mortality, health)

The choice of which test(s) to perform will be a judgment based on each situation. If potential contamination conditions are present near the well (i.e., landfill, chemical storage/handling, or fuel storage) it would be advisable to test more frequently and for a wider range of potential contaminants such as pesticides, synthetic organic chemicals, volatile organic chemicals, and radionuclides. See the K-State Research & Extension publication *Recommended Water Tests for Private Wells*, MF-871, for information on what to test for and how often.

Previously untested wells should be tested for basic water chemistry. This includes evaluation for the most common minerals and nuisance contaminants. Except in cases of gross contamination or a catastrophic event, basic chemistry usually changes slowly so re-testing every three to five years is adequate. A basic water chemistry test usually includes common cations (calcium, magnesium, sodium, iron, manganese) and anions (chloride, carbonate, bicarbonate, sulfate, nitrate).

Testing should be based upon past, present, and future site uses as well as groundwater quality data. It is advisable to contact a KDHE certified laboratory for specific sampling procedures, sample bottles, and the best time to collect and submit samples. K-State Research & Extension publications provide background information on recommended water tests and sample collection.

See *Appendix B* for a brief description of the standards and significance for common inorganic chemicals.

See *Appendix C* for Homeowner/User Water Quality Screening Results Interpretation and Recommended Corrective Actions For Wells.

Drinking Water Standards

Kansas' regulation of drinking water is authorized by state law, K.S.A. 65-171m. Primary drinking water regulations are outlined in K.A.R. 28-15a-1 through K.A.R. 28-15a-571. Kansas regulations adopt the US EPA Safe Drinking Water Standards by reference.

Drinking water standards are separated into two broad groups: primary standards or maximum contaminant levels (MCL), and secondary standards or secondary maximum contaminant levels (SMCL). Primary standards are established for substances which may produce adverse health effects (i.e., bacteria, heavy metals, other inorganic chemicals, and organic compounds). Public water supplies must not exceed the primary standards or regulations. A brief discussion of common inorganic drinking water contaminants is included in *Appendix B*.

In the absence of standards or guidelines for private water supplies, public water supply standards are recommended. K-State Research and Extension publications *Understanding Your Water Test Report*, MF-912 and *Organic Chemicals and Radionuclides in Drinking Water*, MF-1142 lists standards for inorganic and organic contaminants (see references).

Secondary standards are established for aesthetic purposes (taste, odor, appearance, etc.) and certain non-aesthetic effects. EPA recommends secondary standards to the states as reasonable goals. Secondary standards are not enforced by EPA or Kansas laws or regulations.

PROTECTION OF WELLS (WELLHEAD PROTECTION)

Without a well protection plan, there is an increase chance of groundwater contamination from activities near the well. Resultant effects are usually long term or permanent.

Wellhead protection is important because in addition to location and construction management of activities near the well may affect the groundwater or aquifer supplying the well. Groundwater does not recognize property boundaries and may extend hundreds or even thousands of feet from the well site, especially up-gradient in groundwater flow. Protection offered by the soil is missing whenever it is missing or penetrated by abandoned wells, rock quarries, gravel operations, test holes, or other holes. The well's water quality depends on protection and nearby surface activities.

Potential contamination can be decreased or increased by location of the well. Generally, it is best to locate wells as far as practical from sources of contamination, both biological and chemical. Wells located up gradient in groundwater flow direction (usually up-slope on the surface), have a reduced risk of contamination from nearby sources. Surface water should be redirected by installing a diversion, a sloping channel with an integral ridge below, so water does not flow near the well.

The effects of surface activities many times are not immediately obvious, but may have long term consequences. Surface activities that can affect groundwater include application of fertilizer and pesticide, confined animal feeding operations, fuel storage, and failure to provide adequate backflow protection on the plumbing system. It is a fact that excessive fertilization of lawns and crops as well as spills near a well can contribute to an increase in nitrate concentration in the groundwater. Spills that occur while loading and mixing pesticides as well as the practice of flushing containers or equipment onto the ground near a well can contaminate it.

The best protection for private wells from contamination occurs when a wellhead protection plan exists in writing, is followed, and is reviewed regularly. *The River Friendly Farm Plan – Environmental Assessment Tool* and *Kansas Home•A•Syst, An Environmental Risk Management Guide for the Home* materials are available and may help in preparing the plan. First, potential sources of contamination are identified and their relative risk quantified. Then the highest risks, together with actions to reduce these risks are summarized. Finally, the owner acts to correct the highest risks first, then the next highest risks until all risks are reduced to low risks.

A good wellhead protection plan involves careful planning and should include a primary and secondary protection area or zone as shown in Figure I-1. In the primary protection zone all high-risk activities and conditions are prevented and moderate risk activities include measures or management to reduce them to low risks. The radius for the primary protection zone should be a minimum of 100 feet with up to 300 feet or more recommended.

In the secondary protection area or zone, high risk activities or situations employ additions or management to shift them to low or moderate risks. Moderate risk activities include measures of management to shift them to low risks. The radius for the secondary protection area should be a minimum of 200 feet with 400 feet or more preferred. Guidelines for high, moderate, and low risks are shown in Table I-4.

Table I-4. Relative Contamination Risks for Home and Farmstead Activities

Group A: High Risk

- Polluting liquids without secondary containment such as fuel, solvents, chemicals (fertilizer, pesticide, etc.)
- Liquid waste (sewage, manure, etc.)
- Water-soluble materials like fertilizer, pesticides
- Livestock lots, abandoned livestock lots and other wastes
- Buildings and areas where the above materials are used, transferred, mixed, stored or cleaned up (such as: shop or sprayer fill/clean up area)
- No backflow prevention for the water system

Moderate Risk

- Intensive cropland especially irrigated land where chemicals (fertilizer or pesticide) are applied, gardens, home and yard
- Powered equipment storage (tractors, truck, auto, etc.),
- Garage, grain storage, silo
- Livestock buildings with minimum liquids

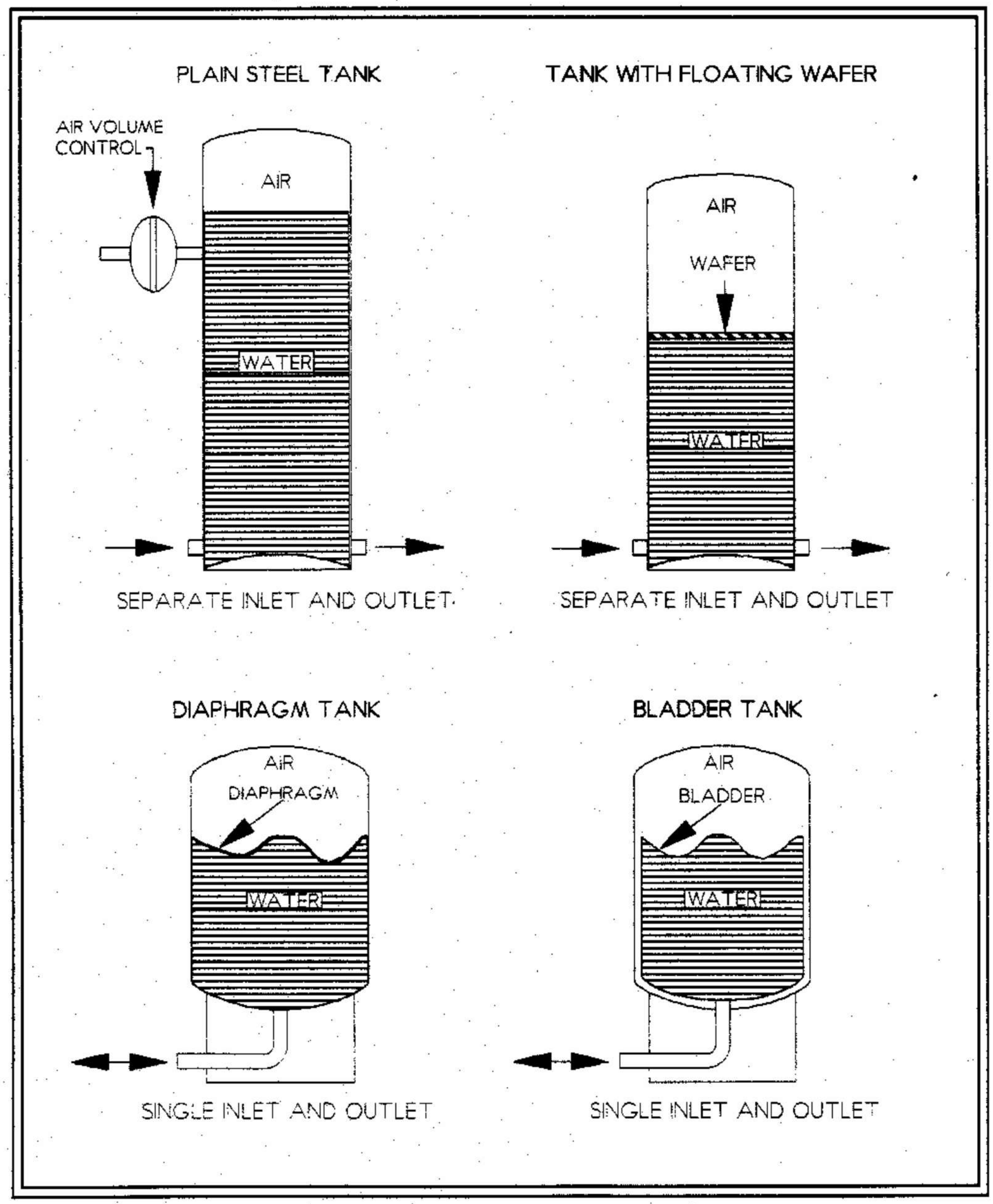
Low Risk

- Pasture rangeland, woodland, low intensity (low or no chemical) cropland
- Nonpowered machine storage
- Windbreak
- Low use buildings
- Organic garden, organic cropland
- Liquid storage with full secondary containment and careful management
- Water soluble materials with full spill protection, cleanup and careful management
- Air gap maintained for all filling operations and backflow prevention is used throughout the water system

PRESSURE TANKS

Most electrical water pump systems include a pressure tank to stabilize water pressure and to relieve the pump from running each time a small quantity of water is used. Pressure is obtained by compressing the air when the water is pumped into the pressure tank. The pressure tank may have a divider to prevent the loss of captive air in the tank. Various air retaining methods have been developed due to the tendency of water to absorb air and the tank to become "waterlogged." Examples of different pressure tank sections are illustrated in Figure I-14.

Figure I-14. Pressure Tank Styles



WATER STORAGE TANK

In some areas of the state there are no water-bearing formations (aquifers) that will yield sufficient quantities of potable water. As indicated earlier, the best water source for domestic use in rural areas without usable aquifers is the rural water district. Where a water district supply is not available, the use of a properly constructed and equipped water storage tank of food grade material is a possible solution.

Water placed in a storage tank should be obtained from a public water supply and should be transported to the reservoir in a clean, closed, food grade tank used exclusively for hauling potable water. All reasonable precautions should be taken to prevent contamination of the water during the transporting, loading and unloading processes. It is a good practice to periodically rinse the tank with a solution of chlorinated water and discharge the rinsate solution onto the ground away from any surface water drainage areas and vegetation.

CROSS-CONNECTION CONTROL

This section is intended as an introduction to the subject of cross-connection and backflow control. It is not within the scope of the section to address specifics. A bibliography of reference materials is included at the end of this chapter.

In plumbing, the term **cross-connection** refers to a **permanent** or **temporary** connection between a potable (drinking) water system and any other source or system containing nonpotable water or any other substance. Cross-connections are a recognized public health problem with many documented cases of accidents, illnesses, and even deaths. Any water supply, from a large municipal system to a private single family or farmstead system, can be subject to cross-connection problems. Permanent or temporary by-pass arrangements or jumper connections are common cross-connection problems. For example, the common garden hose with the discharge end in a bucket or tank is a cross-connection because it is subject to possible backsiphoning.

There are two types of cross-connections: direct and indirect. The difference between the types of cross-connections is very simple. A direct cross-connection is subject to backpressure; an indirect cross-connection is not subject to backpressure. When a cross-connection is present, contamination of the potable system may occur as the result of backflow (reverse flow of water), other liquids, or gasses into the water system. Backflow may be caused by backsiphonage, backpressure, or a combination of the two. This is an undesirable situation because contaminants are often introduced into the potable water system with the backflow.

Backsiphonage is a backflow condition caused by a vacuum or partial vacuum in the water-supply system. This can be caused by gravity, undersized piping or induced vacuum. Gravity backsiphonage occurs when the water flow is interrupted and an elevated valve is open allowing a reversed flow. This could occur when the water supply to a two-story house is temporarily interrupted by shut off or loss of power. During this period if someone should open a valve on the first floor, water would flow from the second floor to the first-floor faucet. Backsiphonage due to undersized piping may occur when water moving at a high velocity aspirates or draws water from branch piping into the rapidly moving stream. This may occur when a valve is opened but water does not come out with pressure.

Backpressure backflow is caused when a higher pressure is exerted from some point downstream than is present in the piping system. Examples would include a booster pump used for livestock watering or a second livestock water system connected to the household system.

Both backsiphonage and backpressure can be caused by high volume pumping of water from the system. Such an incident might occur when a fire engine is pumping water from a fire hydrant. There are five basic backflow prevention devices that can be used for cross-connection control discussed in the following paragraphs:

Air Gap is a physical separation of the water supply from the nonpotable source using an air gap with a vertical separation distance of at least two times the supply pipe diameter. An air gap provides excellent protection against both backsiphonage and backpressure. **The air gap is usually the simplest, least expensive, and most reliable method of protection from contamination by cross-connection.** An air gap is the only acceptable means of protecting against lethal hazards.

Atmospheric Vacuum Breaker (AVB) is a simple device with an internal mechanism which, in the event of interrupted flow, provides an atmospheric vent to prevent backsiphonage. The AVB is to be installed in a vertical position with no restrictions down stream and the outlet at least six inches below the AVB. This backflow device is commonly used for outdoor hose connections and toilet and urinal flush valves. It is considered suitable for low hazard backsiphonage protection.

Pressure Vacuum Breaker (PVB) is a spring loaded check valve designed to close when flow stops. It also has an air inlet valve which is designed to open when the internal pressure is 1 pound per square inch (psi) above atmospheric pressure. When flow stops the vent opens to prevent backsiphonage. Being spring loaded it does not rely upon gravity to operate as does the atmospheric vacuum breaker. The unit has shutoff valves and test cocks (which should be tested annually to be considered safe) and may be operated under continuous pressure with valves downstream of the device. This device does not provide acceptable protection against backpressure.

Double Check Valve Assembly (DC) is a device consisting of two internally loaded, independently acting check valves with shutoff valves upstream and downstream. The unit also has testcocks and must be tested annually to be considered reliable. This is commonly used at the household water service connection just downstream of the water meter. The DC can be used in low hazard situations to protect against either backsiphonage and backpressure.

The Double Check Director Assembly (DCDA) is a variation of the double check valve. This assembly is used when the protection of the double check valve assembly is required yet where the added requirement of detecting any leakage or unauthorized use of water exists. These assemblies are commonly used for fire sprinkler lines.

Reduced Pressure Principal Assembly (RP) is a device consisting of two internally loaded and independently operating check valves and a mechanically independent, hydraulically dependent relief valve located between the check valves. This relief valve is designed to maintain a zone of reduced pressure between the two check valves at all times. The unit has shutoff valves and test cocks and must be tested by a licensed and trained plumber annually to be considered reliable. In case of check valve leakage, it discharges to the atmosphere thus preventing contamination of the water supply. This device is used for backsiphonage and backpressure protection of potable water supplies from high hazard situations such as chemical feeds.

The Reduced Pressure Principal Director Assembly (RPDA) is a variation of the reduced pressure principal assembly. It is similar to the DCDA in that the bypass meter must register accurately at low flows. This assembly is normally used on fire sprinkler lines which may contain freeze protection or other additives.

The choice of device is dependent upon the degree of hazard posed and local code requirements. To be effective, cross-connection control devices must be properly installed and regularly tested by a trained technician as required. Education concerning potential cross- connection problems is essential to effectively address cross-connection potentials located on private premises.

COMPLAINT INVESTIGATION AND EVALUATION OF EXISTING WELLS

It is common for the sanitarian or county health or Extension office to receive complaints of bad taste, bad odor or other problems. A good response to this requires a thoughtful and thorough site investigation and evaluation of the well and water system. The cause of such problems may be from more than one source. A data collection form is included in Appendix D that can be used to help identify possible sources that may contribute to the problem.

When a request is received to evaluate an existing well for an owner or as required for a property transfer, a careful evaluation of the properties of the well are essential. Many lending institutions require such evaluation to help protect from the possible expense of a water supply correction in the event of a loan default. The investigation depends on collecting accurate information about the well and water system. The owner is in the best position to know answers for many of the well questions. Obtain information about the well or water system from the owner. For guidance about conducting a well evaluation see Protocol: Well Evaluation for a New Site or Existing Private Well and the accompanying data sheet at the end of this chapter.

If the well was installed since 1975 a well log should be available that would document the construction and materials. Possible sources include the owner, the well driller, Kansas Geological Survey web site, and KDHE records. If no well log can be found or the well was installed prior to the 1975 Well Construction Act and construction is unknown, assume that grout does not meet current well construction standards and likely is totally missing. A well that is not adequately grouted is very vulnerable to contamination from the surface and is not a safe well.

PLUGGING ABANDONED WELLS

The plugging of abandoned wells is required by Kansas law and is the responsibility and sole duty of the landowner (K.A.R. 28-30-7). Kansas landowners may qualify for cost share assistance through the county conservation district to help offset the cost of well plugging. They can either hire a Kansas Licensed Water Well Contractor to plug the abandoned or recently used well. Local Codes may require more stringent standards and should always be consulted. A landowner who plugs an abandoned well must follow the Kansas plugging regulations and must also file a record of the well plugging with KDHE (K.S.A. 82a-1212) using their Form WWC-5 (or WWC-5P). For more information about plugging a well see KDHE, Bureau of Water website www.kdhe.state.ks.us/waterwell or K-State Research and Extension publication *Plugging Abandoned Wells*, MF-935. Wells that meet certain minimum standards may be put on an inactive status by completing KDHE *Inactive Water Well Request*, form WWC-6 KSA.

REFFERENCES AND READING MATERIALS

Publications Regarding Private Wells and Related Topics

Available from K-State Research and Extension, Distribution Center, 34 Umberger Hall, Manhattan, Kansas, 66506-3402.

How Kansans Obtain Safe Drinking Water, MF-2333

Kansas Home•A•Syst, An Environmental Risk Management Guide for the Home, June 1999

Kansas Home•A•Syst: for Home Based Occupations and Hobbies, July 2001

Measuring Depth to Water in Wells, MF-2669

Obtaining Safe Water from Private Wells, MF-2345

Organic Chemicals and Radionuclides in Drinking Water, MF-1142

Plugging Abandoned Wells, MF-935

Plugging Cisterns, Cesspools, Septic Tanks, and Other Holes, MF-2246

Prevent Spills and Release of Contaminants, MF-2549

Private Water Well – Owner/Operator Manual (folder), MF-2409

Private Wells – Safe Location and Construction, MF-970

Private Well Maintenance and Protection, MF-2396

Process Water – Minimizing Microbial Food Safety Hazards for Fruits and Vege's, MF-2480

Recommended Water Tests for Private Wells, MF-871

River Friendly Farm Plan – An Environmental Assessment Tool, S-138 www.oznet.ksu.edu/rff/

Safe Water from Wells (video), SV-386

Well Disinfection: Chlorination for Private Wells, MF-911

Shock Chlorination Treatment for Irrigation Wells, MF-2589

Sodium in Drinking Water, MF-1094

Sodium in Public Water Supplies, MF-1114

Taking a Water Sample, MF-963

Testing to Help Ensure Safe Drinking Water, MF-951

Understanding Your Water Test Report, MF-912

Water Supply for Food and Beverage Processing Operations, MF-1122

Why Use Pollution Prevention, (video) SV-176

Available from Kansas Department of Health and Environment, 1000 SW Jackson St, Suite 420, Topeka, Kansas, 66612.

Article 12. Groundwater Exploration and Protection Act, effective September, 1993.

Article 30. Water Well Contractor's License Water Well Construction and Abandonment, effective May, 1987.

Policies, General Consideration, and Design Requirements for Public Water Supply Systems in Kansas, 1995.

How to Review a Water Well Record (WWC- 5 Form and WWC-5p Form) for Compliance to The Water Well Regulations, 2004.

Available from MidWest Plan Service, 122 Davidson Hall, Iowa State University, Ames, IA 50011, phone 800-562-3618, web address www.mwpshq.org/catalog.html.

*Home*A*Syst – An Environmental Risk-Assessment Guide for the Home*, NRAES-87, 122 page handbook, 1997. This handbook helps homeowners and renters in rural and suburban areas assess the home and property for pollution and health risk.

Home Water Treatment, NRAES-48, 128 page handbook, 1995. This two-color manual explains water quality and testing, the basics of water treatment, methods of physical and chemical treatment, and equipment used.

Private Water Systems Handbook, 4th Edition, MWPS-14, 72 page handbook, 1979. This well-illustrated, two-color handbook addresses water quantity and sources, then describes all aspects of constructing, repairing, and maintaining a private water system.

Private Drinking Water Supplies, NRAES-47, 64 page handbook, 1991. Water quality professionals and anyone else wishing to evaluate a private or public water supply will find useful information here.

Reviewers of the Private Water Well Section of the EHH, First Edition, 1998

Darrell Clarke, Clarke Well and Equipment, Inc., Great Bend, KS

Richard Harper, Kansas Dept. of Health and Environment, Bureau of Water, Topeka, KS Bruce Reichmuth, Henkle Drilling Company, Inc., Garden City, KS

Scott Shields, KDHE, Northeast District Office, 800 West 24th, Lawrence, KS Margaret

Townsend, Kansas Geological Survey, University of Kansas, Lawrence, KS

Dr. Donald Whittemore, Kansas Geological Survey, University of Kansas, Lawrence, KS

Dwight Brinkley, Consultant, Lawrence, KS, did final editing and prepared figures for the first edition of this chapter for the Environmental Health Handbook

PROTOCOL
EVALUATION OF A NEW WELL SITE OR AN EXISTING PRIVATE WELL

GOAL: Evaluate whether proposed well location or existing well location and construction meets existing codes, regulations, and guidelines for private wells.

POLICY: The site evaluation will be completed following application to the administrative agency by the landowner, purchaser, contractor, lender, or other involved party. A report summarizing the evaluation should be provided to all individuals who have legal interest in the property. When the site has restrictions, the report shall document reasons for those restrictions and where appropriate offer reasonable alternatives. A file of all original documents including: letters, data, supporting information, etc. shall be maintained by the administrative agency.

PROCEDURE:

1) The applicant shall provide a map and complete the application (see sample included) to request the site or well evaluation. The applicant's signature shall provide assurance of completeness, accuracy of information, and give the agency permission to enter the property as needed to conduct the evaluation and take samples. The well log for all existing wells should be provided when such exists.

2) The applicant should be informed that he or she is responsible for collecting information about groundwater availability and quality. Possible sources include Kansas Geological Survey web site; DASC web site and Kansas Department of Health and Environment contaminated site information web site. The applicant should be provided with a copy of current local code requirements for wells.

3) The inspector collects available information about the site from the soil survey, current aerial photo from county appraiser, any available agency records, and other sources as appropriate. Include information such as photos that would document historical land use and possible contaminant sources.

4) A site visit shall be made by the inspector to examine the proposed or existing well location. The landowner (or his or her representative) should be present, if possible, as well as other interested parties.

5) The proposed site shall be evaluated for conditions which could limit the location or provide evidence of possible contamination for a well. Such conditions include, but are not restricted to current and historical land uses, especially separation distances in Table I-2.

6) The proposed well location(s) selected by the applicant shall be marked with flags.

THE SITE VISIT

Preparation for the Visit

1) Obtain readily available information including site plan, map, and soil survey map.

2) Make an appointment for a site visit with the appropriate people.

For New and Existing Well Sites

1) Locate existing well or prospective well locations.

2) Visually identify contamination sources and topography within a 400 foot radius from the well or location. The ground surface should slope away for the well in all directions, or if located on a slope, a stormwater diversion should be provided on the uphill slope.

3) Measure and record setback distances from property boundaries, easements, and current and known historical contamination sources, see Table I-2.

4) Evaluate and record approximate well elevation with respect to potential contamination sources. An instrument such as a hand level, clinometer, contractors level, engineers level, or laser level with appropriate eye height rod or level rod are essential for this task.

For an Existing Well

1) Casing must extend at least 12 inches above surrounding natural ground surface and surface must slope away from the well in all directions.

2) Casing must be of approved material (Schedule 40 steel or PVC) with no penetrations of the casing except for a pitless adapter which shall be double gasket sealed to the casing.

3) Sanitary seal must be of KDHE approved type with no modifications; securely installed; all fittings secure and water tight; and downward opening vent screen in place, clear, and secure. If used, ropes must be contained inside the casing and cap and electrical wiring contained in conduit with water-tight fittings. Confirm that the sanitary seal gasket is compressed tightly around casing and all penetrations.

4) If the well log does not exist (i.e. well drilled prior to 1975 or the driller did not complete paperwork) assume that grout does not exist and indicate the lack of grout on the report. A probe inserted adjacent to the outside of the casing may help evaluate the existence and type of grout.

5) Obtain the type and rating of the pump and note location, type, and capacity of pressure tank.

6) Record location and description of all water treatment devices (including filters) attached to the water system.

7) Ask questions and look for evidence of cross-connections with other water sources and possible backflow hazards.

Note: Do not collect a water sample for bacteria analysis from a well that does not meet well construction standards.

Sampling and Testing

1) Collect a water sample for coliform bacteria only from properly constructed wells.

2) Check the water source to assure that there is no chlorine residual. Do not collect a bacteria sample if any chlorine residual exists.

3) Collect sample from an indoor water faucet that is in regular use where water has not been through a treatment device. KDHE advises not to use a swinging faucet as on a kitchen sink.

4) Follow laboratory, KDHE, or K-State Research and Extension guidelines for collecting the water sample for bacterial analysis. Collect a separate water sample for screening nitrate level.

5) Recommended sampling: chlorine residual, total and fecal coliform bacteria, nitrate as nitrogen [NO3 – N]. Testing pH and total dissolved solids [TDS] are also encouraged to establish baseline conditions and changes in water properties (indicate possible pollution sources) that may have health effects.

6) Because lead [Pb] is a health concern testing is recommended whenever lead pipe has been used. It may be a concern and testing is suggested when pH and TDS levels are low and there is a source of lead in the system including in brass pump parts and plumbing fixtures, or in solder containing lead.

7) If the nitrate concentration is high (above 10 mg/L) and pesticide usage, storage, handling, mixing, spills, or clean-up have occurred within 400 feet of the water source, then testing for the specific pesticide(s) is recommended. If NO3 is high and chemicals other than pesticides have been used, stored, handled, mixed, spilled, or cleaned up within 400 feet, testing for those chemicals is suggested.

Reporting and Cautionary Statements

1) Provide verbal and written educational material to buyer and seller related to protection of their water supply in the form of a letter with brochures, pamphlets, publications, inspection form, and/or handout materials. Suggest completion of *River Friendly Farm Plan - Environmental Assessment Tool* or *Home*A*Syst* as a practical way to do a private well assessment, wellhead protection plan, and action plan to improve protection. See references.

2) Written documentation describing the evaluation should be provided to all individuals who have an interest in the outcome of the assessment (i.e., buyers, sellers, lenders, realtors, zoning boards, and contractors).

3) In situations where the site evaluation found deficiencies, the report shall document the findings and provide reasons and if possible offer a reasonable alternative.

4) A file of all data collected, reports, documents, and letters for that property shall be maintained by local authority

WELL SITING AND WELL EVALUATION APPLICATION AND DATA

Sample Form for Use with Well Evaluation Protocol

Date: ________________________________ Applicant: __________________________________

Location: Co. _____________,______¼, ______¼, ______¼, Sec.______, T______S,R______E/W

Subdivision: _________________________ Lot #: ________________ Parcel #: ____________

Owner(s): ____

Address: ____

Phone: H:_________________ O: __________________

Renter(s): ____

Address: ____

Phone: H:_________________ O: __________________

Owners Agent:_______________________________________ Phone: ______________________

Driller: ____________________________ Phone: ___________________ License #: ___________

Well Depth: _____ Water Depth: _____ Year Constructed: _____ Year Reconstructed: _____

Well Yield: ____________ Well Logs: Not Available / Available / Attached Indicate All

Well Uses: Household / Livestock / Lawn & Garden / Other: ________________ List All

Water Treatment Devices: ____

Reason for Inspection: ____________________________ Contact: ____________________

Well History (Investigations / Complaints / Past Water Tests / Maintenance / Repairs etc.): ____________

____

____

This information is complete and accurate to the best of our knowledge. Permission is granted for entry, inspection, and sampling as needed.

Above part to be completed by applicant. Signature:____________________________ Date:________________

SITE INSPECTION Inspector: ___________________________ Date: ________________________

Well Type: New / Reconstructed / Existing / Abandoned / Other: _________________________

Well Construction: Date: ___________ Method: Drilled / Driven / Hand Dug / Other: ______________

Pump Type: Submersible / Jet / Hand Pump / Other: ___________ Size (gpm/hp) ______________

Pressure Tank: Size ____________ (gal.) Type: ________________ Material: __________________

Water Treatment Devices (mark all used): sediment filter, carbon filter, water softener, reverse osmosis, distiller, other: ___________________________________

Potential Sources of Contamination, (Existing and Previous) within 1/8 mile (660 ft.)

Contamination Type	Direction and Distance from Well
______ Wastewater systems	______________________________
______ Livestock confinements	______________________________
______ Petrochemical and fuel storage	______________________________
______ Pest./Fert. storage/handling/cleanup	______________________________
______ Other hazardous activities	______________________________
______ Proximity to bldg. foundation	______________________________
______ Other used/unused wells	______________________________
______ Other:	______________________________

Required Setbacks (separation distances) (Have, Have not) been met (list): _________________________
____

TEST RESULTS: Total Coliform: _________ Fecal Coliform/E. coli: ___________ Nitrate: ____________
Chlorine: ____________ Other (attach report): ____

CONDITION of WELL CONSTRUCTION:
____ Ground surface slopes away from well in all directions for at least 20 feet and surface water does not pond within 50 feet.
____ Casing is at least 12 inches above surface grade or high water level.
____ Sanitary seal approved, properly installed, tight, & unmodified (brand/model): ____________
____ Top of well appears to be tightly sealed but is not an approved type.
____ Identified potential cross-connection, backsiphonage, or backpressure (where and what):________
____
____ Casing from 12 in. above ground to top of well screen is approved and seems watertight.
____ Casing properly grouted (how determined) ____
Casing diameter: ______ ID / OD Pitless Adaptor/Unit approved type & secure: ____________
Casing Material: PVC ____, ABS ____, Steel ____, Iron ____, Other ___________________
Other comments: ____
____
____

Recommendations to upgrade well: ____

APPENDIX A. WELL DISINFECTION

Before a well is disinfected, it should be inspected to assure that it is not being contaminated due to poor location, poor construction, damage or inadequate maintenance. If a well is poorly constructed, allowing the entry of surface water, dirt, insects, or other contaminants, then chlorination of the well and the water system will provide only a temporary solution to the problem. If the well appears to be sealed to keep contaminants out, or if repairs or changes have been made to the pump, well or, other parts of the water system, then proceed with disinfection of the well and water system as follows:

1) Remove the sanitary well seal and place it into a clean container. Pour an appropriate amount of chlorine solution into the well casing. The amount of chlorine solution to use is not less than one-half (½) gallon of chlorine bleach containing 5¼ percent sodium hypochlorite to 100 gallons of water.

2) Attach a garden hose to a tap or water hydrant that is supplied water from the well and place the free end of the hose into the top of the well casing. Circulate the chlorinated water from the well through the hose and back into the well by opening the valve, tap or water hydrant to which the hose is attached. Manually rotate the discharge end of the hose in a circular motion around the inside of the well casing. This allows the chlorine solution to wash down the interior wall of the well casing and the exterior wall of the pump column pipe. This procedure is repeated and continued for at least 15 minutes after a strong chlorine odor is detected from the discharge end of the hose. A good practice is to allow the recirculating hose to continue to flow while step 3 is being done. Be sure to wash down the sanitary well seal with the chlorine solution. The top of the well casing then should be resealed by installing the clean sanitary well seal (never leave the top of the well open).

3) Open a different outside tap, closest to the well, and let the water run to waste until the unmistakable strong odor of chlorine is detected. Close that tap and proceed to the next closest tap to the well and repeat the discharge of the chlorinated water. Continue this procedure, tap by tap, throughout the entire distribution system (both cold and hot water lines) including hydrants, faucets, toilets, and showers until the chlorinated water is distributed throughout the entire water system. If at any time no chlorine odor is noted in the water at any tap, repeat the procedures in Steps 1 and 2 above. After distributing the chlorinated water throughout the distribution system allow the chlorinated water to remain in the distribution lines for a minimum of 12 hours. Do not use any of the water during this time period.

4) After the chlorinated water has been in the lines for at least 12 hours, open an outside tap and flush the chlorinated water to waste until no chlorine odor is detected. This large volume of highly concentrated chlorine should not be discharged to the septic system nor should it be discharged to the surface in contact with vegetation which the owner wishes to maintain. Flushing onto a gravel drive or road is acceptable. Continue to flush the system tap by tap, leaving inside faucets until last. Do not allow anymore high chlorine water than absolutely necessary to be wasted to the wastewater system.

5) Wait at least seven (7) days or more after chlorination before taking another water

sample to be tested. Before taking the water sample it should be tested to make sure the sample does not contain any chlorine. Water samples may be collected by the local health department or the homeowner. Samples which will be forwarded to a certified laboratory must be sent to the laboratory the same day they are collected, and submitted only in sterile containers supplied by a state certified laboratory. The test for total and fecal coliform should begin at the certified laboratory within 24 hours of sample collection.

In cases where contaminated water has entered the well, such as from a flood or damaged casing, a more elaborate disinfection procedure may be required. The recommended procedure is to use a 300 to 500 gallon clean tank that is constructed of food grade materials that has not had contaminants in it. Mix up a strong chlorine solution in the tank and allow it to flow into the well. In the case of a deep well with lots of water this may have to be repeated two or more times. The objective is to get the chlorinated water into the gravel pack and aquifer formation surrounding the well. The chlorinated water should remain in the well for at least 24 hours.

Three times during the process, pump out a tank full and then let it run back into the well.

This mixes the chlorine and forces the solution through the formation. If a strong chlorine odor is not detected, add more chlorine to the tank before letting it flow back into the well. If the water becomes murky with residue, pump the contents to waste until clear water is achieved and begin the process again.

For more detailed instructions about well disinfection including tables to help determine water volume and chlorine doses, see K-State Research and Extension publication *Shock Chlorination for Private Water Systems*, MF-911.

APPENDIX B. COMMON INORGANIC DRINKING WATER QUALITY PARAMETERS

ALKALINITY (CaCO3). The recommended value for alkalinity is between 60 and 100 mg/L. The alkalinity of water is a measure of its capacity to neutralize acids. Bicarbonate and carbonate are the major contributors to alkalinity, but borate, hydroxide, phosphate and silicate also contribute. The relationship of pH, calcium and alkalinity determines whether a water is corrosive or whether it will deposit calcium carbonate. Water with an alkalinity value below 50 mg/L may be corrosive, which could cause deterioration of plumbing and an increased chance for lead in water, if present in pipes, solder or plumbing fixtures. Alkalinity greater than 500 mg/L will be noticeably hard, but does not have any adverse health effects. Alkalinity is an indicator of the stability of water (see Langlier Stability Index worksheet).

CHLORIDE (Cl). The suggested limit for chloride is 250 mg/L. Some people can detect a salty taste when chloride exceeds 250 mg/L. Chloride has no known physiological effect.

FLUORIDE (Fl). The maximum contaminate level (MCL) for fluoride is 4.0 mg/L with a suggested limit of 2.0 mg/L. A fluoride concentration of approximately 1.0 mg/L helps prevent dental caries (cavities in teeth) but below 0.7 mg/L, fluoride will not be of any benefit. At concentrations above 1.8 to 2.0 mg/L, fluoride may cause mottling of the teeth. This is most commonly a problem for children up to 10 years old while permanent teeth are forming.

HARDNESS (CaCO3 equivalent). Total hardness over 400 mg/L (23.4 grains per gallon) is considered excessive in Kansas. Calcium and magnesium are the principal minerals contributing to total hardness. Hard water has a tendency to develop scale deposits, especially when heated above 140° F. If the thermostat on the hot water heater is set too high, excessive scale may form. This scale can be carried into the water pipes and will plug up screens on faucets and appliances. Soft water may be corrosive, and can slowly dissolve metal pipes or metal plumbing fixtures. Acceptable levels for hardness are based on the user's preference, cost to treat, cost for increased cleaning and laundry, shortened life of appliances, and increased water heating costs for hard water.

IRON (Fe). The suggested limit for iron is 0.3 mg/L. Iron contaminated water is objectionable because of taste or odor and it often causes reddish-brown stains to develop on bathtubs, sinks and toilet bowls. It can also stain laundry a pink or reddish color. Iron has no significant direct adverse health effects but people may not drink enough water. Animals may be sensitive to changes in iron concentrations in their drinking water. Dairy cows may not drink enough water to maintain optimum milk production if the water is high in iron. Dissolved iron in water used for washing and sanitizing milk-handling equipment may impart an oxidized or cardboard-like flavor to the milk.

Frequently, water with dissolved iron also shows evidence of iron bacteria. These organisms use the iron as a source of energy and accumulate in masses that may plug well screens, pumps and pipelines. In time, a rust-colored, jelly-like mass will break loose and enter the plumbing system. Iron bacteria coat nearly everything, including toilet tank, pipes and storage tank. Decaying dead bacteria impart a bad taste and odor to the water and leave stains that are very difficult to remove.

MANGANESE (Mn). The suggested limit for manganese is 0.05 mg/L. Manganese contaminated water is objectionable because it may impair the taste of tea, coffee and other beverages and produce black or gray color in laundered goods, and cause dark stains on plumbing fixtures and showers. Manganese may form a coating on distribution pipes which may become detached, causing dark stains on laundered clothing or black particles in the water. Manganese has no physiological effects.

NITRATE (NO3). The MCL for nitrate, is 10 mg/L as nitrate nitrogen (NO3-N). Nitrate values are usually expressed as nitrogen (N), but may be expressed as "NO3". When expressed as NO3 the drinking water standard is 45 mg/L.

An annual check of nitrate is recommended with additional checks before pregnancy, during pregnancy and when infants (less than one year) are present or will be present. Excessive nitrate may cause infant cyanosis, also known as methemoglobinemia or "blue baby syndrome", in children less than one year of age. Pregnant and lactating women should also avoid water above this standard. A known safe water source should be used to mix formula or to feed the infant until one year of age. Children over one year of age and adults may be able to safely drink water with nitrate concentrations above the standard and even much higher for short periods. However, concentrations more than twice the standard (20 mg/L) are considered an unreasonable risk to health. Boiling water concentrates rather than remove nitrate so this make the problem worse. The best control is to eliminate excess nitrogen sources within at least 200 feet of the well.

Nitrate greater than 20 to 30 mg/L (as N) can be of concern in water used for livestock. Poor conception rate, increased abortion rate and a loss of feed conversion may occur in livestock.

Nitrate from water and feed sources is additive. Consult your veterinarian or Extension Office if you suspect a problem with nitrate for livestock.

POTASSIUM (K). The concentration of potassium normally found in drinking water has no physiological or aesthetic effects on drinking water users.

SODIUM (Na). Persons on a restricted sodium diet need to be aware of the sodium level in their drinking water, especially if the sodium value is greater than 100 mg/L. If you are on a low sodium diet, consult your physician or dietitian about sodium in water. People not on a restricted sodium diet do not need to be as concerned about the sodium level in their drinking water. Water softeners which are recharged with salt further increase the sodium.

High sodium levels may adversely affect the use of water for irrigation purposes. A relationship between the ratio of sodium and total hardness in the water, the type of soil being irrigated, and the type of crops being irrigated, determine if water can be used for irrigation. For further information on whether water can be used for irrigation contact your County Extension or Natural Resource Conservation Service office.

SULFATE (SO4). The suggested limit for sulfate is 250 mg/L. High sulfate concentrations in drinking water have three effects:

1) formation of hard scales in boilers and heat exchangers,

2) bitter taste, and laxative effects for those not used to it.

Diarrhea can be induced, especially for those who are not used to the water, at sulfate levels greater than 500 mg/L but more typically near 750 mg/L. After a few days or weeks, people and animals usually adjust to the sulfate and then are not bothered by the laxative effect. People and animals that are used to high sulfate water may experience constipation from low sulfate water.

TOTAL DISSOLVED SOLIDS (TDS). The suggested limit for TDS is 500 mg/L but many water in the water. Its value is useful in determining the usability of the water. The approximate value of TDS can easily be calculated by adding the values of calcium, magnesium, alkalinity, chloride, sulfate, nitrate and fluoride. Water with a TDS greater than 1000 mg/L may have adverse effects, such as a laxative effect on people not accustomed to the water, and is objectionable because of the mineral taste and possible physiological effects.

Water with a TDS less than 500 mg/L will have no adverse effect for watering animals. A TDS of 1000 to 3000 mg/L is acceptable for watering livestock, but may cause diarrhea in livestock not accustomed to the water or watery droppings in poultry. Water with a TDS of less than 500 mg/L should have no adverse effects for irrigation. A TDS of 500 to 1000 mg/L can have adverse effects on sensitive crops such as radishes, beans, and fruits. Water with TDS values of 1000 to 2000 mg/L can be used for irrigation but may require specific management practices especially for some crops. TDS over 2000 mg/L may not be suitable or will require detailed management.

SIGNIFICANCE OF INORGANIC WATER ANALYSIS - HEAVY METALS

ARSENIC (As). Maximum contaminant level (MCL) is 0.05 mg/L. Chronic health effects may include weight loss, depression and lack of energy. The high toxicity of arsenic and its widespread occurrence in the environment necessitate the limit on arsenic concentrations in drinking water. At one time arsenic compounds were used extensively as pesticides but their use for these purposes has been dramatically reduced. Arsenic is one of the few known human carcinogens.

BARIUM (Ba). MCL is 2.0 mg /L. Barium is fatal to humans in doses over 550 mg/L. Barium can accumulate in the liver, lungs and spleen. It can cause nervous system disorders, heart disease and circulation impairment. No study appears to have been made of the amount of barium that can be tolerated in drinking water, but because of its toxic effects on the heart, blood vessels and nerves, a level with a large safety factor has been set.

CADMIUM (Cd). MCL is 0.005 mg/L or 5 µg/L. As far as is known, cadmium is biologically a nonessential element of high toxic potential. The health effects of long-term exposure in the United States appear to be from diet, cigarette smoking and seepage into the groundwater from industrial plants, especially wastewater. Cadmium is believed to be mutagenic but not carcinogenic.

CHROMIUM (Cr). MCL is 0.1 mg/L. Though chromium is considered an essential nutrient, it is toxic to humans at low concentrations. Chromium is involved in the body’s use of blood sugar but excesses cause skin irritations and produce lung tumors when inhaled. Long-term exposure may cause skin and nasal ulcers. Chromium accumulates in the spleen, bones, kidney and liver.

It occurs in some foods, in air (including cigarette smoke) and in some water supplies. The level of chromium that can be tolerated over a lifetime without adverse health effects is still undetermined.

LEAD (Pb). MCL is 0.015 mg/L. Exposure to lead in water, either brief or prolonged, can seriously injure health. Prolonged exposure to relatively small quantities (more than 0.05 mg per day) may affect health. Lead exposure occurs from air, food and water sources. All exposures are additive and lead accumulates in the bones which results in elevated lead levels in blood. Known effects range from subtle biochemical changes and reduced mental efficiency at low levels of exposure to severe neurological and toxic effects and even death at much higher levels.

Water may be contaminated by lead from rocks and soil. However, most of Kansas has little lead in these sources and most of the water's pH is above neutral, and is alkaline where lead is less soluble. There is little reason to expect lead above the MCL in water supplies. Most lead in water will be dissolved from lead pipe, solder, and brass plumbing fixtures.

MERCURY (Hg). MCL is 0.002 mg/L. Mercury is distributed throughout the environment as a result of industrial and agricultural applications. Large increases in concentrations above natural levels in water, soils and air may occur in localized areas, though significant mercury problems are rare in Kansas. Outside of occupational exposure, food (particularly fish), is typically the greatest contributor to total mercury intake. Poisoning is characterized by major changes in the brain, including loss of vision and hearing, intellectual deterioration, and even death.

SELENIUM (Se). MCL is 0.05 mg/L. There is considerable difficulty in determining the toxic level of selenium intake in humans because the diet contains an unknown variety of selenium compounds in varying mixtures. Signs of toxicity have been seen at an estimated intake of 0.7 to 7.0 mg per day. Possible health effects include growth inhibition; skin discoloration, dental and digestive problems, liver damage and psychological disorders. Some studies have raised concern over the possible carcinogenic properties of the element, but is not believed to be carcinogenic.

For further discussion of additional inorganic analysis for drinking water including inorganic heavy metals (antimony, asbestos, beryllium, copper, cyanide, nickel, silver, thallium, zinc, and copper) refer to *Understanding Your Water Test Report*, MF-912, K-State Research and Extension. For information and interpretation of organic chemicals and radioactivity in drinking water see publication *Organic Chemicals and Radionuclides in Drinking Water*, MF-1142.

COMMON MEASUREMENT UNITS AND CONVERSIONS

1 grain per gallon (gpg) = 17.1 mg/L

mg/L = milligrams per liter (parts per million)

µg/L = micrograms per liter (parts per billion)

1 gram = 1,000 milligrams (mg) = 1,000,000 micrograms (µg) 454 grams = 1 pound

1 liter = 1.05 quarts

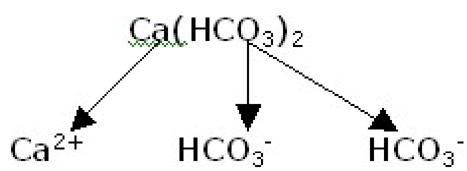
WATER STABILITY AND CORROSION CONTROL

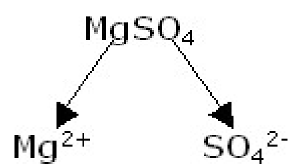
Few homeowners with private water supplies think about the stability of their water. Water stability is an important consideration in swimming pools and spas, as it affects water clarity and equipment maintenance. Private water systems can experience problems related to stability of the water, which lead to concerns related to personal health and aesthetics. Water stability is described as the ability to dissolve or deposit calcium carbonate ($CaCO_3$). Unstable water either deposits $CaCO_3$ as a film or scale inside pipes and fixtures, or it dissolves the scale and exposes metals in the system. Dissolving water is also called aggressive or corrosive.

Hard Water

Most well waters in Kansas are classified as hard or very hard due to the level of total dissolved solids (TDS), primarily the soluble ions of calcium and/or magnesium (Ca^{2+}, Mg^{2+}). The sources of these ions are certain common soluble salts:

1) Calcium Hydrogen Carbonate $Ca(HCO_3)_2$
2) Magnesium Hydrogen Carbonate $Mg(HCO_3)_2$
3) Calcium Sulphate $CaSO_4$
4) Magnesium Sulphate $MgSO_4$





These compounds interfere with suds formation so that more soap or detergent is necessary to clean effectively. The calcium and magnesium ions react with soap making a curdy scum. Soap will form a lather when there are no calcium or magnesium ions in the water. Therefore, extra soap is needed to form a lather in hard water. The extra soap removes the calcium and/or magnesium ions, softening the water.

Hard waters leave white mineral deposits (commonly called lime) when the water evaporates.

Most (but not all) hard waters tend to deposit $CaCO_3$ as a lining in pipes, tanks, and fixtures. As these deposits continue, the inside diameter of the pipe becomes smaller, lowering water pressure and delivery. Eventually such pipes and fixtures must be replaced to restore water pressure.

Some of the hardness can be removed by boiling; this is called temporary hardness and is caused by calcium hydrogen carbonate (also called calcium bicarbonate) and magnesium hydrogen carbonate.

Boiling causes these to change into insoluble calcium and magnesium carbonate, which settle out as scale or lime in kettles, boilers, and water heaters. This is the reaction:

$Ca(HCO_3)_2$ + Heat -> $CaCO_3$ + H_2O + CO_2 $Mg(HCO_3)_2$ + Heat -> $MgCO_3$ + H_2O + CO_2

Where: $CaCO_3$= calcium carbonate; $MgCO_3$= magnesium carbonate

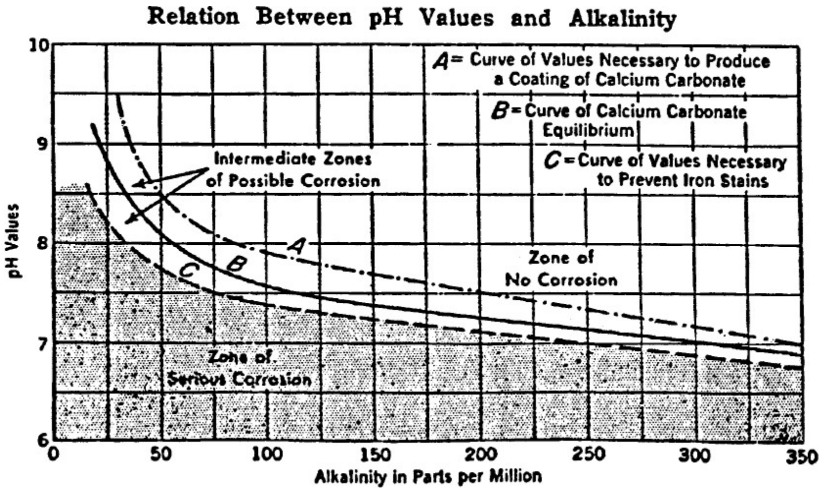
Calcium carbonate and magnesium carbonate are insoluble and so do not release calcium or magnesium ions into the water – they do not cause hardness. Permanent hardness is not removed by boiling. It is caused by the presence of calcium sulphate and magnesium sulphate.

$CaSO_4$ + Heat -> $CaSO_4$ $MgSO_4$ + Heat -> $MgSO_4$

Soft Water
"Soft" water contains respectively fewer calcium and magnesium compounds and allows suds formation with smaller amounts of soap or detergent. This is an advantage when cleaning, bathing, and doing laundry, and is the usual reason for installing a water softener. If corrosive, soft water can dissolve any $CaCO_3$ lining, exposing the pipe. In the case of metal pipes and fixtures, heavy metals such as iron and lead are dissolved in the water, resulting in equipment failure, leaks, and unhealthy lead levels in the water. In times past, rainwater was caught and stored in a cistern for use in laundry and garden irrigation. Rainwater the product of Nature's distillation, is usually very soft, with very low TDS and virtually no calcium or magnesium, making it also corrosive.

Water Stability
There are several stability indices that calculate the water's ability to dissolve or deposit $CaCO_3$. Public water systems are required to evaluate their water's stability and to maintain a condition that allows for slight deposition as a protective liner in distribution. The Baylis Curve is a chart which shows the relationship between pH, total alkalinity, and water stability. It is simple to use and provides a reasonable indication of water stability; however, water temperature is not taken into account. When water is heated (as with a household water heater), it can become more corrosive as temporary hardness precipitates out, lowering the alkalinity.

Figure I-15. Baylis Curve Showing Zones of Severe, Intermediate, and No Corrosion



Total alkalinity is not the same as hardness. It is the measure of all the alkaline material in the water and is really an indicator of the ability of the water to resist change in pH. Calcium (Ca^{2+}) and magnesium (Mg^{2+}) are primarily responsible for hardness. However, in most Kansas well waters, alkalinity and hardness have similar values because the carbonates and bicarbonates responsible for total alkalinity are commonly in the form of calcium and magnesium carbonate or bicarbonate. Be aware that waters with high total alkalinity are not always hard, since the carbonates in the water can be in the form of sodium or potassium carbonate. This is the case in water softened by the ion exchange method where calcium is exchanged for sodium or potassium, leaving the carbonate levels unchanged.

How Does Water Stability Cause Problems

Depositing water creates problems with adequate supply over long periods of time. Fixtures tend to clog and aerator screens can literally grow closed with lime deposits. These are not human health problems, but cause expensive repairs.

Corrosive or dissolving water causes problems for human health and aesthetics. Of concern in plumbing is the use of leaded solder on copper piping in homes built before 1986. Brass items and fixtures made before that date also contained lead. Corrosive water can leach lead from any exposed solder and brass components, creating a danger to health. Orange (rust) staining of laundry and fixtures is usually related to iron dissolved in the water.

Solving the Problem

The first step is determining water stability. A swimming pool test kit will include both pH and total alkalinity. The results of those two tests can be plotted on the Baylis curve. It is worthwhile to test and compare results for:

- hot water
- cold water
- untreated/unsoftened water
- treated/softened water

If the results are inconclusive, a more precise analysis can be calculated using the Langlier Saturation Index, which requires these water tests: pH, temperature, total dissolved solids, total alkalinity, and calcium. The Saturation Index (SI) is typically either negative or positive and rarely zero. A SI of zero indicates that the water is “balanced” and is likely not scale forming. A negative SI suggests that the water would be undersaturated and potentially corrosive. If the SI lies between -1.0 and +1.0, treatment is usually not needed.

If the water is determined to be depositing (a positive SI), a water softener can be installed. The most common water softener exchanges calcium ions for sodium and uses brine (salt) to recharge. If sodium in the diet is a concern or the taste of softened water is offensive, it is a simple matter to install a separate line carrying untreated cold water to the kitchen sink for cooking and drinking purposes. If the water is softened to zero hardness, there is the potential to create a dissolving (negative SI) water. It is a good idea to recheck the water’s stability after installing a softener and make adjustments as needed.

If the water is determined to be dissolving (corrosive), raising the pH is usually the solution. This can be accomplished by feeding a basic solution (soda ash) or passing the water through a neutralizing filter. In Kansas, ground waters are commonly basic (high pH), but shallow wells drawing from surface water sources may exhibit lower pH, and be corrosive.

APPENDIX C. KDHE PRIVATE WELL WATER QUALITY SCREENING RESULTS INTERPRETATION

Parameter	Acceptable[+] for consumption no evidence of risk	Limited acceptability for consumption may present risk [(1)]	Unacceptable for consumption [(2)]
Total Coliform			XXXXXXXXXXXXXX
Fecal Coliform		XXXXXXXXXXXXXXX	
E. Coli		XXXXXXXXXXXXXXX	

[(1)] The presence of total coliform bacteria in your water supply suggests structural problems with your well, household plumbing, or the presence of nearby sources of or points of entry by bacteria. Follow the steps on the continuation of this report to correct the contamination and improve the structural integrity of the well.

[(2)] The presence of fecal coliform or *E. coli* bacteria indicates that domestic sewage or animal waste is entering the well or household plumbing. Water should not be consumed until the problem is corrected. Follow the steps on the other side of this report to correct the contamination and improve the structural integrity of the well.

Parameter	Acceptable[+] for consumption ≤ 10 mg/L (ppm)	Limited acceptability for consumption > 10 ≤ 20 mg/L (ppm)[(1)]	Unacceptable for consumption > 20 mg/L (ppm) [(2)]
Nitrate (as N)			

[(1)] **Water with nitrate levels in this range should not be consumed by infants under one year of age or pregnant or lactating women.** An alternate known safe source of water for drinking and cooking should be obtained for pregnant or lactating women and for children under one year of age. Although the EPA recommends that all drinking water be below 10 mg/L, there is no evidence that consumption of water with nitrate levels in this range, and which is otherwise uncontaminated, poses an unreasonable risk to health for non-pregnant and non-lactating adults and children over one year of age. A decision to continue consumption of water with nitrates in this range is an individual decision to be made in consultation with one's physician.

[(2)] An alternate source of safe water for drinking and cooking should be obtained until the problem is corrected and the level is below 20 mg/L.

Parameter	Acceptable[+] for consumption < 15 µg/L (ppb)	Unacceptable for consumption ≥ 15 µg/L (ppb) [(1)]
Lead		

[(1)] An alternate source of water for drinking and cooking should be obtained until and unless corrective actions have effectively reduced the level of lead below 15 µg/L (ppb). Plumbing containing lead is usually the cause of lead contamination. Contact your health department for assistance in locating the specific source(s).

[+] Acceptability for consumption or other use is determined on the basis of each parameter individually.
Acceptability on the basis of any single parameter does not guarantee that other parameters (tested or untested) are within an acceptable range. Other factors such as poor siting or poor construction may cause a well to be vulnerable to contamination even if all laboratory parameters are within acceptable range on a single test.

APPENDIX C. (CONT.) RECOMMENDED CORRECTIVE ACTIONS FOR WELLS

If the water is acceptable for all parameters tested, do steps 1 through 7 below:

1) Continue to have water screened for listed parameters at least once a year.
2) Keep the area within a radius of at least 400 feet of the well free of potential sources of contamination including chemicals (gasoline, oil, cleaning fluids, pesticides, fertilizers), animal pens, or septic system components.
3) Check and maintain the site of the well so surface water runoff does not drain to or pool within 50 feet of the well site.
4) Check and maintain the construction of the well so openings do not exist which would let insects, animals, or surface runoff enter the well.
5) Do not mix chemicals or rinse containers and application equipment within 400 feet, or uphill from the well, and always use a backflow prevention device to prevent back siphoning.
6) Confirm that no cross-connections exist between the well and any potential source of contamination.
7) Do annual well disinfection as part of regular well maintenance program.

If water has limited acceptability for any test, in addition to steps 1 – 7 above do steps 8 through 16:

8) Have the water tested in a certified laboratory for the specific parameters indicated in the category.
9) Contact the County Environment or Health Department, county Extension Office, or KDHE District Office for information on correcting problems related to your specific results.
10) Inspect the area around the well (within 400 feet) for any potential sources of contamination related to your specific results.
11) Inspect the construction of the well to identify any openings which could allow insects, animals, surface water or shallow subsurface groundwater to enter the well directly.
12) Review household plumbing for potential defects or opportunities for cross-connections.
13) Contact the County Environment or Health Department, county Extension Office, or KDHE District Office for guidance and correct any contaminant source or well construction problem(s) noted in 10 through 12 above.
14) If the well tested positive for any bacteria categories, disinfect the well (see Appendix A or K-State Research and Extension publication *Shock Chlorination for Private Water Systems*, MF-911 for instructions). Well disinfection **will not correct** high lead or nitrate.
15) Retest the water for specific parameters noted after waiting for at least 7 days and after no chlorine is detected.
16) If the water tests are “acceptable”, perform the basic water screening tests quarterly for one year, then follow steps 1 through 7, above, on a regular basis.

If the water is unacceptable for consumption, in addition to steps 1-16, also do steps 17 through 19:

17) Do not use the water for drinking and food preparation until water meets drinking water standards. Obtain an alternate safe water supply (i.e., public water supply, bottled water) for drinking purposes until the problems are corrected.
18) Follow steps 8 through 16 above.
19) After the quality problems are corrected, restore the water system to full use and annually follow steps 1 through 7.

Prepared by the Kansas Department of Health and Environment, September 1997, Revised 6/20

APPENDIX D. EVALUATION OF TASTE AND ODOR COMPLAINTS (TROUBLE SHOOTING GUIDE)

Description of Taste / Odor: ______________________________

Source of water: ______________________________

	Circle appropriate parameter			
1. Odor predominates or is only in hot water – suspect water heater[1]	Yes	No	Psbl	NA
2. Chemical(s) storage in pump house or within 200 feet	Yes	No	Psbl	NA
3. Underground petroleum storage or pipelines	Yes	No	Psbl	NA
4. Frost-proof hydrant used to fill chemical spray tank	Yes	No	Psbl	NA
5. Automatic livestock water devices (backsiphonage)	Yes	No	Psbl	NA
6. Other backsiphonage potential ____________	Yes	No	Psbl	NA
7. Foundations treated for termite control within 50 feet of well	Yes	No	Psbl	NA
8. In-line water treatment equipment (softener/filter/other)	Yes	No	Psbl	NA
9. Well is large diameter (greater than 8 inches diameter)[2]	Yes	No	Psbl	NA
10. Abandoned well/cistern/cesspool within 400 ft. of well	Yes	No	Psbl	NA
11. A slimy growth in toilet tank – suspect iron bacteria	Yes	No	Psbl	NA
12. Brownish or reddish staining of plumbing fixtures – suspect iron	Yes	No	Psbl	NA
13. Black staining of plumbing fixtures – suspect manganese	Yes	No	Psbl	NA
14. Oil or iridescence observed on surface[3]	Yes	No	Psbl	NA
15. Groundwater less than 20 feet deep/Spring-like water source	Yes	No	Psbl	NA
16. Well improperly sealed (not water-tight, electrical seal)	Yes	No	Psbl	NA
17. Contamination of well by near-by potential sources	Yes	No	Psbl	NA
Frostproof hydrant(s)	Yes	No	Psbl	NA
Well pit / Sump pump	Yes	No	Psbl	NA
Air-conditioner discharge	Yes	No	Psbl	NA
Roof or surfaced areas	Yes	No	Psbl	NA
Water softener recharge/effluent discharge	Yes	No	Psbl	NA
18. Corrosive or highly mineralized water (evaluate Langlier index, see discussion in Appendix B)				
Total dissolved solids (TDS): greater than 1,000 mg/L	Yes	No	Psbl	NA
Total hardness: greater than 700 mg/L	Yes	No	Psbl	NA
Chlorides: greater than 250 mg/L	Yes	No	Psbl	NA
Sulfates: greater than 500 mg/L	Yes	No	Psbl	NA
Iron: greater than 0.3 mg/L	Yes	No	Psbl	NA
Manganese: greater than 0.05 mg/L	Yes	No	Psbl	NA
Other: ____________________	Yes	No	Psbl	NA
19. Individual detecting problem has recently changed medication?	Yes	No	Psbl	NA

PUT COMMENTS AND OTHER INFORMATION ON A SEPARATE SHEET

[1] Suspect magnesium anodes in water heater. Change anode to aluminum. Removing the anode will shorten the wh life.

[2] Well may contain rotting wood, animal, debris, or other contaminants.

[3] Suspect leak from submersible pump or contamination of well.

Chapter II

WASTEWATER CHARACTERISTICS AND HEALTH CONCERNS

TABLES

INTRODUCTION

Many Kansas residents and rural businesses must rely on individual household wastewater treatment systems called onsite wastewater systems. Adequate household wastewater system standards provide for a safe and sanitary means of treating and dispersing household wastewater. When designed, installed, and maintained properly, many can function well for several decades. A well-functioning system is designed to treat and disperse the wastewater in a way which protects public health and the environment. Onsite wastewater systems must be used where public sewers are not available or feasible.

Wastewater must be managed in such a way that:

- Quality of water for beneficial uses is protected. Beneficial uses include drinking water, recreation, aquatic life support, irrigation and industry.
- A breeding place will not be created for insects, rodents, or other creatures which may come into contact with food and drinking water.
- Wastewater will not create a significant health hazard by being exposed on the ground surface where it is accessible to children or pets.
- State and federal laws and local regulations governing water pollution or wastewater disposal will be met.
- Nuisance conditions or obnoxious odors and unsightliness will be avoided.

This handbook applies to small wastewater systems which are not required to hold a Kansas Water Pollution Control Permit pursuant to State Statute K.S.A. 65-165. The principles contained here apply to year-round households, businesses, seasonal or temporary systems, and recreational area systems. Many of these principles are also applicable to larger wastewater flows. Specific standards and permit requirements for institutional, industrial, or municipal systems can be obtained from the Kansas Department of Health and Environment (KDHE).

WASTEWATER COMPOSITION

Wastewater may be divided into two categories: blackwater and greywater. Blackwater refers to toilet waste and greywater refers to the remaining wastewater from sinks, showers, laundry, and water treatment devices. Refer to Table II-1 for a comparison of the two wastes. Both blackwater and greywater may contain disease causing microbes, nutrients, and hazardous chemicals. The septic tank provides primary treatment for both types of wastewater by settling out the solids and providing space for floating scum to be retained. Relatively clear (but not clean) water is discharged from the septic tank to the absorption field. The soil provides for further treatment when the wastewater percolates through the soil profile.

Table II-1. A Comparison of Greywater with Blackwater

- Greywater is about 70% of the total household flow.
- Greywater is very similar to Blackwater or toilet discharges. There are slight differences; Greywater is stronger in organic matter but weaker in nitrogen and coliform bacteria. Although Greywater carries about 70% of the household phosphorous discharge, the phosphorous concentration is nearly the same.
- Greywater contains significant concentrations of coliform bacteria, therefore, it must be considered to have a potential to be pathogenic.
- Greywater must receive adequate treatment in the same fashion as Blackwater.

J. Howard Duncan, 26 March 1992

Untreated or improperly treated wastewater contains biological contaminants known to cause disease. These contaminants are known as germs or pathogens. Pathogens fall into five main categories: bacteria, viruses, protozoans, fungi, and worms. Most of these pathogens use the fecal/oral route to spread disease. Fecal material, including human wastes, contains pathogens. The usual method of infection requires you to touch the fecal material with your hands and then transfer it to your mouth, either directly or through food and water or touching objects that other people have touched. Pathogens can contaminate water supplies when wastewater is allowed to reach the water table before adequate treatment occurs.

Bacteria

Bacteria are microscopic, single-celled organisms that are typically round (Cocci), rod-shaped (Bacillus), or spiral (Spirochestia). Bacteria may be associated in three different ways. Diplo means two bacteria attached together, strepto means a twisted chain of bacteria, and staphlo refers to a large clump of bacteria. Although a microscope must be used to see bacteria, the damage bacteria can do is very visible. Several diseases have been found to be transmitted primarily by contaminated water such as: Cholera, Typhoid, Salmonella, and Shigella. Cholera causes vomiting, diarrhea, dehydration, and may cause death. Typhoid causes fever, chills, and sometimes causes death. Salmonella causes fever, nausea, vomiting, bloody diarrhea, cramps, but rarely death. Shigella causes fever, nausea, vomiting, and diarrhea. Staphylococcus may cause skin and mucus membrane infections. However, almost any disease can be transmitted by water under the right circumstances.

Virus

Viruses use living cells to reproduce and cause infections. The virus penetrates the cell wall of the host and injects genetic material into the host cell so that the infected cell makes more virus. Viruses are generally smaller than bacteria but they can be more deadly. Diseases caused by viruses include Hepatitis A, a viral infection of the liver which causes nausea, vomiting, diarrhea, skin and urine discoloration, weakness, and sometimes liver damage. Acute gastroenteritis is a viral infection of the intestinal tract which causes fever, nausea, vomiting, diarrhea, and pain. Polio causes inflamation of motor neurons of the spinal cord and brainstem, leading to paralysis, muscular atrophy, deformity, and can result in death.

Fungi

Fungi are non-phytosynthetic living organisms such as yeast and bread mold. They can be single-celled or long, multi-celled branching filaments. Disease caused by fungi include candidiasis which is transmitted by contact with feces or secretions from infected people.

Although they usually cause mild infections, occasionally they may cause ulcers in the intestinal tract or lesions in the kidneys, brain, or other organs.

Protozoans

Protozoans are large (compared to bacteria), single celled animals which may have the ability to move. Diseases caused by protozoa include amoebiasis, giardiasis, and cryptosporidiosis. Amoebiasis causes bloody diarrhea and sometimes death while giardiasis causes diarrhea and severe gas.

Perhaps the best known incidence of sickness caused by a protozoan is Cryptosporidiosis, which is caused by Cryptosporidium. The infection in humans can be divided into two distinctly different diseases depending on the patient's immune status. Both forms have an incubation period of fourteen days. In the immune competent host, the onset is sudden and characterized by watery diarrhea, cramping, abdominal pain, and flatulence. Nausea, vomiting, fever, anorexia, weight loss, myalgia, and malaise may also be present. Symptoms usually begin to subside in five to ten days. In immuno-compromised patients, (cancer, AIDS, elderly, previously diseased), the onset is more gradual, and the symptoms are more severe. Fluid loss may be excessive.

Weight loss may exceed 10 percent of the patient's original body weight. The duration of the illness is indefinite. The deaths are usually in the immuno-compromised host and are usually due to loss of water, loss of nutrition, and the inability of the patient to fight the disease. Few medications are available to fight this disease.

Worms

Worms such as the hook, round, pin, tape, and flatworm may be transmitted by water. In an ancylostomiasis infection, a hookworm penetrates the skin of the feet and travels to the gut where it attaches to the host. Ascariasis, a roundworm, lays eggs in soil contaminated by sewage and then it can be ingested by an individual with dirt on hands or root vegetables that are eaten raw. The worms develop in the intestinal tract, and may attack the lungs, liver, and other organs.

Nitrate

The primary health concern associated with nitrogen is the reduction of nitrate to nitrite in the digestive tract of infants by nitrate-reducing bacteria. Nitrite is readily absorbed into the bloodstream where it combines with the oxygen-carrying hemoglobin to form methomoglobin. Methemoglobin cannot carry oxygen and if the situation is not corrected, the disease can be life threatening. As methemoglobin levels increase, oxygen supply to tissues decreases and the affected individual becomes stressed; characterized as "failure to thrive". This condition may cause spontaneous abortions in women and livestock and low breeding conception. High enough levels will cause those affected to exhibit symptoms of suffocation. This condition is called "methemaglobinemia" or blue baby syndrome in infants because of the blue color that develops around the eyes and mouth. Livestock may also develop this condition.

Infants are particularly susceptible to nitrate poisoning because bacteria capable of converting nitrate to nitrite are abundant in the digestive systems. Infants have little acid in the digestive tract, and depend on nitrate reducing bacteria to help digest food. Generally by six months of age, hydrochloric acid in the baby's stomach increases to a level at which the nitrate reducing bacteria cannot thrive.

When people ingest food and water containing nitrate, the nitrate is readily absorbed from the digestive tract. In older children and adults, nitrate that is ingested and absorbed is normally excreted in urine. The ingestion of nitrates by healthy adults is not known to cause any direct health affects, however, chronic exposure to nitrates is currently being researched.

Chemical Pollutants

Household cleaning products, pesticides, fertilizers, and other petroleum products are used in a variety of ways in homes and businesses. Table II-2 is a partial list of the types of chemicals which may be found in general household use. These chemicals may contain heavy metals or other poisons which may pass through the onsite wastewater system into the environment. Additionally, these chemicals may cause an onsite system to fail. Even a small amount of some chemicals can cause enormous contamination. Just one gallon of gasoline can contaminate one million gallons of drinking water. Chemical pollutants may cause long term health problems or may destroy the environment. Regulations on the use and disposal of many chemicals have become more stringent, however, the average homeowner may be unaware of the dangerous health hazards associated with improper disposal of common household chemicals.

Homeowners and small businesses which use an onsite wastewater system must be informed about chemical use and general maintenance of the system.

Table II-2. Common Household Chemicals

*Medications or **large amounts** of disinfectants and/or other chemicals can disrupt biological processes in septic tanks. Normal household use of cleaning compounds for laundry, dishes, and household fixtures, can be safely put in the septic tank. The use of disinfectants in all loads of laundry and for all household cleaning tasks in not a good idea and is discouraged for use with onsite wastewater system systems. **Leftover and unused portions of household hazardous waste, such as those listed here, should never be put into an onsite system.***

Rug and Upholstery Cleaners	Floor and Furniture Polish
Bleaching Cleaners	Mothballs
Pool Chemicals	Ammonia-based Cleaners
Abrasive Cleaners or Powders	Antifreeze
Transmission Fluids	Brake Fluids
Used Oils	Batteries
Household Batteries	Oven Cleaners
Toilet Cleaners	Photographic Chemicals
Disinfectants	Drain Cleaners
Arsenical Pesticides	Medications
Carbamate Pesticides	Chlorinated Hydrocarbons
Organophosphate Pesticides	Flea Collars and Sprays
Roach and Ant Killers	Rat and Mouse Poisons
Herbicides	Enamel or Oil Based Paints
Latex or Water Based Paints	Rust Paints
Paint Thinners and Turpentine	Furniture Strippers
Wood Preservatives	Wood Stains and Finishes
Plant Nutrients or Fertilizers	House Plant Insecticides
Fungicides	

ENVIRONMENTAL CONCERNS

Failing onsite wastewater systems may allow excess nutrients to reach nearby lakes and streams, promoting excess algae and aquatic weed growth. Algal blooms and abundant weeds make the lake unpleasant visually, interfere with for swimming and boating, and affect water quality for fish and wildlife habitat. As plants die and settle to the bottom to decompose, they use oxygen that fish need to survive. These nutrients can have a devastating affect on recreational uses of the surface waters such as lakes, rivers, and streams. Many of the sport fishes are very intolerant of nutrient rich waters. In addition, when algae blooms occur the public drinking water supply may have severe taste and odor problems.

WATER USE AND CONSERVATION

The most critical aspects of onsite wastewater system operation are the total water use and the patterns of use. Water conservation can significantly reduce the amount of wastewater which must be treated, thereby increasing the useful life of the onsite system. Table II-3 shows basic water conservation options. Water conservation must be a part of any onsite wastewater system from the day of installation in order to protect and prolong the life of the system.

Table II-3. Basic Water Conservation Options

Bathroom	Kitchen	Laundry
• Install a low-flow toilet. New units give a complete flush with 1.6 gallons per flush. But in old toilet tanks, displacing water with bricks or bottles often gives less than a total flush. • Flush toilets less often. • Toilets can be used several times for liquid waste before flushing. • Do not use toilet bowl disinfectants that are placed in the tank or bowl. • Do not flush cigarette butts or unwanted medications down toilet. • Use moderate amounts of white toilet paper. Toilet paper should break down in water but some dyes are difficult for bacteria to decompose. • Take showers; showers use less water than baths. • Install low-flow shower heads, or hand held showers with pause, temperature balance valve controls. • Reduce use of drain cleaners by minimizing amount of waste that goes down the drain. • Turn off the water while brushing teeth or shaving. • Replace leaky faucets.	• Keep a pitcher of drinking water in the refrigerator instead of running the tap to get cool water. • Be conservative with the amount of soap used to get a job done. • Do not use a garbage disposal to dispose of food wastes; instead, use composting or throw them into the trash. • Repair leaky faucets. • Reduce use of drain cleaners by preventing grease and food from going down the drain. • When using drinking water treatment devices, be certain they have a shut-off valve to prevent the system from running continuously when the reservoir is full.	• Select a front-loading washing machine; this uses 40 percent less water. • Wash only full loads and adjust size settings for small loads. • Distribute wash loads evenly throughout the week to keep from overloading the system with large volumes of water. • Be certain washing machine has a filter to remove lint and clean this before each load. • Use liquid no-phosphate laundry detergents.

Simply repairing leaks from a sink or toilet has a significant impact on the total water volume used. Table II-4 shows the volume of water produced by leaking plumbing. Remember that leaks occur 24 hours a day, seven days a week. A steady stream of leaking water becomes quite large in just one day. Table II-5 lists some common, easy to do ways to detect water fixture leaks. Sometimes it makes sense to upgrade the fixture rather than make expensive repairs. Table II-6 shows the flow reduction that is provided by replacing existing fixtures with low volume fixtures. Leaks should be fixed immediately to keep the onsite wastewater system functioning properly.

The homeowner must understand that not only the volume of water used but the pattern of use is important for onsite wastewater system operation. For complete treatment of wastes, the onsite wastewater system needs time to work. If a large volume of water is used in a short period of time, the system may become hydraulically overloaded. Hydraulic overload can cause turbulence and washout of solids, sludge or scum, from the septic tank. If solids enter the drainfield, the life expectancy of the soil absorption system is greatly diminished. Homeowners should modify their water use pattern to achieve a uniform flow, avoid large water use in a short time. From a practical viewpoint, homeowners must learn to stagger dishwashing and loads of laundry to times during the day when other water uses (such as showers) are low.

Table II-4. Common Water Leak Volumes and Repairs

	Faucets	**Toilets**
Problem or Symptom	A slow drip is 15 to 20 gallons per day. A 1/16th inch stream is about 100 gallons per day	Water level too high in the tank causes a continuous trickle down the overflow tube. Water leaks past the flush valve and periodically comes on to refill the tank. Either can lose as much as several hundred gallons per day.
Repair	Replace worn washers or eroded valve seat.	Bend float arm for cutoff at least a half inch below top of the overflow pipe or replace the flapper valve.

Table II-5. Leak Detection

Overall	Shut off all water use and observe water meter 15 to 30 minutes
Toilet Tank	Dye or food coloring in tank should not get to bowl without flushing
Reconciling winter water use by meter or bill records	> 75 gallons per capita day (GPCD) probable leak > 100 GPCD sure leak or wasteful habits

J. Howard Duncan, 26 March 1992

Table II-6. Household Wastewater Flow Generation and Reduction

A reduction of 10 Gallons per Capita Day (GPCD) is readily available. This is about 20 percent of the total sewage generation from a household.	
Toilets	**Conventional Type** 4.6 gallons average flush 3.5 uses per person per day 16 GPCD typical generation **Tank Inserts** 4 gallons average flush 14 GPCD typical generation **Water Saving Type** 1.6 gallons average flush 5.6 GPCD typical generation **Reduction** Total toilet reduction 2 to 10 GPCD or up to 20 percent of daily flow
Showers	**Conventional Head** 25 gallons used every 2.5 days 10 GPCD typical generation **Low Flow Showerhead** 15 gallons used every 2.5 days 6 GPCD typical generation **Reduction** Total shower reduction 4 GPCD or about 8% of daily flow
Laundry	**Top Loader** 37 gallons/load, 10 GPCD **Front Loader** 23 gallons/load, 6 GPCD **Reduction** Total laundry reduction 4 GPCD or about 8% of daily flow
Total Reduction from All Sources up to 18 GPCD or about a third of daily flows	

J. Howard Duncan, 27 March 1992

FAILURE OF ONSITE WASTEWATER SYSTEMS

Two conditions are by far the largest contributors to onsite system failure:

1) excess wastewater flow.
2) inadequate septic tank maintenance resulting in solids carried into the soil absorption system.

In the soil absorption portion of an onsite wastewater system, bacteria and viruses are filtered out by the soil and microscopic organisms that occur naturally in the soil. Nutrients are absorbed by the soil particles or taken up by plants. These processes only work in unsaturated soil that has enough oxygen to keep the aerobic microorganisms active. Soil conditions may be saturated near lakes, streams and wetlands, in areas with seasonal or perched high water tables and poorly drained soils. In these cases, biological breakdown will be incomplete and nutrients will move much greater distances. Ironically, numerous unsewered communities exist around lakes, where saturated conditions are likely to exist. Originally intended as part-time vacation homes, residents may now occupy the homes year round. Full-time use may cause many of these onsite wastewater systems to fail.

As discussed above, water conservation is an important tool for keeping onsite wastewater systems in operation. High water use will disrupt the physical, chemical, and biological processes which are needed to keep an onsite system functioning properly. Public education of homeowners who use onsite wastewater systems is critical to prevent the failure of these systems.

Operation of an onsite wastewater system refers to the daily use of the system. All owners of onsite wastewater systems should practice water conservation. Table II-3 has some practical guidelines to help avoid excess water flow. The homeowner has some control over the quality, quantity, and use patterns of the wastewater.

In more complex systems, operations may include maintaining an uninterrupted power supply and response to an alarm system. Maintenance is the periodic work which must be done to keep the system operating properly. Maintenance includes the repair, replacement, cleaning, and lubrication of all mechanical parts of the system.

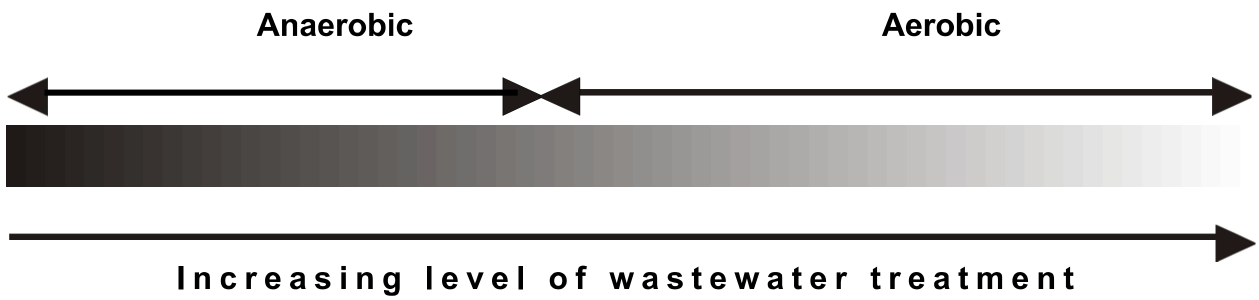
The onsite treatment system must be maintained by the homeowner or a qualified service provider. Even a simple septic tank and absorption field must have maintenance. In the past, these systems were buried and forgotten until problems began to surface. Homeowners must understand that the system must be pumped to remove solids, drain lines must be cleaned to prevent clogging, and the absorption field must be protected from damage and root intrusion.

Lack of simple maintenance is the most common reason for the failure of an onsite system.

MANAGEMENT FOR ONSITE WASTEWATER TREATMENT SYSTEMS

The sections which follow discuss the treatment processes and components which are available to treat wastewater in onsite wastewater systems. These systems may be combined in different ways as indicated by Table II-7. In the past five years, the technology for onsite wastewater systems has exhibited remarkable growth. New technologies and new applications for existing technologies are being developed at a rapid rate. This handbook is designed to provide as much information about the processes and components of an onsite wastewater system as possible, with the understanding that newer equipment and processes will become available. As new technology develops, the operational principles contained in this handbook may be applied to understanding and properly using these newer techniques.

Table II-7. Onsite Wastewater System Combinations and Treatment



Septic Tank	Soil Distribution [1]	
Septic Tank	Enhanced Treatment [2]	Soil [1]
Aeration System with septic tank [3]		Soil [1]
Septic Tank	Mound Including Soil Beneath	
Lagoon		Percolates Through Soil

[1] Soil profile. Site and soil conditions determine what methods of soil distribution will be most effective for a location. In many cases, any of the soil distribution methods may be used for any of the septic tank or septic tank plus enhanced treatment options, including aeration. The mound provides dosed distribution over the soil covered by the mound. At this time, using an aeration system, sand filter, or one of the other media filter enhanced treatment systems, with drip irrigation is recommended. Research is not conclusive about using septic tank or rock-plant filter effluent with drip irrigation.

[2] Enhanced treatment systems include sand filters, other media (peat, foam, textile), rock-plant filters, and aeration systems that use a separate septic tank.

[3] Aeration Systems are of many different designs, some are installed in a septic tank, some have specially designed tanks, and some may not require a tank for physical separation of the sewage. Follow local codes and manufacturer's recommendations.

As the technology for onsite wastewater treatment becomes more complex, the need for management of these onsite wastewater systems becomes more critical. Management includes the operation, maintenance, and monitoring of an onsite wastewater system. For a septic tank and gravity drainfield, the required management may be as simple as practicing water conservation, removing septic tank sludge as needed (usually every 3-5 years), and replacing broken pipes, risers, and caps as needed. However, when an onsite wastewater treatment system components include complex mechanical and/or electrical components such as: pumps, filters, small diameter orifices, or aerators, then the management of the system must be more intensive, frequent, and extensive. Service contracts are highly recommended for these systems.

Chapter III

LEGAL AUTHORITY FOR POLLUTION CONTROL

INTRODUCTION

The Clean Water Act, passed in 1972 by the US Congress, is the backbone of consistent water pollution control law throughout the nation. This Act sets the goal of achieving feasible and swimmable water for all waters of the United States. To accomplish this, the act contains provisions for control of pollution from point sources and nonpoint sources. Implementation of this act is delegated to the US Environmental Protection Agency (EPA). Point sources are regulated by the issuance of permits which establish allowable levels of pollutants that can be discharged into receiving waters. Nonpoint sources are addressed by the establishment of total maximum daily loads which are intended to ensure that the total amount of pollution, including point source and nonpoint source, entering a water body does not result in a violation of established water quality standards.

In Kansas as in most states, implementation of the Clean Water Act is delegated by EPA to the state. This is referred to as “primacy” for program implementation. States that have primacy for the Clean Water Act establish their own laws and regulations and then implements these.

EPA still provides oversight and assures that minimum national standards are met. Kansas Department of Health and Environment (KDHE) is charged with protecting water quality in Kansas.

The authority for pollution control in Kansas is divided between state and local governments, and in many cases it is shared. Whenever authority is shared, the enforcement of local rules and regulations is the preferred method of achieving pollution control. Local authority predominates in the control and regulation of onsite wastewater, nonpoint source pollution, and land use management. Local rules and regulations must be at least as strict as state standards.

A statute is a law enacted by a legislative body. Kansas Statues Annotated (K.S.A.) contains the statutes effective in the state. A regulation is a set of procedures to implement a statute and has the force of law. Kansas Administrative Regulations (K.A.R.) contain the regulations effective in the state. An ordinance is a statute or regulation, typically adopted by a municipal government. A resolution is a formal statement of a decision put before, or adopted, by a governmental assembly. In this chapter the statutory and regulatory authority for control and management of pollution to water within the state is set forth. This will help the local authority better understand and implement the controls for which they are responsible.

Note: Statutes are listed as Chapter; Article; and Section. For example, “K.S.A. 65-159" is section 59 (Abatement of Nuisances, etc.) of article 1 (Secretary of Health and Environment) of chapter 65 (Public health). Regulations or “K.A.R.s” also use a three-part system of numbers divided by hyphens. The first number indicates the agency; the second number indicates the article (a group of regulations of such agency upon the same subject); the last number indicates the specific section or regulation within the article. For example, “28-5-4" refers to agency No. 28 (KDHE); article No. 5 (Sewage and Excreta Disposal) and section No. 4 (Public Health Nuisances)

STATUTORY AUTHORITY OF KDHE

The Kansas Department of Health and Environment (KDHE) publication, January 1997 is available on request from KDHE by calling (785) 291-3092. These statutes are primarily concerned with point source discharges. The following paragraphs contain summary **excerpts of pertinent materials** contained in Kansas Statutes governing domestic wastewater.

CHAPTER 65 - PUBLIC HEALTH

Article 1 - Secretary of Health and Environment, Activities

Article 1 includes the water pollution control and water quality protection objectives for Kansas. Briefly stated these statutes provide that all human or human induced activity shall be carried out in a manner that will not result in impairment of the quality of the state's surface water and groundwater resources.

K.S.A. 65-159. Abatement of nuisances, failure to remove, penalties. This statute outlines the authority that KDHE and the county commissioners or the county board of health have in investigating nuisances, sources of filth and causes of sickness. Whenever these conditions exist on any private property or upon any watercourse, KDHE or the county has the power and authority to order, in writing, that the owner or occupant remove the condition at their expense. If the owner or occupant fails to obey the order, a fine of not less than ten dollars ($10) nor more than one hundred dollars ($100) shall be accessed. Each day's continuance of the condition after the owner or occupant has been notified to remove the condition shall be a separate offense.

Note: This statute clearly establishes the authority of county health boards and/or county commissions to abate pollution conditions within their jurisdictional borders.

K.S.A. 65-164. Sewage: definitions, complaints, investigations, orders, administrative review. This statute states that it is illegal to discharge sewage into any of the waters of the state. Sewage is defined as any waste products from the bodies of human beings or animals; or chemical; or other wastes from domestic, manufacturing, or other forms of industry. It also states that whenever a complaint is received by KDHE from a mayor of any city or by a local health officer of the county, complaining of a polluted condition of any waters of the state it shall be the duty of KDHE to investigate the complaint.

K.S.A. 65-171d. Prevention of Water Pollution; Standards; Permits; Exemption; This statute requires KDHE to establish standards to prevent surface and subsurface water and soil pollution detrimental to health and life of the state; and water quality standards to protect designated uses of the waters of the state. It also directs KDHE to make regulations to control the disposal, discharge or escape of sewage as defined in K.S.A. 65-164. KDHE is allowed to adopt by reference any federal regulation relating to water quality and effluent standards.

This statute defines pollution as contamination of any waters of the state that creates or is likely to create a nuisance or be detrimental to the designated use of the water body or a discharge that exceeds state effluent standards. Pollution applies to both point and nonpoint sources. The statute defines confined animal feeding, animal unit, animal unit capacity, habitable structure, wildlife refuge and defines minimum separation distances from existing habitable structures.

K.S.A. 65-171h. Minimum standards for sanitary water and sewage systems. KDHE is empowered to develop minimum standards of design, construction, and maintenance of sanitary water and sewage systems.

K.S.A. 65-184 through 189f establishes requirements for water supply, wastewater and refuse disposal in areas surrounding certain water impoundments. Also known as the Sanitation Zone Law. This applies to zones surrounding the large, federal reservoirs.

Article 33 - Water Pollution Control

K.S.A. 65-3301 through 3313 establishes the State Water Pollution Control account to provide financial assistance to municipalities, which includes any county, city, sewer district or other public agency, to abate and prevent the pollution of water by constructing water pollution control facilities. This article contains the authority for the development of countywide wastewater management plans and outlines the Kansas Water Pollution Control Revolving Fund.

K.S.A. 65-3321 through 3329 establishes the Kansas Water Pollution Control Revolving Fund that is funded by EPA.

Article 45 - Certification of Operators of Public Drinking Water Supply Systems and Wastewater Treatment Facilities

K.S.A. 65-4501 through 4517 sets forth requirements for operator certification.

Chapter 68 - Roads and Bridges

Article 5 - County and Township Roads

K.S.A. 68-545 County and Township Roads (not administered by KDHE, but relevant) states, in part, that it is unlawful to dump sewage on any highway or any ditch along any highway. This makes it unlawful for sewage to enter the ditch of any public road in the state.

REGULATORY AUTHORITY OF KDHE

The entire set of pertinent regulations can be found in the KDHE document entitled *Article 5, Article 16, Article 18, Water Pollution Control Regulations*, September 1996 and is available upon request from KDHE by calling (785)296-5506.

Agency 28 - KDHE

Article 5 - Sewage and Excreta Disposal

K.A.R. 28-5-1 through 9, sets forth the regulations by which sewage is discharged to the environment from both public and private systems. These regulations were revised effective July 1997 and set forth minimum separation distances of wastewater systems to water wells, direct the discharge of wastewater to a KDHE approved public sewer or a private system approved by KDHE or appropriate local authority that is located, designed, and operated in accordance with standards set forth in KDHE Bulletin 4-2, *Minimum Standards for Design and Construction of Onsite Wastewater Systems*.

The revised regulations contain a statement that if a county sanitary code was adopted before June 30, 1997, the county code would provide the minimum standards. All county codes are reviewed for consistency with existing statutes and regulations prior to KDHE approval. The revisions in Bulletin 4-2 present some requirements that are more stringent than those contained in some county codes that were adopted prior to June 30, 1997. These codes may remain in effect until such time as a provision in the code that is also addressed in Bulletin 4-2 is amended. At that time, the provision must be brought into compliance with the standards set forth in Bulletin 4-2.

Article 16 - Water Pollution Control

Article 16 covers Sewage Discharge Permits; River Basin Water Quality Criteria; Surface Water Quality Standards; Requirements for Water and Wastewater Operator Certification; State Grants to Municipalities; Critical Water Quality Management Areas; Countywide Wastewater Management Plans; and Pretreatment. Pertinent sections are summarized below.

Surface Water Quality Standards. The regulations for surface water quality standards in Kansas are found in **K.A.R. 28-16-28(b) through (f)**. As directed in the federal Clean Water Act, each state must specify appropriate water uses to be achieved and protected. The classification of the waters of a state must take into consideration the use and value of water for public water supplies; protection and propagation of fish, shellfish, and wildlife; recreation in and on the water; agricultural, industrial, and other purposes, including navigation. Each state sets their standards for the beneficial uses that they define with EPA approval. States may not adopt waste transport or waste assimilation as a designated use for any waters of the state.

In designating uses of a water body and the appropriate criteria for those uses, the State must take into consideration the water quality standards of downstream waters and shall ensure that its water quality standards provide for the attainment and maintenance of the water quality standards of downstream waters.

All perennial streams in Kansas have been classified as to their designated uses according to state statutes and regulations as summarized above. Based on these designated uses, certain numeric water quality standards apply. Any discharge into these streams must not, by itself or cumulatively with other discharges, result in a violation of the water quality standards. For example, if a water body is designated for primary contact recreation (swimming or other activity that would easily allow ingestion of water), the fecal coliform count cannot exceed 200 colonies/100 ml. If a nonpoint or point source wastewater discharge will cause that count to be exceeded, it is not allowed and a higher level of treatment must be achieved before discharge of that wastewater.

Point Source Discharge Permitting. Regulations for point sources are found in **K.A.R. through 28a.** Every point source discharge, including municipal and industrial discharges and certain livestock facilities, must have and comply with a permit from KDHE. The permit will state the quality of the effluent allowed to be discharged. These permit limitations are based on the designated use of the receiving water, the water quality standards associated with that use, the stream flow, and the discharge flow.

Note: This provision prohibits onsite wastewater system discharge to the surface. KDHE does not issue discharge permits for individual systems.

Requirements for Certified Operator. K.A.R. 28-16-30 through 36 establish requirements for operator certification. Any wastewater collection and treatment system operating under a permit from KDHE must be operated by a certified wastewater operator.

STATUTORY AUTHORITY TO FORM SEWER BENEFIT DISTRICTS

Chapter 19 - Counties and County Officers

Article 27a - Sewer Districts

These statutes included in Article 27a outline the authority of counties to form sewer districts, designate the Board of County Commissioners as the governing body of the district, define those conditions that can cause a sewer district to be formed (by petition or unsanitary conditions), conditions of the preliminary survey; requirements for public notification, resolution of the district, cost of the project, lateral districts, and maintenance funds.

Also addressed in this article is sewage received from other districts, costs of combined or enlarged districts, disposal works and pumping station costs, joint sewer districts, enlargement of boundaries, annexation, alteration of boundaries, inspections, acceptance of federal aid, public bidding requirements, and uses of expended bond proceeds. Finally, deficits in bond and interest funds, revenue bonds, delinquency in payment, annexation of territory within a city, additional user charges, districts in Sedgwick County, and existing districts are discussed.

Chapter 12 - Cities and Municipalities

Article 5 - Additions, Vacation and Lot Frontage

K.S.A. 12-519 through 537 covers when and how a city can annex a county sewer district, including conditions which permit annexation, petitions, fire district annexation, filing of ordinances, effective dates, severability, annexation of lands located in water districts, use of other funds, and other aspects of the authority of cities to annex land.

LOCAL AUTHORITY OF PARTICULAR IMPORTANCE

K.S.A. 19-101(a) through 101(f) establishes home rule powers; limitations, restrictions and prohibitions; and procedures.

K.S.A. 12-3301 through 3305 describes procedures to be followed to adopt codes by reference in cities and counties.

Note: Article 33 gives counties the authority to adopt KDHE Bulletin 4-2 or the *Environmental Health Handbook* by reference.

K.S.A. 65-3308 through 3313 and **K.A.R. 28-16-76 through 82** establishes the authority for the development of County Wastewater Management Plans. These plans were required to be developed until 1983 when funding through the Construction Grants Program was converted to the State Low Interest Revolving Loan Fund. The plans provide comprehensive countywide management of wastewater to be effective throughout the county. The five required elements of the plans are:

a) City and county cooperation in management of existing point sources of pollution

b) The management of onsite residential wastewater treatment facilities, including septic tanks

c) Industrial waste treatment

d) Procedures for approval of water delivery and wastewater systems for new developing areas

e) Urban storm water runoff

K.S.A. 65-3313 of the act states "No provision of this act shall be deemed mandatory until seventy-five percent or more of the moneys necessary to implement such provisions are certified by the secretary of health and environment to be available from the federal government." These moneys are no longer available, thus the requirement is no longer in place. Even though they are no longer required, development of and adherence to County Wastewater Management plans is still highly recommended when planning for future development.

K.S.A. 19-3701 et. seq. authorizes county commissioners to adopt sanitary codes administered by the local health department or other local agency. Sanitary codes contain rules and regulations designed to minimize or control those environments and environmental conditions that may adversely affect the health and well-being of the public. Such environments and environmental conditions may include, but are not restricted to: sewerage and sewage disposal; water supply; food and food handling; insects and rodents; refuse storage, collection, and disposal; housing, trailers, and trailer courts. Sanitary codes may provide for permits, licenses, or other activities, and fees for these may be adopted. Authority to license septage haulers is also found in this act. County Sanitary Codes may contain provisions that are more restrictive than those required by the state in **K.A.R. 28-5-1 through 9**.

K.S.A. 75-5657 establishes the Environmental Protection Grant Program. This program provides environmental protection grants to local entities for the purpose of developing and implementing environmental protection plans and programs. Program requirements are outlined in **K.A.R. 28-66-1 through 4**.

Statutes governing planning and zoning are found both in Article 29 of Chapter 19 and Article 7 of Chapter 12. In order for a city or county to be zoned, a county comprehensive plan must have been developed, subjected to public review and approval, and adopted by the city council or county commission. Planning commissions, as subsets of these authorities, are responsible for implementation of the plan, subject to the approval of the city or county commissioners. Townships may request zoning within their boundaries if the county does not have countywide zoning, and must also have a planning commission to implement the requirements. No zoning applies to land used exclusively for agriculture.

- **K.S.A. 19-2901 through 2913** covers zoning within designated townships;

- **K.S.A. 19-2914 through 2966** covers zoning in counties;
- **K.S.A. 12-701 through 732** covers city planning and subdivision regulations;
- **K.S.A. 12-741 through 768** covers county planning and subdivision regulations.

Local regulatory controls present the opportunity to protect resources and prevent the development of public health or pollution problems **before they occur.** Ideally, land use planning occurs on a watershed basis. Comprehensive land-use planning guides land use to appropriate areas, reduces suburban sprawl, and inventories and prioritizes natural resources for protection. Protection of natural resources involves soils-based zoning, cluster housing, open space protection, and natural resource inventories. With planning of this nature, areas in watersheds that are not conducive to the use of conventional onsite systems will not be used for these purposes or advanced treatment before discharge to the soil will be required. Factors involved in making these decisions include soil type, slopes, proximity to sensitive water bodies, depth to groundwater, location in a source water protection area, and natural drainage flows.

The current state of land-use planning in Kansas is traditional development oriented, transportation-based planning. Areas suitable for development are identified based upon factors such as accessibility to roads, utility lines, and other infrastructure. Often, the entire community is designated suitable for development with the only differentiation being the particular uses and densities allowed in given areas. Natural resources are seldom factored in, unless they pose an obvious significant barrier, such as in areas of federal or state regulation of wetlands.

Land use management happens at the local level. Water resource programs, or any other natural resource initiatives, can no longer be conducted in isolation from other land use planning issues. The emerging realization of the close relationship of natural resource protection to quality of life and community character is a strong factor arguing for the pursuit of watershed management programs.

The charge for those interested in protection of water resources is not to replace local political boundaries with natural watershed boundaries, but to find creative and effective ways to reconcile the two. This must include cooperation with entities located in the same watershed.

AUTHORITY OVER TOTAL MAXIMUM DAILY LOADS

Like many other states, Kansas is under a court decree to establish Total Maximum Daily Loads, or TMDLs, for the impaired stream segments and lakes of the state. A TMDL is the maximum amount of pollutant which may enter a water body without causing a violation of the water quality standards. As of June 2004, Kansas has completed the first round of establishing TMDLs for all impaired waters within the state to meet the requirements of the court decree.

Since 1972, states have been required to list the water bodies which are impaired by pollutants and establish TMDLs for those water bodies. Listing began in 1992, but it took litigation on the part of environmental groups to bring about TMDL establishment.

Kansas uses its existing data base to examine water quality and further define the impairment issues relative to seasonal trends and flow conditions. The basic goal of the Kansas TMDL process is to reduce over the long run, the frequency of violations of water quality standards. This goal is achieved by assigning responsibility for corrective actions and management practices to the point and nonpoint sources within a given watershed. Kansas TMDLs rely on watershed management as the pathway for water quality improvement, because of the multitude of sources which may contribute to the impairment and recognition of the pervasive impact of runoff on water quality in our streams and lakes.

Using the State's Water Planning Process, the Kansas TMDL program establishes a hierarchy of priority among the TMDLs. The Basin Advisory Committee in each of the 12 planning basins helps the Department set these priorities, which then become incorporated within each basin plan of the Kansas Water Plan. This setting of priority directs the applicable state programs to pollutants and geographic areas of the highest concern. Medium priority TMDLs are relegated to additional data collection. Many medium priority TMDLs are influenced by natural processes which impair water quality making correction of these problems very difficult.

Chapter IV
SITE AND SOIL EVALUATIONS

PROTOCOLS

TABLES

FIGURES

INTRODUCTION

A comprehensive site and soil evaluation is the key component impacting design and long term performance of onsite wastewater systems. A thorough site and soil evaluation requires more than a walk on the site and a quick look at the soil. A complete evaluation includes an understanding of the owner's expectations and knowledge of all the factors that may impact the selection and design of a system. Such factors include soil conditions, slope, zoning restrictions, wetlands, separation distances from structures, wells, and property lines, easements, and rights-of-way. Sites characterized by slowly permeable (tight, low perc rate) soils, shallow soil over rock, high groundwater, poor drainage, or steep slopes are unsuitable for conventional soil absorption systems and may require more elaborate and expensive alternative methods for treatment of wastewater. If design considerations are not comprehensive, the system life is often substantially shortened and the total annual cost rises dramatically.

Poorly drained sites or sites with a high water table may require special surface and/or underground drainage to prevent periodic failures caused by rising groundwater levels or impounded surface drainage. The solution and control of such problems require consideration of the total drainage area and planning. Good designs for problem cases often increases the cost of onsite systems significantly. In some cases, wastewater treatment systems may be prohibited on such sites.

Site specific soil information is available from the Natural Resources Conservation Service (NRCS), K-State Research and Extension, or local Health or Environmental Departments. The site evaluator and designer should take into consideration all sources of site information and supplement that information with onsite investigations.

A thorough site evaluation will locate the area to be used for the onsite wastewater system. A soil evaluation is required to assess the suitability of an area and is used to determine the soil loading rate for effluent so that the required absorption field area can be calculated. The absorption field area and an alternate area for future use should be marked so they will not be disturbed during construction.

SANITARIAN TOOLS

A sanitarian needs a set of tools to do the job properly. Several practicing sanitarians who work with wastewater systems have collaborated to compile a list of useful tools. See Table IV-1 for a list of recommended tools. Sanitarians are encouraged to add items to this list that they find helpful to do their jobs.

The initial investigation of the soil and site conditions for an onsite wastewater system is crucial for identifying what is most suitable for the site. This investigation must thoroughly evaluate the site and soil constraints and determine from among the various onsite systems which are suitable and also meet provisions of the local code. A protocol for this investigation is contained in Protocol One at the end of this chapter.

TABLE IV-1. Suggested Tools for the Sanitarian

1) Heavy steel rod to probe tank and laterals	12) Shovel(s)
2) Soil probe, soil sampler, or soil auger	13) Soil color book (Munsell Color Chart)
3) NRCS county soil survey	14) Water soluble dye (two colors and two forms are recommended)
4) Clinometer or Abney hand level	15) Rope
5) Tape measures (100 and 10-20 foot)	16) Equipment for perc test
6) Hoe and clear acrylic tube with cork	17) Sturdy sealable plastic bags for samples
7) Engineer's level and rod, or laser level	18) Bags for trash collection
8) Rubber gloves	19) First aid kit and disinfectant, tincture of iodine is recommended
9) Work gloves	20) Tool box or other container to hold and carry equipment
10) Squirt bottle and paper towels	21) Camera and log book
11) Heavy sheath knife	

SITE EVALUATION

Selection of the wastewater disposal area must be an integral part of planning prior to home construction. The site evaluation of the property should be conducted before purchase and certainly before beginning construction. Low areas that are likely to be flooded should be avoided. Slopes greater than 20 percent will cause considerable difficulty during construction and are not recommended for onsite systems. Grading and landscaping should be utilized to help minimize soil erosion and allow the diversion of runoff.

Rock outcrops warn of shallow soil and may suggest the probable direction of groundwater flow. Examination of the soil profile on the site should assure that the required four feet of suitable soil is available below the bottom of the absorption area and above any restriction such as bedrock, unsuitable soil, high groundwater table, or perched water table. If four feet is not available beneath the absorption laterals, alternative designs are required. Table IV-2 shows recommendations for system selection based on percolation rate, slope, depth to high water table or bedrock, and depth to impermeable layers.

The area required for the soil absorption system depends on the wastewater flow and the design loading rate. Wastewater flow is a function of the wastewater source and how the source is used. Wastewater flow from homes is estimated by multiplying the number of bedrooms by 150 gallons per day (gpd). The calculation is based on 75 gallons per person, per day, for two people in each bedroom. Thus the design flow is determined for the number of people that can occupy the home for extended periods rather than how many actually live there when the system is installed. Houses frequently experience a change in ownership and occupancy over the life of the onsite wastewater system but if designed properly, the system can handle the maximum occupancy. When calculating wastewater flow, note that a water softener may increase water use by as much as 10 gallons per capita per day or possibly more where water is very hard. The design loading rate is a function of soil conditions and requires considerable information about the soil**.**

Table IV-2. Recommendations for System Selection

Limitation or Site Restriction	Traditional Lateral Field	Wastewater Pond (Lagoon)	Dosed In-ground System	Mound, Pump Dose to Shallow or At-grade	Drip Irrigation
Slope					
> 15%	x[1]	—	x	x[1]	x
5%-15%	x	—	x	x	x
< 5%	x	x	x	x	x
Depth Below Absorption Surface (feet)					
> 6	x	x	x	x	x
2-6	—	x[2]	x	x[3]	x
< 2	—	x[2]	—	x[3]	—
Soil Perc Rate (minutes/inch)					
< 5	—	—	—	x	x
5-30	x	—	x	x	x
30-60	x	—	x	x	x
30-60	x	—	x	x	x
60-120	—	x	x	x	x
> 120	—	x	—	—	x

x *means suitable*

— *means not suitable*

[1] *- limitations during construction may be a significant factor*

[2] *- depth to limitation may be overcome by importing suitable soil to the site and constructing the lagoon in that material*

[3] *- absorption fields receiving septic tank effluent require 4 feet soil depth to limitations. If enhanced treatment is used ahead of the absorption system this may be reduced to 1 foot.*

A thorough soil analysis should be done as part of the site evaluation. The soil evaluation will verify that the soil is suitable for an onsite wastewater system and provide information needed to determine the soil loading rate. If a complete soil analysis is not done as part of the site evaluation, a conservatively low loading rate should be assumed so a large enough area is reserved for the soil absorption field. Having more area than required is not a problem and will probably increase the life of the system

A topographic map of the site is helpful when designing a system. It enables the evaluation of surface water movement and slopes. When the map is to scale, it can be used to locate the area and assure that separation distances are adequate. USGS 7½ Minute Quadrangle maps are a readily available source of general topography information. When a topographic map is not available, more work must be done on the site to gather information about elevation and slopes.

SOIL EVALUATION

The preferred way to evaluate a site for an onsite wastewater system is a thorough investigation of the soil conditions. The soil evaluation includes examining the soil profile, determining soil texture, soil structure, soil consistence, measuring depth and looking for evidence of restrictive conditions. A soil profile usually identifies several soil layers. The properties of each layer are evaluated separately and recorded.

Describing the soil profile is important when evaluating the site for wastewater absorption and treatment capacity for designing an onsite wastewater system. A soil absorption field is normally constructed in naturally occurring soils. Satisfactory soil evaluation depends on how thorough the inspector is and how experienced he or she is with utilizing available resources to make a detailed site evaluation.

To perform a soil profile analysis, an excavator usually opens a pit to expose the soil profile. The soil evaluation should be performed by a trained and qualified person. The evaluator determines the soil horizons (layers), texture, structure, color, consistence, depth, and looks for evidence of a high or perched water table or other restrictions. The soil profile should be examined to a depth of at least 4 feet below the bottom of the absorption field laterals, or at least 6 feet below the natural ground surface.

Because OSHA regulations require shoring for trenches deeper than 5 feet for some soils, it is recommended that the pit be constructed so a person is not required to enter a trench deeper than 5 feet. Soil below 5 feet can be examined from cuttings, observation from a distance, or/and by digging a small hole in the bottom of the pit.

At least three pits should be opened in the area to establish the range of soil characteristics that are present on the site and to determine the best location for the absorption field. Sanitarians or environmental health specialists (usually found at county health or environmental departments) are available to assist in the site and soil evaluations. Some consultants such as engineers, soil scientists, or design/installation contractors, also provide this service.

Soil properties can limit the suitability of soil absorption system use. The USDA, Natural Resources Conservation Service has interpreted the suitability of each of the soil series for septic systems. As shown in Table IV-3, the range of values for each of several properties that cause the soil series to be classified as a slight, moderate, or severe limitation rating for septic systems. Note that site specific soil information is preferred to the County Soil Survey that presents general conditions for an area. After studying Table IV-3, one can better understand why some soil profiles are limited. Later chapters of this handbook describe other soil absorption systems that should aid in overcoming the limiting property

Table IV-3. Soil Limitation Ratings Used by USDA, NRCS for Onsite Suitability

Property	Slight	Moderate	Severe	Restriction or Feature
USDA Texture	------	------	Ice	Permafrost (not found in Kansas)
Flooding	None, Protected	Rare	Common	Flood water inundates site
Depth to Bedrock, (in.)	> 72[1]	40 - 72	< 40[2]	Bedrock, weathered bedrock restricts water movement or reduces treatment capacity
Depth to Cemented Pan, (in.)	> 72	40 - 72	< 40	Reduces water and air movement
Depth to High Water Table,	> 6 (ft below surface)	4 - 6	< 4	Saturated soil, poor aeration anaerobic soil, restrictive movement
Permeability, in./hr layers <24 in.	------	------	> 6.0	Poor filtration of effluent
24 - 60 in. layer	2.0 - 6.0	0.6 - 2.0	< 0.6	Slow Perc Rate, poor drainage
Slope, (percent)	0 - 8	8 - 15	> 15	Difficult to construct and hold in place
Large stones >3 in., (percent by wt)	< 25	5 - 50	> 50	Restricted water and air movement results in reduced treatment capacity

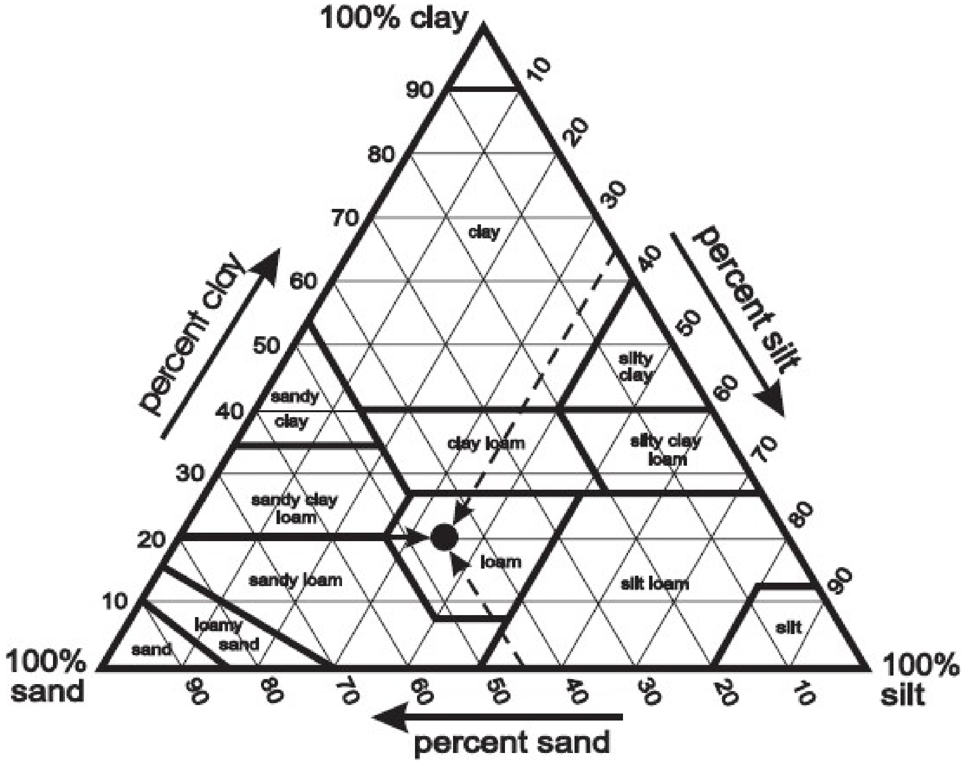
[1] *> means greater than*
[2] *< means less than*
Source: Design Manual - Onsite Wastewater Treatment and Disposal Systems, EPA Technology Transfer, Office of Water Program Operations, 1980.

SOIL CHARACTERISTICS

Soil texture is composed of a mixture of soil particles, including sand, silt, and clay. The textural class is one basis for determining wastewater loading for soil absorption systems. All soil materials fit a specific spot in the soil texture triangle (Figure IV-1). An experienced soil evaluator can accurately estimate the soil texture in the field. A procedure for evaluating soil texture from the soil feel is shown in Protocol Two. Laboratory measurements are relatively inexpensive and can be used to accurately determine the amount of sand, silt, and clay and thus determine the soil texture with laboratory precision.

Soil structure refers to the aggregation of soil particles into clusters of particles, called peds, that are separated by surfaces of weakness. These surfaces of weakness provide planar pores between the peds that are seen as cracks in the soil. Structure often has a marked influence on water and air movement in soil especially in fine textured soils. Therefore, soil structure is the second critical aspect for selecting the design loading rate. A discussion of soil structure is also included in Protocol Two.

Figure IV-1. USDA Soil Textural Triangle



Source: USEPA Onsite Wastewater Treatment Systems Manual, 2002, page 5-19.

Soil consistency describes the cohesion between soil particles and the adhesion of soil to other surfaces and is the third aspect of soil that affects the loading rate. Consistency characteristics of individual soils vary widely according to moisture content of the soil.

Consistency characteristics are described for wet, moist and dry conditions. Moisture content can have a dramatic affect on the action of roots and animals in the soil. Soil consistency characteristics in addition to soil texture and structure may limit the installation of the onsite wastewater system until dry conditions prevail to avoid damage to the soil that would reduce water movement and cause early failure.

When the soil texture, structure, and consistence as well as the wastewater strength are known, the designer is prepared to select a suitable loading rate for soil absorption. Table IV-4 gives the recommended loading rates based on soil texture and structure information for two effluent qualities. These loading rates are based on research showing that soil characteristics and wastewater quality provide a strong basis for wastewater system design loading rate.

Table IV-4. Recommended Design Loading Rat for Various Soil Textures, Structures, and Two Effluent Qualities

Texture	Structure		Hydraulic loading (gal/ft^2-day)	
	Shape	**Grade**	**BOD=150[1]**	**BOD=30[2]**
Coarse sand, sand, loamy coarse sand, loamy sand	Single grain	Structureless	0.8	1.6
Fine sand, very fine sand, loamy very fine sand	Single grain	Structureless	0.4	1.0
Coarse sandy loam, sandy loam	Massive	Structureless	0.2	0.6
	Platy	Weak	0.2	0.5
		Moderate, Strong		
	Prismatic, blocky, granular	Weak	0.5	0.7
		Moderate, Strong	0.6	1.0
Fine sandy loam, very fine sandy loam	Massive	Structureless	0.2	0.5
	Platy	All grades		
	Prismatic, blocky, granular	Weak	0.2	0.6
		Moderate, Strong	0.4	0.8
Loam	Massive	Structureless	0.2	0.5
	Platy	All grades		
	Prismatic, blocky, granular	Weak	0.4	0.6
		Moderate, Strong	0.6	0.8
Silt Loam	Massive	Structureless		0.2
	Platy	All grades		
	Prismatic, blocky, granular	Weak	0.4	0.6
		Moderate, Strong	0.6	0.8
Sandy clay loam, clay loam, silty clay loam	Massive	Structureless		
	Platy	All grades		
	Prismatic, blocky, granular	Weak	0.2	0.3
		Moderate, Strong	0.4	0.6
Sandy clay, silty clay, clay	Massive	Structureless		
	Platy	All grades		
	Prismatic, blocky, granular	Weak		
		Moderate, Strong	0.2	0.3

[1] *typical septic tank effluent BOD concentration*
[2] *typical enhanced (advanced) treatment component effluent*
Source: Adapted from EPA Onsite Wastewater Treatment Systems Manual, page 4-12

Color patterns in the soil are good indicators of the drainage characteristics of the soil. Light brownish, yellowish, or reddish colors are indicative of soils that are well drained and aerated. Bands or mottles of brighter color should be noted, particularly if they are interspersed or underlain by layers of grayish soil. This may indicate a seasonal or perched water table. Grayish colors indicate poorly drained soils. Evidence of seasonal or perched water tables is one of the most important aspects to be determined by the soil evaluation. If any evidence of restrictive conditions are detected in the first 4 feet of soil beneath the trench bottom, the site may not be well suited to a conventional soil absorption system. The designer should then consider other absorption system designs or wastewater stabilization pond that are better suited to restrictive soil conditions.

CRITERIA FOR LOADING RATES

System design shall be based on the most limiting soil texture found in the first 4 feet below the bottom of the proposed absorption system. Once the wastewater flow and the loading rate for the soil are known, the area needed for the absorption system can be calculated. The absorption field and an equal area reserved for future use should be marked and fenced so they will not be disturbed during construction. Required setback distances to property lines, wells, surface water, and buildings must be checked and included in the site plan.

Where evaporation substantially exceeds precipitation, as in central and western Kansas, a reduction in soil absorption area may be acceptable when the soil is well suited to wastewater absorption. A well suited soil has medium to coarse texture, perc rates less than 45 minutes per inch and wastewater loading rates of at least 0.5 gallons per square foot, per day. For marginal, high clay soil that has low loading rates, no reduction should be used, regardless of location in Kansas. Recommended allowable soil absorption system reductions and percent of total absorption area for central and western Kansas is shown on Table IV-5.

Table IV-5. Allowable Absorption Reductions for Dry Climate

	Western Kansas	Central Kansas	Eastern Kansas
Actual Absorption area (percent)	65	80	100
Allowed reduction (percent)	35	20	0

Source: KDHE, Bulletin 4-2 Minimum Standards for Design and Construction of Onsite Wastewater Systems

The soil profile evaluation provides a comprehensive assessment of soil characteristics and is the most accurate method for determining the suitability of the soil to accept and treat wastewater and to establish the design loading rate.

No onsite wastewater system shall be loaded at a rate greater than 1.23 gpd/ft^2, regardless of soil permeability. (Research indicates that the clogging mat which forms at the bottom of the trench has a maximum filtration rate of 5 cm/day or 1.23 gpd/ft^2.) A wastewater flow of 150 gpd/bedroom is assumed.

PERC TEST

The “Perc Test” (short for percolation) is another common method of determining the soil’s ability to accept wastewater. The word percolation means movement through a porous or permeable substance, in this case soil. The perc test really measures an infiltration rate for water into a wet, but unsaturated soil at the depth of expected absorption system placement. Since the driving force is gravity, the movement will be downward.

Permeability, or hydraulic conductivity, as used by soil scientists is a term applied to saturated or water table conditions. All pores are completely filled with water and water would freely flow out to the side. Permeability is measured at a unit gradient for each unit of thickness. Permeability will be greater than percolation because of the saturated conditions. Permeability, however, is usually measured in the laboratory because of the difficulty of creating a saturated condition in the field without a water table.

The perc test was first used for soil absorption system evaluation in New York in the 1920's. It has become widely used as a basis for designing the loading rate, and thus sizing the soil absorption field. This measurement is not a good representation of either the hydraulic conductivity or downward percolation which are measured under different conditions. The test is helpful for sizing soil absorption systems in many soils when combined with other tests.

The primary limitations of the perc test are in soils that shrink and swell with changes in soil moisture and soils that have perched or seasonal high water table. During dry periods, shrink/swell soils can develop wide cracks. A perc test that will reflect wet period conditions is most difficult, if not impossible, when beginning with dry, cracked soil. A seasonal perched water table is not detected by the perc test. However, it can easily be detected in an evaluation of the soil profile. **Because the perc test can lead to bad decisions about a suitable loading with soils that have shrink/swell or seasonal water tables, the preferred method is to establish soil loading rates based on soil evaluation.** When the perc test is used the best approach is to understand the limitations of the perc test and not rely on it alone. The procedure for conducting a perc test is given in Protocol Three.

Once the soil perc rate is known, the loading rate and soil absorption field area are obtained from Table IV-6. The loading rates in Table IV-4 and Table IV-6 may not always agree. The preferred loading rate as given in Table IV-4, is research-based and is more recently developed. Therefore, if a soil evaluation and a perc test should result in two loading rates that do not agree, always use the smaller rate. The use of a lower loading rate provides a larger absorption area and will result in a longer life system with less risk of failure.

Table IV-6. Loading Rate and Absorption Area Recommendations Based on Perc for Septic Tank Effluent

Perc Rate (minutes/inch)	Loading Rate (gpd/ft^2)	Required Absorption Area (ft^2/bedroom)
Less than 5 minutes	Not suitable for conventional soil absorption system[1]	
5 - 10 minutes	0.91	165
11 - 15 minutes	0.79	190
16 - 30 minutes	0.60	250
31 - 45 minutes	0.50	300
46 - 60 minutes	0.45	330
Greater than 60 minutes	Not suitable for conventional soil absorption system[2]	

[1] *Soil is too coarse for conventional soil absorption designs. Use pressure distribution dosing or other alternative system to prevent too rapid infiltration.*

[2] *Soils with these conditions may be acceptable for wastewater ponds or possibly other alternative systems (See Table IV-2). Enhanced treatment of wastewater (see Chapter VI) before delivery to the soil distribution systems may also be suitable.*

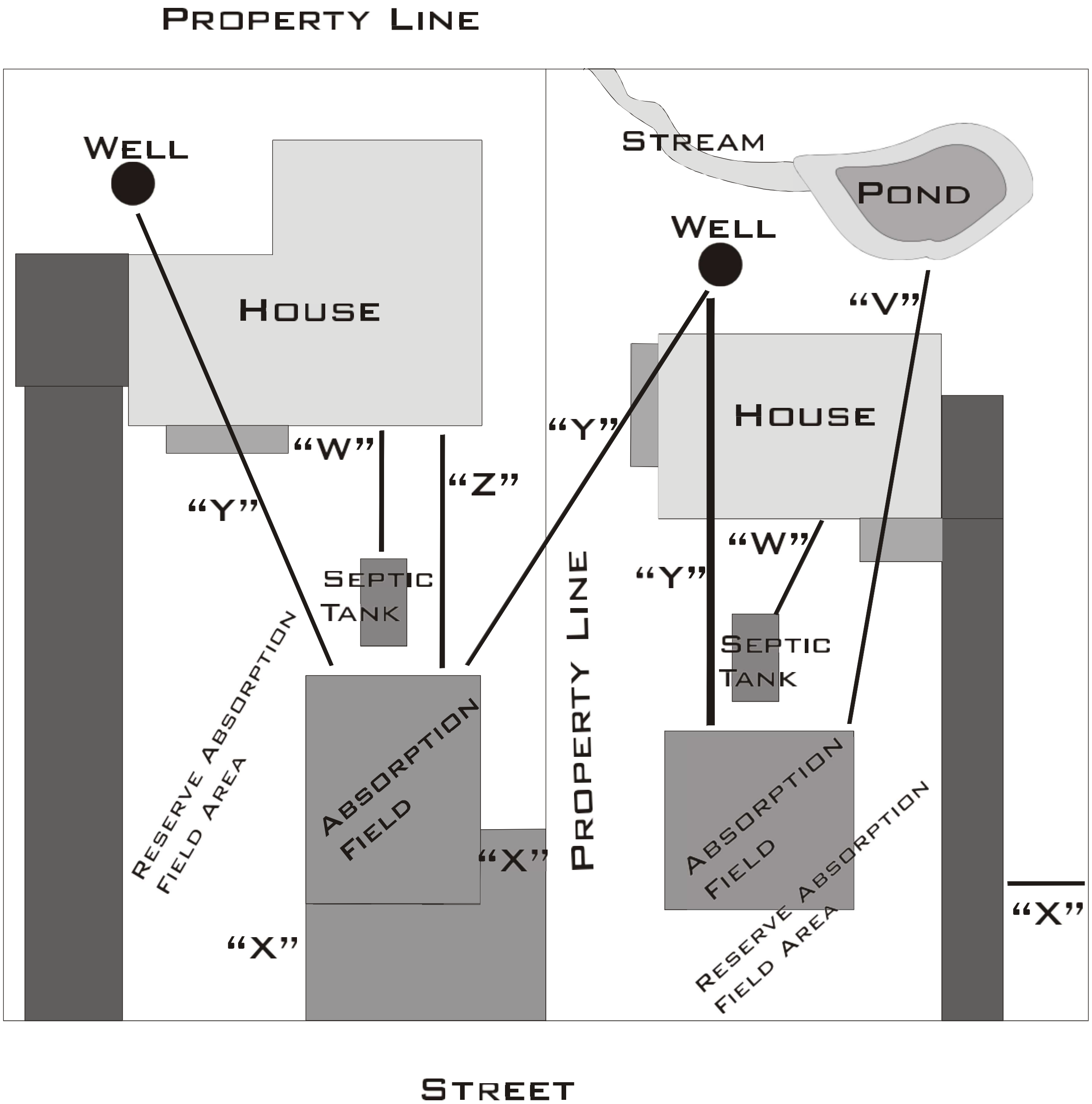
SEPARATION DISTANCES FOR WASTEWATER SYSTEMS

Adequate separation distances must be maintained between onsite wastewater systems and other structures and facilities both on the site and on adjacent property. Separation is required to maintain system performance, to permit repairs, and to reduce undesirable effects of underground wastewater flow and dispersion.

The structures to consider include buildings, property lines, utilities, components of the wastewater treatment and absorption system, and especially wells and surface water. Minimum required and minimum recommended separation distances for onsite wastewater systems are given in Table IV-7.

The optimum time to establish the best location for the septic tank and soil absorption field with respect to structures, utilities, surface water, wells, and other features is when doing the site and soil evaluations. Figure IV-2 depicts an example of site plan showing two adjacent lots with septic tanks, absorption fields, and wells. Separation distances that must be met for the wastewater systems on each lot are shown.

Figure IV-2. Site Plans for Adjacent Lots Showing Onsite Wastewater System Separation Distances



"V" -50' minimum
"W" -10' minimum
"X" -50' minimum

"Y" -Public Well =100' minimum
-Private Well = 50' minimum

"Z" - 20' minimum

In order to meet these separation distances, a lot size of 2 acres is needed.

Table IV-7. Minimum Required and Minimum Recommended Separation Distances for Onsite Wastewater Systems

	Minimum Distance (ft.)	
Separation Distances	**Required**	**Recommended[1]**
Septic Tank to foundation of house or other buildings	10	10
Soil Absorption System to dwelling foundation	20	50
Any part of a wastewater system		
to: public potable water line	25[2]	25
private potable water line	10	25
property line	10	50
public water supply well or suction line	100[3]	200
private water supply well or suction line	50[3]	100
surface water course	50	100
Wastewater Lagoons		
to: property line	50[4]	200
dwelling foundation	50[4]	200

[1] These recommended separation distances reduce the risk of future problems, but they are not a guarantee that problems will not result.
[2] The minimum distance specified by KDHE guidelines for public water supplies.
[3] The minimum distance required by K.A.R. 28-30-8(a).
[4] When lot dimension, topography, or soil condition make maintaining the required 50 feet separation distance impossible, a written variance from the affected property owners shall be obtained from the owner and filed with deed for the property.

DETERMINING THE ABSORPTION FIELD AREA

Only the bottom area of the trench is considered in determining the needed absorption area. The absorption trench width should be 18 to 36 inches, preferably 24 inches. The design flow and loading rate based on the soil evaluation (or perc) are used to calculate the required absorption area (see following example). The total lateral length is determined by dividing the required absorption area by the lateral width. A 1,500 square foot absorption area and three foot wide lateral, as in the example, require 500 feet of lateral. Using a lateral 100 foot long and 3 foot wide, 5 laterals are needed for the 1,500 ft^2 area required. If trenches are two feet wide, then the total lateral length is 750 feet. This is met by either 10 laterals each 75 feet long or 5 laterals each 150 feet long are needed. Other lateral length options could also be used.

An area equal in size to the absorption field used should be reserved for the future expansion and/or replacement of the field. If this area reserved for future use does not have soil properties equally as good as properties on the initial field site used, expansion options may be limited, and any needed absorption system replacement may require an alternative system.

EXAMPLE LOADING RATE CALCULATIONS

This example illustrates how to select a suitable loading rate and how to use the loading rate to size the system with the following wastewater and site characteristics:

- four-bedroom home
- septic tank effluent
- Harney silt loam soil series.
- Light silty clay loam with medium, subangular blocky structure at 17 to 40 inches
- greater than 6 feet to restrictions of rock or perched water table
- perc rate 40 minutes per inch
- trench width 3 feet
- undisturbed soil width between trenches is 6 feet

Wastewater Flow. Size of house (number of bedrooms) × flow rate (gpd) per bedroom = total daily wastewater production. For this example the numbers are

4 bedrooms × 150 gpd/bedroom = 600 gpd

Design Loading rate. From the soil evaluation, Table IV-4 recommends a loading rate of 0.4 gpd/ft^2 and from the perc test using Table IV-6 the loading rate is 0.5 gpd/ft^2.

Use the smaller of these, or 0.4 gpd/ft^2 for the design loading rate.

Note: No loading rate adjustment is used in this example but depending on location an adjustment based on Table IV-5 could be made.

Absorption Area. Wastewater flow divided by the design loading rate equals absorption area or

$$\frac{600 \text{ gpd}}{0.4 \text{ gpd/ft}^2} = \frac{600 \text{ ft}^2}{0.4} = 1{,}500 \text{ ft}^2$$

Trench Length. Absorption area (ft^2) ÷ trench width (ft) = length of lateral trench or

$$\frac{1{,}500 \text{ ft}^2}{3 \text{ feet}} = 500 \text{ feet of lateral trench length}$$

Total Absorption Field Area. To find the total area for the absorption field, include the undisturbed soil medians between trenches (recommended minimum six feet) plus half of the undisturbed median on each side of the absorption area. For this example the total width includes the 5 laterals, 4 medians between laterals, plus half of a median width on each side of the field or

Width = (5 × 3 ft) + (4 × 6 ft) + (2 × 3 ft) = 15 ft + 24 ft + 6 ft = 45 feet.

The total field area is the total width times the lateral length or

45 ft × 100 ft = 4,500 ft^2

REFERENCES AND READING MATERIALS

USEPA *Onsite Wastewater Treatment Systems Manual*, 2002

KDHE *Minimum Standards for Design and Construction of Onsite Wastewater Systems*, Bulletin 4-2, November 1997; K-State Research and Extension MF-2214.

Publications Regarding Site and Soil Investigation – available from K-State Research and Extension except as noted.

Estimating Soil Moisture by Appearance and Feel, G84-690, NebGuide, University of Nebraska, Cooperative Extension.

How to Run a Percolation Test, AG-FO-00583 Minnesota Extension Service, University of Minnesota, accessible on the web at www.extension.umn.edu.

Land Judging and Homesite Evaluation, S-34, April 1994.

Locating On-Site Home Sewage Treatment Systems, FO-00797, December 1993, Minnesota Extension Service, University of Minnesota, accessible on the web at www.extension.umn.edu.

Selecting an Onsite Wastewater or Sptic System, MF-2542, August 2004.

Site and Soil Evaluation for Onsite Wastewater Systems, MF-2645 K-State Research and Extension, Kansas State University.

Publications out of print but available from Extension Biological and Agricultural Engineering, 147 Seaton Hall, Kansas State University, Manhattan, KS 66506 except as noted.

Kinds and Types of Levels, LR-17, Cooperative Extension Service, Kansas State University.

Operating Checking and Caring for Levels, LR-10, Cooperative Extension Service, Kansas State University.

On-Site Domestic Sewage Disposal Handbook, MWPS-24, Midwest Plan Service, Iowa State University, Ames, Iowa.

Using a Level, AF-19, Cooperative Extension Service, Kansas State University.

PROTOCOL
SITE EVALUATION FOR ONSITE WASTEWATER SYSTEMS

GOAL:
Ensure selection of the best onsite wastewater system suited to the site and designed and constructed to prevent contamination of the waters of the state.

POLICY:
Site evaluation of a new onsite wastewater system will be completed at the request of the landowner, contractor, lending agency or other interested party. The evaluation should address the points listed below. A letter summarizing the evaluation report should be provided to all individuals who have legal interest in the evaluation result. When the site has restrictions, the letter shall document reasons and offer reasonable alternatives, if possible. A file of all letters, data, supporting information, and documents shall be maintained.

EVALUATION:

1) The landowner shall complete an application requesting a site evaluation and a permit to construct a wastewater system. This should also include permission for the agency to enter the property as needed to conduct the evaluation .

2) A site visit shall be made by the inspector to examine the proposed location of the system. Available information about existing site conditions should be obtained from county soil survey and other sources before making this visit. The landowner should be present, if possible, as well as other interested parties.

3) The proposed site shall be evaluated for conditions which could limit the onsite wastewater system. Such conditions include, but are not restricted to, wells, property lines, easements, utilities, topography, soil conditions, depth to rock, and depth to ground water.

4) The proposed wastewater system location shall be marked with flags.

5) The systematic soil profile evaluation is highly recommended over perc tests and such evaluation should be conducted and recorded by a qualified person.

   a) The pits to examine the profile shall be within the flagged area. If the site slopes and has a difference in soils, two or more pits may be necessary.

   b) The soil profile examination will verify the soil series and the texture of each horizon.

   c) Soil texture shall be used to determine soil class.

   d) Loading rate (see Table IV-4) will be determined for the most restrictive horizon texture, structure and consistence.

   e) Loading rate and wastewater flow, based on number of bedrooms, will determine the size of soil absorption system.

6) When soil evaluation is not available and not possible, perc tests may be used to determine design loading rate and system area requirements. Refer to Protocol Three.

    a) Perc tests shall be conducted within the flagged area.

    b) Results of such tests shall be utilized to determine the design loading rate (see Table IV-6).

7) If the soils on the site are found to be favorable, the system shall be sized according to currently approved standards.

8) The owner and contractor shall be provided with all the necessary requirements, instructions, and diagrams for construction.

9) A permit to construct shall be provided to the landowner. The permit shall contain the following information:

    a) Time limit for construction. (The landowner must be instructed that delays which will prevent completion by the agreed upon time will require the owner to contact the inspector for an extension.)

    b) It is the owner's responsibility to contact the inspector for an inspection of the system **before** the tank or absorption field is covered or the lagoon is in use or fenced.

10) The inspector shall inspect the construction before the system is covered with soil, to assure compliance with construction requirements. If construction is acceptable, permission shall be given to cover the system. A permit to operate shall be issued at that time.

11) The permit to operate shall state that the regulating agency has the right to inspect the onsite wastewater system at any time deemed necessary to determine compliance with county code.

PROTOCOL
SOIL PROFILE EVALUATION: TEXTURE, STRUCTURE, AND CONSISTENCE

SOIL TEXTURE
Texture is the proportional amount of sand, silt, and clay in a soil. Each horizon may have a texture different from any other. Texture, in combination with soil structure, affects moisture-holding capacity, permeability, capacity to hold and furnish nutrients, tillage operations, bearing capacity, and erosion. The textures of both surface and subsoil layers should be determined. Texture of the underlying material is also important, especially for onsite wastewater systems, and building foundations.

The sand, silt, and clay particles of a soil are defined on the basis of their size. See the size relationship in Figure 1. Sand grains are large enough to be seen – 0.05 to 2.0 mm (0.002 to 0.08 inch) average diameter. They impart a gritty feeling to the soil. Silt particles are 0.002 to 0.05 mm (0.00008 to 0.002 inch) average diameter.

Silty soils feel powdery (like flour) and do not hold together well when wet, though they are more cohesive than sandy soils. Clay particles are the smallest, less than 0.002 (0.00008 inch) across and usually flat. Clay particles are small enough to make the soil sticky when wet or hard when dry. The size ratio of these particles is about 1000:25:1. Gravel is larger than 2.0 mm diameter (0.8 inch). Loam is a mixture of sand, silt, and clay with a minimum and maximum content of each size particle.

The textural triangle shown in Figure 2 indicates the percent sand, silt, and clay for a soil. The terms sand, silt, clay, and loam are used in various combinations to name 12 soil textural classes shown in the figure. For example, one of the classes is loamy sand and another is silty clay. A simpler classification containing five textural groups will be presented here. These five groups are called *coarse, moderately coarse*, *medium moderately fine, and fine.*

Figure 1. Relative Sizes of Sand, Silt, and Clay Particles

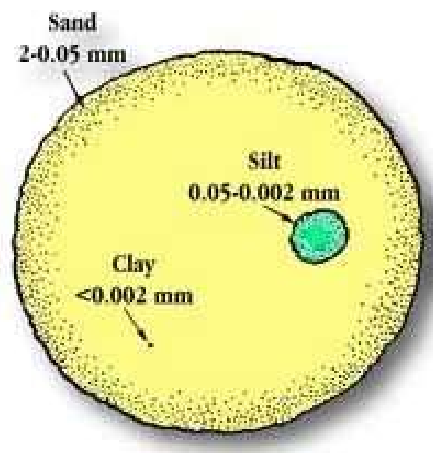
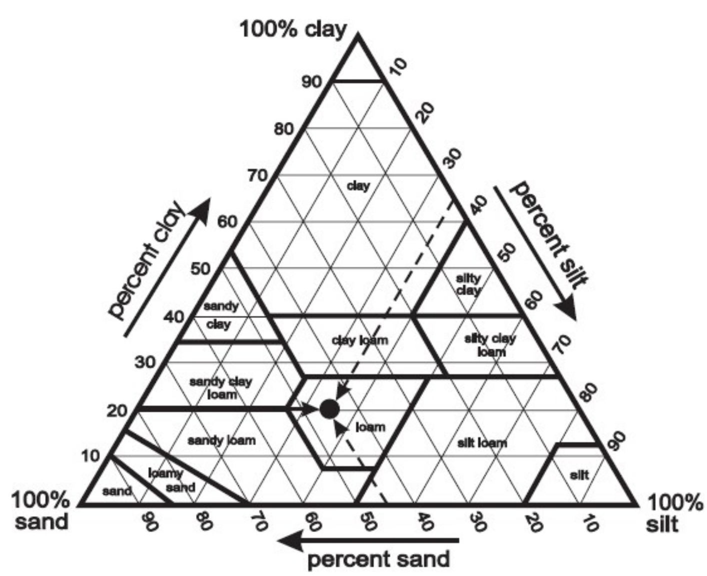


Figure 2. USDA Soil Textural Triangle



Soil texture can be determined by a laboratory procedure or in the field. The field method requires feeling the soil with the fingers. This skill can be developed and perfected with practice. Sanitarians should practice with samples of known texture. A brief description of each of the five textural groups follows:

Coarse-textured soils are loose, friable, and individual grains can be readily seen or felt. When squeezed between thumb and forefinger, the soil feels gritty. If squeezed when dry, it falls apart as pressure is released. If squeezed using moist soil, it is possible to form a mold but it is unstable and crumbles easily as the soil is handled.

Moderately coarse-textured soils are gritty but contain enough silt and clay to make moist soil hold together. The individual sand grains can readily be seen and felt. If squeezed when dry, it forms a mold that breaks readily upon handling. If squeezed when moist, it will form a mold that can be carefully handled without breaking.

Medium-textured soils have a slightly gritty, smooth, or velvety feel when moist. If squeezed when dry, the soil forms a mold that will bear careful handling. The mold formed by squeezing when moist can be handled freely, without breaking. When the moistened soil is squeezed out between thumb and forefinger it makes only a weak ribbon, less than an inch long.

Moderately fine-textured soils usually break into clods or lumps when dry. When the moist soil is squeezed out between thumb and forefinger; it forms a short ribbon, 1 to 2 inches long, that tends to break or bend downward. The soil also may have a slightly gritty or velvety feel when moist.

Fine-textured soils form hard lumps or clods when dry and are plastic and sticky when wet. When the moist soil is squeezed out between thumb and forefinger, it forms a long ribbon, greater than 2 inches, that will support itself. It may also have a slightly gritty or velvety feel when moist.

SOIL STRUCTURE

Soil structure is important in its effect on permeability and land use. Soil structure is individual grains of sand, silt, and clay bound together in larger units called peds. Plant roots, soil, organic matter, and clay particles provide physical and chemical binding agents.

Soil structure is important because it modifies some of the undesirable effects of texture on soil behavior. Structure creates relatively large pores which favor water passage in and through the soil. Moderate and strong soil structure that is small to medium in size means good aeration and favorable balance between pores that transmit air and pores that contain water. Soils with good structure are easy to work and provide an ideal environment for plant root growth.

The shape and arrangement of soil particles into clusters or aggregates determine the type of structure.

Granular structure is of spherical particles, 1 to 10 mm in diameter. The structure is most common in the surface soil, where plant roots, microorganisms, and sticky products of organic matter decomposition bind soil grains into granular aggregates.

Platy structure can occur as a tillage pan or at the bottom of the tillage layer. Platy structure is made of flat pads that lie horizontally in the soil. Most platy structures are less than 3/4 inch thick.

Blocky structures are roughly cube shaped, with more or less flat surfaces. There are two types of blocky structure, angular blocky and subangular blocky. Angular blocky structures have sharp edges and corners. In subangular blocky structure, the edges are rounded. Blocky structures range from ¼ inch to 2 inches across. Blocky structures are typical of the subsoil layer, or B horizon.

Prismatic structures are larger, vertically elongated blocks. Sizes are commonly $^{3}/_{8}$ inch to 4 inches across.

Massive structures are compact, coherent soil, not separated into pads. Massive structures can be found in very slowly permeable soils with high clay.

Single grain structure occurs in some sandy soils where every grain acts independently and there is no binding agent to hold the particles together. You can observe this structural type by carefully observing the soil and gently breaking it apart. It is best to observe soil structure in the undisturbed soil profile. The first step is to fill your hand with a large lump of soil and then gently apply pressure to break the soil apart. The shapes of the pads you broke out of the soil indicate the structural type.

SOIL CONSISTENCE

Consistence describes a soil particles cohesion and adhesion or resistance to deformation or rupture. It is used in soil evaluation for onsite wastewater treatment systems to describe the strength of the soil structural particles. Consistence is highly dependent on the soil-water state (moisture) and the description has little meaning unless the moisture state at the time is specified or is implied by the test. Unless specified otherwise the soil-water state is assumed to be that indicated for the horizon or layer when described.

In the laboratory, procedures and devices have been developed to apply pressures in increments to standardized blocks of soil. Using laboratory procedures results are reasonably reproducible within the range of normal soil variability. Obtaining reproducible measurements of resistance of a soil in the field is difficult and requires considerable practice. A common method has involved using standardized block-like specimens of about 25-30 mm (1 inch) on a side. When blocks of this size cannot readily be obtained smaller sizes can be tested, however, the force withstood may be assumed to decrease as the size of the block is decreased. A block of 10 mm should take a force of only a third of that for a 30 mm block to produce rupture. The block is placed between the thumb and forefinger and pressure is slowly applied gently at first and then greater pressure until the block ruptures.

.

PROTOCOL
CONDUCTING A PERC TEST

PURPOSE:
To obtain information regarding the rate that water moves into fully wet soil.

1) To assess suitability of soil on a specific site to adequately accept septic tank effluent.

2) To select from among alternative onsite wastewater systems and determine a design loading rate.

Note: A soil profile evaluation is required to reveal subsurface restrictive soil and/or rock layers.

BRIEF DESCRIPTION:
Four to six holes are placed throughout the proposed site of the absorption field and soaked with water until the clay is swelled (usually for at least 24 hours). The perc rate is then measured in each hole and reported as the number of minutes it takes for an inch of water to be absorbed by the soil surrounding the hole. To ensure maximum benefits, all available information should be utilized, including history of high water tables and description of soil profiles from county soil surveys. The optimum time to conduct a perc test is in the spring when soil is usually wet.

PROCEDURE:

1) **Select Proposed Site of Lateral Field -** Site preferably should be located downslope from the septic tank. If effluent will not flow by gravity, an effluent pump may be used to move effluent from the septic tank to the absorption field. For new home sites, the area reserved for future use should also be checked for suitability.

2) **Number and Location of Tests -** Four to six holes are placed uniformly over the proposed absorption field site. If the site is sloping, it is especially important to have test holes at all elevations to be used so that the different soils are evaluated.

3) **Type of Test Hole -** Dig or bore the hole to the depth of the proposed trench (usually 18 to 30 inches) and with a diameter of about eight inches. All test holes must be the same dimension to provide consistency in results. Scratch the sides of the hole to eliminate sealed soil surfaces and remove loose material from the hole. Place two inches of washed gravel in the bottom of the hole. The gravel can be contained in a mesh bag for easy removal and reuse at other sites. This gravel protects the bottom of the hole from scouring and sediment when water is introduced.

4) **Allow Time for Soil Saturation and Swelling -** Saturation means that the voids between the soil particles are filled with water. This can happen in a short time for soil in contact with water. Swelling is caused by intrusion of water into the clay particles and can take many hours, or even days, when the soil is quite dry.

    a) Carefully add 12 to 14 inches of water. Using a hose will prevent soil washing down from the sides of the hole.

b) Maintain the water level for at least 24 hours to allow for swelling to occur. In most cases it will be necessary to add water periodically from a reservoir. A float supplied by a hose from a reservoir simplifies the procedure.

c) If the soil appears to be sandy or lacking soil moisture, plan to check the condition of the perc test after 12 hours or overnight. If there is no water left in the hole and the reservoir is dry, refill the reservoir and holes. After the full 24 hours have passed since soaking was initiated, begin measuring as described in below in the Perc Test Measurement Section.

MATERIALS NEEDED TO CONDUCT THE PERC TEST

1) Metal measuring device (yard stick)

2) Four to six batter boards - 1" x 2" boards of 18" length.

3) Number each board so that each test hole will be distinguishable.

4) Mark a center line on each batter board. This will provide a consistent reference point to place the measuring device.

5) Plan of the site, proposed absorption area and location of test area. Dimensions will ensure the test holes are properly located.

6) Supply of water; may have to be transported to the site. 200-300 gallons is usually adequate.

PERC TEST MEASUREMENT

1) Remove the apparatus used to add water to the hole.

2) Place the batter board across the top of each hole and secure with weights, spikes, or attach to stakes. Be sure that the centerline mark is centered over the hole.

3) Align the measuring device with the marks and lower until it just touches the water surface. Record the measurement.

4) Measure at 30-minute intervals until two consistent measurements are recorded. If the water level in the hole drops too rapidly, it will be necessary to reduce the time interval for measurement. The time interval should be short enough that the water level should not fluctuate more than 25 % of the wetted hole depth. For rapid perc rates, the hole must be refilled between each set of measurements. If the holes have been properly soaked for the full 24 hours, consistent measurements are usually found after the first few readings.

Note: If the water drops more than two or three inches in 30 minutes, it will be necessary to add water to the hole after each reading until it is the same depth as recorded initially.

COMPARE PERC WITH PERMEABILITY IN THE NRCS SOIL SURVEY.
The perc should be no greater than about 3 times the permeability rate shown in the table of physical and chemical properties of soils in the soil survey report. If it is higher than this, suspect a problem with the perc test. A well aggregated, undisturbed soil may have a good perc rate.

CALCULATION OF RESULTS

1) Convert fractions to decimals (1 $^{3}/_{16}$" = 1.19")

2) Perc rate is obtained by dividing the number of minutes between readings by the number of inches the water dropped.

3) *EXAMPLE: 30 minutes ÷ 1.19 inches = 25minutes/inch*

4) This test is concluded when three consecutive measurements vary by no more than 10 percent between the high and low value. Average these three numbers.

5) Determine the average perc rate for the site by adding the results of the average from each hole and dividing by the number of holes.

Note: If one reading is much faster or slower than the others, determine if soil is consistent. When there is no apparent explanation such as compaction, cracks in the soil, etc. disregard the different reading and average only the remaining readings.

CHECK LOADING RATE
The design loading rate from the perc test should be checked with the loading rate based on soil texture in Table IV-4.

Note: The size of the absorption field must be designed for the number of bedrooms, not the number of people currently living in the residence. Thus it is important to use the table of absorption area requirements for private residences because different size families may live in the same residence at different times. Refer to Table IV-6 for the minimum square footage of absorption area required based on perc results. In all cases, sufficient area should be provided for at least three bedrooms. The absorption area is figured as trench bottom area only. This table allows for the use of typical water appliances including garbage grinder, automatic washer and dishwasher. If other appliances, such as whirlpool, water softener, filter backwash, and A/C condensate are used and discharge to the septic system, a larger absorption area may be necessary.

Chapter V
SEPTIC TANKS

TABLES

FIGURES

INTRODUCTION

The solids in raw household wastewater will quickly clog all but the most porous gravel formations. To enhance soil absorption, raw wastewater is discharged to a septic tank where solids are retained. A septic tank is a watertight chamber that:

- separates the settleable and floatable solids,
- promotes the growth of anaerobic bacteria necessary to decompose the solids, and
- provides storage for the resulting sludge and scum.

The septic tank reduces the velocity of wastewater and permits the settling of materials heavier than the liquid. Concurrently, scum, grease and other materials lighter than the water float to the top. A vertical section of a properly operating tank would show it divided into three distinct layers; scum at the top, a middle zone of generally clear water relatively free of solids called the "clear space", and a bottom layer of sludge.

Septic tanks are designed to handle all the normal daily flow a household or business produces and should have sufficient capacity for a minimum detention of at least 2-3 times the daily wastewater flow. For this reason, design should be based upon the maximum capacity of a home rather than its number of inhabitants at any particular time. Minimum capacities for septic tanks are shown in Table V-1. The design should allow for the inclusion of laundry and garbage grinder wastes.

It is desirable to install larger tanks whenever possible. Tanks larger than the minimum have the advantage of more solids separation into the scum and sludge layers, and more solids storage. The larger capacity provides less carryover of solids, resulting in prolonged life of the soil absorption unit. Larger tanks also require less frequent cleaning and allow for future expansion of the home, which provides a positive cost-benefit return. Design flow capacity does not allow for roof drainage, other surface water, footing drainage, sump pump, or any other subsurface drainage, so these must be excluded from the system.

Table V-1. Minimum Septic Tank Capacities Based on the Number of Household Bedrooms.

	Septic Tank Capacity (gallons)[2]	
Number of Bedrooms[1]	Minimum	Recommended
3	1,000[3]	1,350
4	1,200	1,800
5	1,500	2,250

[1]*For each additional bedroom add 150 gallons to the recommended value.*
[2]*Volume held by the tank below the liquid level (invert of the outlet pipe).*
[3]*Minimum tank size is 1,000 gal*

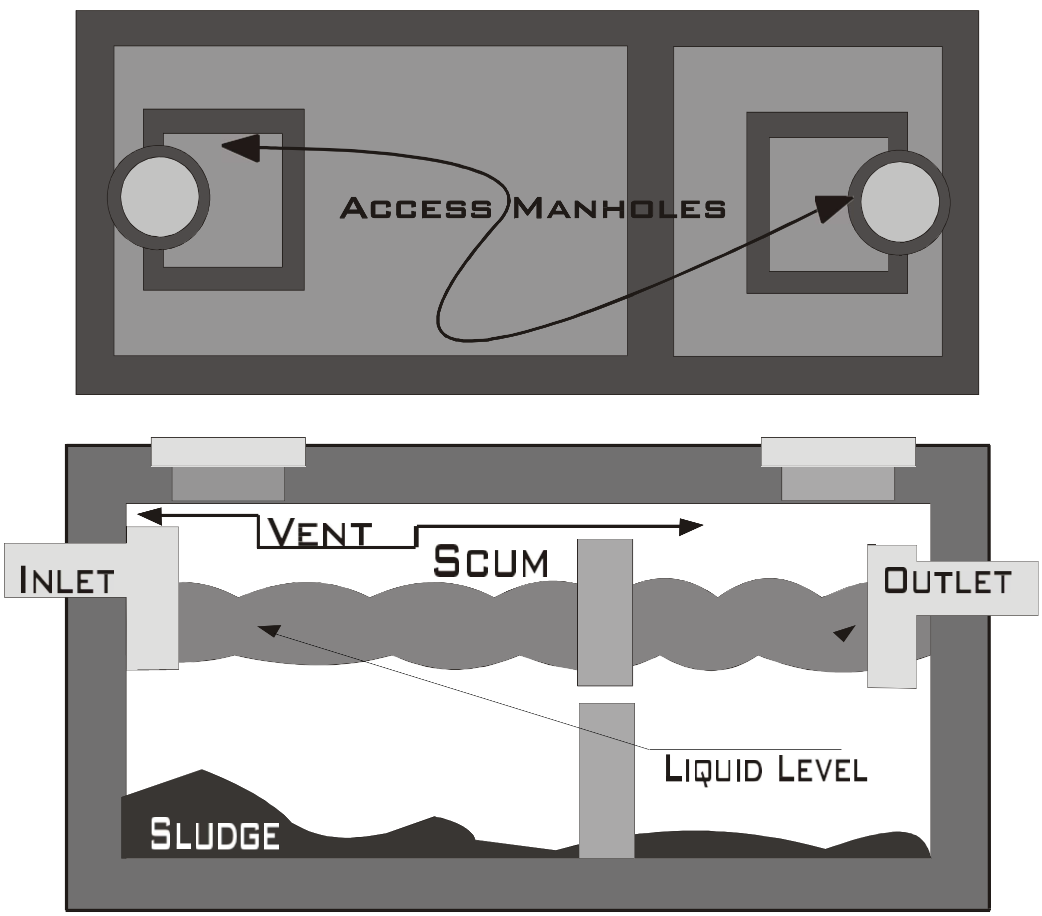
Septic tanks are constructed with baffles or sanitary tees on both the inlet and outlet pipes. Baffles or tees retain floating scum and minimize the disturbance of the settled sludge or floating scum as wastewater enters and leaves the tank. Septic tank design should include provisions for two openings through the top that are large enough for clean out and repair. These should be located to permit easy access to the tank inlet and outlet devices. It is important that the openings themselves are accessible and have covers that exclude water. Section views showing details for a concrete septic tank are in Figure V-1.

TANK MATERIALS AND SHAPES

Three types of materials have proven to be acceptable for long-term use of a tank: concrete, polyethylene plastic, and fiberglass. Although tanks have been made from metal, the corrosive atmosphere and contents cause rapid disintegration. The metal is soon compromised, leaving nothing but a rust-lined underground void, subject to collapse and obviously leaking. Simply stated, metal tanks should never be allowed in a wastewater treatment system.

Figure V-1. A Two Compartment Septic Tank

a. Top View, b. Side Section View



Box-like concrete septic tanks are the most common. Properly reinforced and mixed, concrete forms a pre-cast tank that is strong, durable, stable, and modest in cost. The metal reinforcement used in the sidewalls must be positioned in the form so that the metal is always covered by at least an inch of concrete. If the rebar or wire mesh is exposed, not only is the concrete strength compromised, but the metal deterioration (as discussed previously) further weakens the tank. Any exposed reinforcement is a valid reason to reject that the tank.

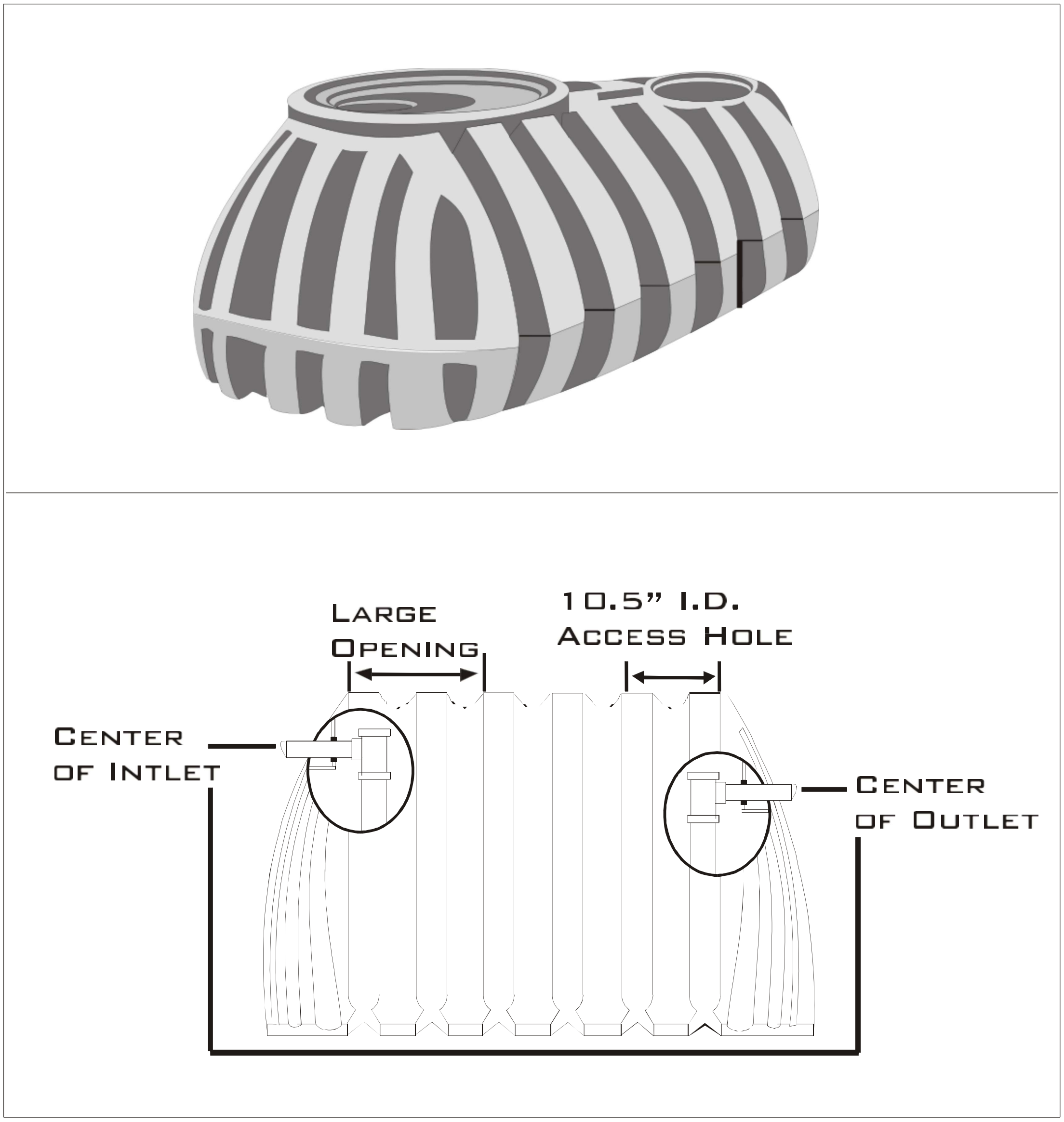
Concrete septic tanks are very heavy, requiring special trucks for transport and placement. If struck or dropped, the concrete may crack. A cracked tank will leak and must be rejected. The tank forms should be filled with a single pour. If the form is partially filled and the concrete hardens before the rest of the fill, a “cold joint” is created. Cold joints are prone to seeping or leaking and are not acceptable in septic tanks. It is a good idea to fill a tank with water and check for leaks before placement in the ground.

A two-piece septic tank with a horizontal joint around the middle (also called a clam shell tank) is designed as two boxes that fit together, rim to rim. One box forms the bottom half and the other box (with the inlet and outlet in opposite ends and the hatch or hatches in the top) is the top half. The bottom half is placed in the excavation, a rubber or asphalt sealer is fitted completely around the rim before the top half is lowered into place on the sealer. This design divides the weight between the two halves, making it easier to handle and position. However, the potential for leakage is great along the seam where the two halves meet. This tank can only be checked for leakage **after** it has been placed. Should leaks be detected, it is necessary to pump out the water and reseal before testing again. Leakage has been a real disadvantage of the two-piece design, and its use has fallen out of favor.

Fiberglass and polyethylene plastic tanks are so similar that both are discussed here as “plastic tanks”. Plastic tanks are manufactured by molding and are usually round or capsule- shaped (horizontal cylinder). Because the entire tank is formed as a single piece, there are no seams to seal, and the material is resistant to impact damage. These tanks’ great advantage as well as their disadvantage, is their light weight. The lightness allows these tanks to be transported in an ordinary pick-up. The tank can be set in place with only a backhoe or hand- carried by a few people. These tanks are life-savers in situations where a heavy truck cannot gain access to place a concrete tank. Figure V-2 shows an example of a polyethylene plastic septic tank.

Due to their lightness, plastic tanks **must** be installed according to the manufacturer’s instructions. This usually involves setting the tank on a carefully leveled and compacted sand or small gravel bed in the bottom of the excavation. Sand or fill is tamped around the tank as it is filled with water. Failure to observe the procedures stipulated by the manufacture can result in a tilted or deformed tank, or one that literally floats out of the ground. Plastic tanks are deeply ribbed for reinforcement and for a better “grip” by the soil. Although plastic tanks are readily available for many uses, only those specifically designed for use as septic tanks can be used for this purpose.

Figure V-2. Example of Polyethylene Plastic Tank



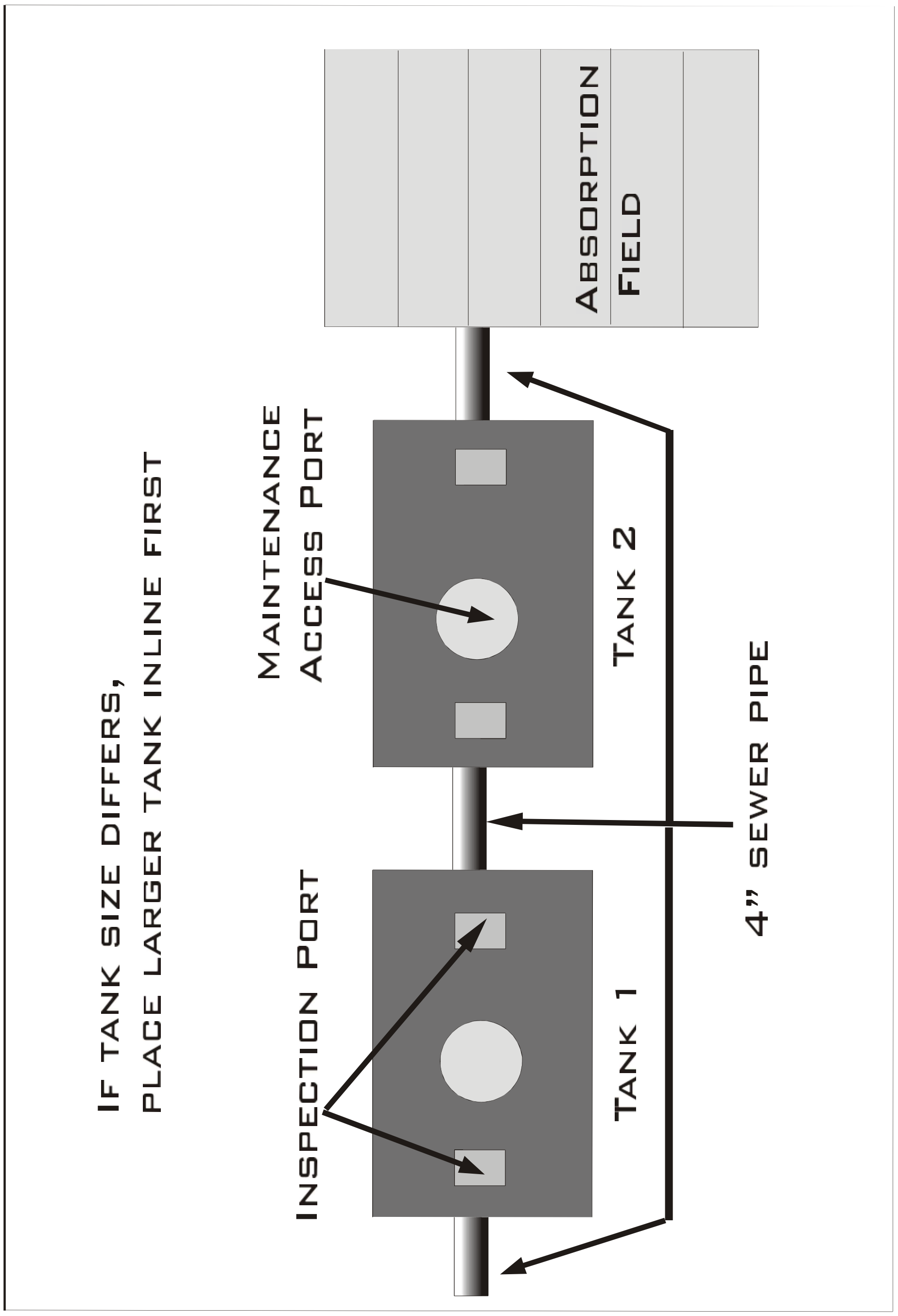
COMPARTMENTED TANKS

Although a single compartment tank can give acceptable performance, research data indicates that multiple compartment tanks perform better because they provide greater protection against solids carryover into the discharge pipe. Multiple compartment tanks have been recommended because of improved effluent quality. Adding a high quality effluent filter to a single compartment tank may provide equal or higher quality effluent than a 2 compartment tank with no effluent filter.

The term "compartmented" as used here, refers to chambers within a tank or tanks placed in series. A number of arrangements are possible. Figure V-1 illustrates a single tank with a watertight partition separating the individual compartments. The first compartment should have a volume of one half to two thirds of the total tank capacity. The total tank capacity must meet the minimum capacities shown in Table V-1 and should be 2-3 times the expected daily flow. Separate units can be linked together, one flowing into another as in Figure V-3.

Figure V-3. Two Septic Tanks In Series

(plan view, not to scale)



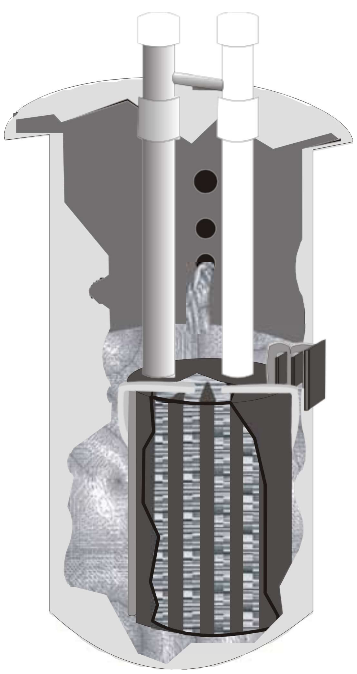
SEPTIC TANK EFFLUENT FILTERS

Septic tank effluent filters, see figure V-4, are usually placed inside a septic tank at the outlet. Effluent filters are effective in reducing the amount of suspended solids and BOD in effluent from the septic tank. These internal filters provide an added measure of protection for the soil absorption field. Effluent filters can reduce the effects of water that surges through the septic tank and also reduce or prevent damage to treatment components that follow the septic tank. Septic tank effluent filters may increase the life of soil absorption systems and their use is highly recommended.

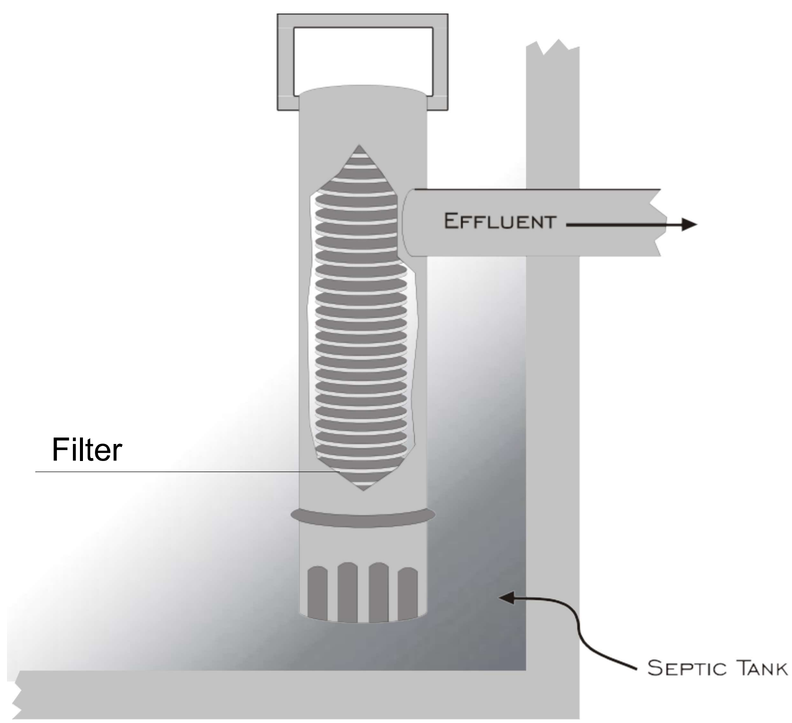
Effluent filters should be cleaned according to the manufacturer's directions. They may be cleaned by the system owner or by a qualified maintenance technician on a periodic schedule. If the filter is not periodically cleaned, it will eventually clog, causing the effluent to back-up into the house and/or overflow the top of the tank. Effluent filters can provide an important safeguard against solids entering the drainfield but they require maintenance. Should the occupants notice water draining slowly, the filter should be checked immediately.

The cleaning process involves removing the effluent filter from the septic tank and spraying the filter clean with a garden hose. To prevent the spread of infectious agents and other pollutants from the tank, all the debris from the filter should be washed back into the tank for removal when the tank is pumped.

Figure V-4. Septic Tank Effluent Filters



Wet well with filter –
can be added into effluent
line from septic tank



SEPTIC TANK LOCATION

The location chosen for a septic tank must consider:

- potential pollution of groundwater and surface water
- protection of a foundation's structural integrity
- protection of the septic tank from damage
- access for maintenance (pumping)
- possible future construction

Septic tanks should be located where they will not cause contamination of any well, spring, or other source of water supply. Underground pollution usually moves in the same direction of the normal groundwater movement in the locality, (i.e. from the area of higher water table to the area of lower water table). In general, the water table follows the contours of the ground surface. However, rock layers, their slope, fractures, and joints may cause dramatic differences in this general rule.

Surface elevations can be deceiving. Pollution from an onsite wastewater system at a lower surface elevation may travel downward into the same water-bearing stratum that supplies a well located uphill. Horizontal and vertical separation distances are critical for the protection of groundwater from septic system effluent. Tanks should never be closer than 50 feet to any source of water and greater distances are preferred, if possible. A 100-foot separation is required if the water source serves a public drinking water system.

Contrary to popular belief, septic tanks do not provide a high degree of bacteria removal. Although the sewage undergoes some treatment as it passes through the tank, this does not mean that infectious agents will be removed. Septic tank effluent is not safe for discharge onto the ground surface or into ditches or watercourses. The liquid discharged from a tank is in some respects, more objectionable than that which goes into a tank; it is septic and malodorous. This, however, does not detract from the value of the tank. As previously explained, the primary purpose of the septic tank is to remove solids and scum from the sewage to prevent clogging of the soil in the absorption field. Further treatment of the effluent, including removal of disease-producing organisms, is accomplished by water movement through the soil. Bacteria are removed as the sewage is filtered by the soil, and bacteria die out quickly in the unfavorable environment of the soil.

The septic tank should not be located closer than 10 feet from any building or within the 100-year flood plain. The tank should not be sited in swampy areas, or in areas subject to flooding. In general, the tank should be located to allow the largest possible area available for the soil absorption system. There must be no permanent cover (patio, building, driveway, etc.) over the tank, lateral, or any other part of an onsite wastewater system. Consideration should also include easy access of trucks and equipment for pumping, maintenance, and repair. To avoid damage to the system, heavy equipment should not have to cross any portion of the wastewater system when servicing the septic tank. In addition, the tank should not be located in an area of any future construction

Minimum separation distances from property lines, foundations, and other objects must be maintained. Required and recommended separation distances are addressed in the previous chapter, Chapter IV, *Site and Soil Evaluations*; see Table IV-7 and Figure IV-3.

Septic tank covers should always be easily accessible. Access ports at the surface are most desirable and must be within 12 inches of final surface grade. If it is not possible to have the tank this shallow, an extension collar or riser should be provided over each opening so the lid is no deeper than 12 inches from the surface. When a riser is necessary, the riser must be installed carefully and must be water tight. All joints and covers on the septic tank must be waterproof to prevent the introduction of surface water or groundwater into the tank.

A sketch of the onsite wastewater system, as constructed, should be made by the inspector and/or contractor and delivered to the regulating agency. This information should be kept on file with the agency and a copy provided to the homeowner. Each access manhole for the septic tank and other system components should be shown on the sketch with reference points and distances to at least two permanent surface objects at cross angles to each other. This process will permit locating the tank for future inspection and maintenance while minimizing disturbances to the landscape.

Both onsite systems serving new facilities and existing onsite wastewater systems at times need to be inspected. Inspection protocols and example forms for new onsite systems and for evaluating existing systems are included in Chapter VII, *Soil Absorption Systems*.

OPERATION OF SEPTIC SYSTEMS

Operation and maintenance of a septic tank system is important. A system that is neglected or misused will have a shortened useful life expectancy. Soil absorption fields must be maintained properly to operate at peak efficiency. When failures occur, immediate repairs are essential to eliminate potential human health hazards and contamination of surface water and drinking water supplies.

Vehicles shall not be allowed to drive over any component of an onsite wastewater system. Vehicles including automobiles, pickups, or other equipment, may cause compaction and /or damage due to settling, shifting, or breakage of septic tank, piping, chambers, or other components. This can lead to sewage surfacing, creating a health hazard. Likewise, vehicles should not be used over any area that is to be or may be used for an onsite system. This includes areas that are intended for system installation in the near future as well as areas designated as reserve for future absorption fields.

Water Use

Water use patterns are the most critical factor in successful onsite wastewater treatment. For complete and uniform treatment of wastes, the onsite wastewater system needs time to work. If a large volume of water is used in a short period of time, the system can become hydraulically overloaded. Hydraulic overload may cause turbulence, washing solids and scum out into the absorption field. Solids and scum carried into the laterals quickly diminishes the life expectancy of the soil absorption system, causing premature failure. Homeowners should spread large water volume activities such as laundry and dishwashing over several days. Water use should be kept as uniform as possible to allow the system the time needed to provide good treatment of the wastes.

The Effects of Water Softener Use on a Wastewater Treatment and Absorption System

A common concern by many homeowners, sanitarians, manufacturers, contractors, and scientists regards the effects of a home water softener on a septic tank and the soil absorption system. Home water softeners are based on the ion exchange principal where sodium on the exchange media replaces the calcium and magnesium hardness minerals in the water. This process gives the softened water a predominant sodium cation. Regeneration requires about 50 gallons and results in a sodium chloride brine flushing the calcium and magnesium from the softener media. Does the sodium in soft water and high salt concentration in the recharge adversely affect any part of the onsite system?

A study at the University of Wisconsin-Madison in 1978-79 confirmed previous government research from 1954. The findings of the earlier research were questioned because they seemed to contradict a large volume of research on irrigation. High sodium water has an undisputed adverse effect on soil structure and permeability especially in high clay soils. It is common knowledge that sodium on clay exchange sites causes some clays to swell, thereby reducing water's ability to seep readily through the soil.

Researchers found that the water softener regeneration brine did not reduce the percolation rate of water in the absorption field of a normally operating septic system. This conclusion was reached because the brine contains sodium, but it also includes significant amounts of calcium and magnesium. The calcium in the brine is thought to act similarly to gypsum, a calcium-rich substance routinely used to increase the porosity of clay soils in agriculture. The research report stated that calcium, therefore, helps counteract any negative effects of the sodium.

The Wisconsin study speculated that if all household water is softened and the softener recharge containing calcium and magnesium is not discharged into the onsite wastewater system, the absorption field soil may be irreversibly damaged by the predominately sodium cations in the household sewage. (Corey and Tyler, 1978)

A second research study by the National Sanitation Foundation (NSF) found that brine wastes had no negative effect on the bacterial population living in the aerobic treatment tank, even when the system was loaded with twice the normal amount of brine. The tests determined that water softener wastes actually help with the treatment processes. The NSF final report states that the wastewater has "a beneficial influence on a septic tank system." In other words, the researchers in this study found that microorganisms living and working in a home aerobic treatment system are not harmed by water softener salts. (NSF, 1978).

As with most scientific research, these two studies answered each of the proposed questions under the specific conditions of the project. It should be recognized that other variables exist that were not included in the studies. For instance, would the results be the same if a conventional anaerobic septic tank had been used in the NSF study? The Wisconsin study examined effects on a normally operating absorption system. Would there be a difference if the system had been installed in a marginal soil or was operating at capacity? The research examined ideal conditions. Water softeners that malfunction or are not used correctly (i.e., timed to regenerate too frequently) have been known to cause problems.

It appears that more research should be done before conclusive statements are made about the effects of water softener regeneration brines on onsite systems. Ion exchange water softeners probably most affect septic systems that may be undersized, or are installed in marginal (clayey) soils. In addition, the hardness of the water is a factor in that very hard water (> 400 ppm) requires more frequent regeneration, with a greater potential for hydraulic overloading.

When there are concerns about a water softener creating septic system problems, an alternative is to soften only the hot water side. This provides soft water for most cleaning chores and the softness of the blended water may be quite satisfactory to the homeowner.

SEPTIC TANK MANAGEMENT AND MAINTENANCE

To slow sludge accumulation and prolong the time between pumping, septic tank users can make some adjustments in waste disposal. Use of garbage grinders is discouraged because they can nearly double the solids accumulation in the septic tank. Anything that is inert or slow to break down should not be put into the onsite wastewater system. See Table V- 2 for a list of things to avoid putting into the septic tank because they do not degrade well and thus increase the need for solids removal. The recent widespread use of antibacterial soaps may have an adverse effect on bacterial action in the septic tank and absorption field. Table V-3 lists common household hazardous materials that should not go into onsite wastewater systems because they are not degraded in the system and thus pose a risk to groundwater pollution.

Table V-2. Inert or Slow to Decompose Items that Should Not Go into a Septic Tank

Kitchen	Bathroom	General
• Coffee Grounds • Excessive Oils or Fats • Bones, Egg Shells • Wet-Strength Towel • Glass • Soil from Produce or Plants • Tough or Stringy Vegetables such as Onion Skins, Celery, Swiss Chard	• Facial Tissue, Q-tips, Cotton Balls • Panty Liners, Tampons, Sanitary Napkins • Dental Floss • Condoms • Disposable Diapers • Hair • Bandages	• Cigarette Filters • Dirt from Soiled Articles (sand, silt, or clay) • Fabric • Cat Litter • Strings and Thread Lint from Washer

Some materials can disrupt biological action in a septic tank. Other compounds are not easily degraded by onsite systems thus they risk contamination of the groundwater. Medications or **large** doses of disinfectants or other chemicals can disrupt biological processes in septic tanks. Normal household use of cleaning compounds for laundry, dishes, and household fixtures, can be safely put in the septic tank. **Leftover and unused portions of hazardous waste should never be put into a septic system.** Large quantities of the materials in Table V-3 should never be put in the onsite wastewater system.

Table V-3. Common Household Hazardous Waste

Rug and Upholstery Cleaners	Floor and Furniture Polish
Bleaching Cleaners	Mothballs
Pool Chemicals	Ammonia-based Cleaners
Abrasive Cleaners or Powders	Antifreeze
Transmission Fluids	Brake Fluids
Used Oils	Batteries
Household Batteries	Oven Cleaners
Toilet Cleaners	Photographic Chemicals
Disinfectants	Drain Cleaners
Arsenical Pesticides	Medications
Carbamate Pesticides	Chlorinated Hydrocarbons
Organophosphate Pesticides	Flea Collars and Sprays
Roach and Ant Killers	Rat and Mouse Poisons
Herbicides	Enamel or Oil Based Paints
Latex or Water Based Paints	Rust Paints
Paint Thinners and Turpentine	Furniture Strippers
Wood Preservatives	Wood Stains and Finishes
Plant Fertilizers – Especially Nitrogen	House Plant Insecticides
Fungicides	

Septic Tank Start-up

The optimum time of year to start operation of a septic system is in late spring or summer. The tank needs to be filled prior to use to check for leaks, allow for settling, and prevent the tank from floating to the surface in the event groundwater collects around the tank. The addition of hot water speeds the start-up process of bacterial action in the tank, especially if it has to be started in the winter.

Septic Tank Maintenance

The purpose of the septic tank is to remove and store solids, preventing them from being carried into the absorption field. A septic tank is designed with storage capacity to gradually accumulate sludge and floating scum, even with the most careful use. If the outlet baffle is damaged or the sludge or scum gets too close to the bottom of the baffle, solids are carried by the effluent into the absorption field, clogging pore spaces in the soil. Clogging soon results in system failure. At this point, the tank must be pumped and irreparable damage to the soil absorption field will likely have occurred. Rather than allowing this costly damage to happen, the homeowner or a qualified technician should inspect the system annually and when needed, have the tank contents pumped to prevent solids from being carried into the soil absorption field. An effluent filter as previously described is effective protection against solids flowing into the absorption field.

Effluent filters should be checked routinely based on the recommendations of the manufacturer and cleaned when necessary. Large capacity filter units probably do not need to be cleaned between tank pumping intervals. The smaller filters need at least annual inspection. In some cases, where the wastewater contains many solids, inspection should occur more frequently.

No additives are needed to begin the bacterial action in a tank. Sewage contains a very high concentration of bacteria, billions per ounce, and those best adapted will multiply in the system. The tank could be seeded with septage from another tank with similar conditions but this is not necessary.

There have been many products marketed that are supposed to “clean” a septic tank or help it function better. These materials have a wide range of properties. Some actually can harm the system by causing an increase in particle buoyancy or sludge bulking and carryover to the absorption field, which accelerates clogging. Another type of product contains solvents that dissolve oil and grease, the scum layer. Solvents are not degraded in the absorption field. Thus, they can contaminate the groundwater. No unbiased tests have shown substantial benefits of additives to the total system. Natural bacteria in domestic wastewater will begin the digestion process automatically as solids start to build up in the tank. Commercial “seeding” products are available to start the breakdown process, but they are not necessary. The homeowner or septic tank user should be advised, **do not use septic tank additives**.

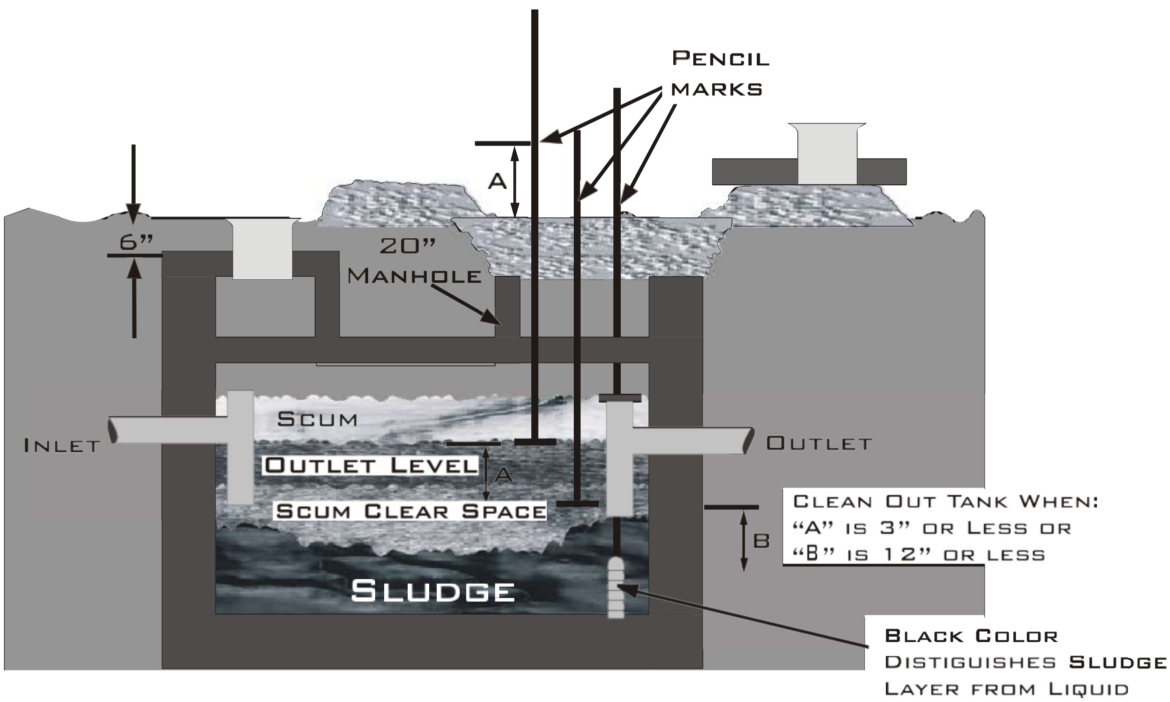
Tank Inspection

Two things are measured when inspecting the tank: scum thickness and sludge depth. Figure V-5 shows the process of measuring the sludge and scum layers in a full septic tank. The sludge is quite liquid and the height of solids are detectable only by attachment of a very rough surface, like terry cloth wrapping, or by removing a column of water in a tube.

The sludge and scum should be checked in the first compartment and when pumping is needed, all chambers should be pumped, cleaned, and more fully examined for structural defects. The condition of the tank and baffles should be investigated in each chamber of a multi- compartment tank or series of tanks.

The condition of the tank's interior is best evaluated when it is empty, but scratching the reachable sides with a metal rod can give an indication of softened or corroded concrete even in a full tank. The condition of the baffles should be examined while the tank is open for inspection. Any apparent damage should be repaired immediately. This damage occurs most commonly in the air space above the liquid level where hydrogen sulfide gas combines with moisture, forming sulfuric acid. The acid attacks and degrades the concrete.

Figure V-5. Measuring Sludge and Scum in a Septic Tank



Septic Tank Pumpers

The condition of the piping, tank, and baffles should be checked at the time the tank is pumped. Occasionally, frost heave or differential settlement will move the house sewer line where it enters or leaves the tank, causing a crack or break in the pipe or joint. When this occurs in the influent line, solids may accumulate at the break, causing a clog that backs up sewage into the house.

The manhole, not the inspection port at the inlet or outlet end, should be used for pumping so that harm to the inlet or outlet baffles does not occur. All tank compartments are to be pumped. An approved septage hauler's fee should include pumping, inspection of the tank, and the proper disposal of septage. The inlet and outlet baffles shall also be carefully checked to assure that they are in good condition when the tank is pumped.

The septic tank should NOT be scrubbed, or disinfected before it is used again, however, most pumpers will rinse out the tank to get a good look at the inside of the tank. A few inches of liquid (not sludge) may be left in the tank. The homeowner is advised to immediately refill the tank to reduce the risk of the tank floating. This is an acceptable time to do several loads of laundry or conduct other activities involving high indoor water use.

Septage Disposal

Septage is considered a public health hazard because of the many disease-causing organisms it may contain. Only companies or individuals approved by the county may engage in the pumping or cleaning of septic tanks or the transport of sewage. The county code should address certification of septic tank pumpers and the proper dispose of the septage. Disposal of septage shall be of in compliance with the US Environmental Protection Agency (EPA) Part 503 regulations. Approved septage haulers know how to manage septic tank waste. The homeowner should be informed about his/her responsibility to make sure that septic tank pumpage, or septage, is properly handled. He/she may be held liable for the improper disposal of household wastewater.

Septic Tank Abandonment

When a septic tank is discontinued from use, the tank must be removed or filled. The tank should be pumped completely to remove all solids and liquid. The best approach is to remove the tank at this point to avoid any potential future problems with later construction. If the tank will not be removed, it should be collapsed and the hole filled in. If not collapsed, the tank may be perforated with several holes drilled in the bottom of the tank. The tank should then be filled with stable fill material such as gravel, sand or other inert non-settling material. This avoids the danger of the tank collapsing later. Inlet and outlet pipes should be plugged at this time.

SEPTIC TANK SAFETY

Excavations for septic tanks can create a safety hazard. Experience shows that depths as shallow as five feet below ground level have resulted in injury and loss of life. The installer is responsible for assuring that working conditions on the site are not hazardous to workers or the public. An excavation deeper than 5 feet cannot be entered unless OSHA standards for the entry are met. Children, animals, and non-authorized personnel should be excluded from the work site. One should never use electrical lights, appliances, or tools in or close to the water or wet ground near the septic tank or drainfield because this can result in explosion or electrical shock.

Because the liquid and solid contents of the septic system are capable of causing infectious diseases, it is important to always wash hands thoroughly after working on any part of the septic system, and before eating, drinking, or smoking. Work clothes should be changed before entering a house, food store, or restaurant, etc. Smoking should be avoided near septic tank openings because combustible gases may be present.

SEPTIC TANK DESIGN STANDARDS

General Requirements

Required of all septic tanks, regardless of the construction material:

1) A recommended minimum liquid depth of three feet (distance from outlet invert to bottom of tank), but shall not exceed six feet. The effective inside length of rectangular tanks must not be less than 1.5 or greater than 4 times the effective inside width.

2) The tank, including all extensions to the surface, must be water tight and constructed of durable material that is not subject to excessive corrosion, decay, frost damage, or cracking. Steel septic tanks have a short life because of corrosion and are not acceptable. The top of all tanks shall be designed and constructed to support a minimum of 400 pounds per square foot (lbs/sq ft). When buried more than 2 feet deep, the top shall support an additional 100 lbs/sq ft. for each foot of soil or portion thereof in excess of 2 feet.

3) The openings of the tank (or top of the riser) should be at the surface and shall be no more than 12 inches below the finished grade. It shall be large enough for inspection, maintenance, and clean-out purposes. The opening or manhole shall be a minimum of 20 inches on the shortest dimension. Where the top of the tank must be more than 12 inches below finished grade, an extension collar shall be attached to bring the top within 12 inches of the surface. All below grade attachments to the tank, connections, riser, extensions and lid shall be water tight. When any opening larger than 8 inches extends to the surface, that opening shall be child and tamper resistant. Some examples include lids that weigh at least 65 pounds, or locks and anchors that are not removable without special tools.

4) There shall be a one inch clearance between the underside of the top of the tank and the top of all baffles and partitions or other adequate openings, to permit venting of gas from the tank through the house stack vent.

5) Space above the liquid line is required for that portion of the scum floating on the liquid. For tanks having straight, vertical sides, the distance between the top of the tank and the outlet invert should be at least 15 percent of the liquid depth, with a minimum of 7 inches. In horizontal cylindrical tanks, an area equal to approximately 12.5 percent of the total volume should be provided above the liquid level. This condition is met if the liquid depth (distance from outlet invert to bottom of tank) is equal to 85 percent of the diameter of the tank.

6) Sewage lines carrying solids from the source to the tank should have sufficient slope to maintain velocities that carry solids. For household lines, a slope of between 1 percent ($^1/_8$ inch per foot) and 2 percent ($^1/_4$ inch per foot) is generally considered essential. The last 15 feet of sewer line preceding the tank shall not slope more than 2 percent ($^1/_4$ inch per foot).

7) The invert of the inlet pipe shall be located at least three inches above the invert of the outlet when the tank is level. This space allows for momentary rise in liquid level during discharges to the tank. Liquid standing in the sewer line between the house and the septic tank causes solids accumulation and may cause stoppage or backup, and should be avoided.

8) The septic tank inlet shall be a sanitary tee, elbow, or long sweep elbow with a low head inlet or baffle to direct incoming sewage downward and prevent flow from disturbing the floating scum layer. It should extend at least 8 inches below the liquid level, but should not penetrate deeper than 20 percent of the liquid depth.

9) The length of the outlet device is important in that it must allow only clear effluent to leave the tank. It extends below the floating scum in the tank and ends above the sludge accumulation. If the length of the outlet "T" is improperly sized, the tank will require more frequent pumping to prevent scum from being carried out or sludge solids from being washed out with the effluent. The outlet device should generally extend below the liquid surface to a distance equal to 35 percent of the liquid depth. For horizontal or cylindrical tanks this distance should be reduced to 30 percent of liquid depth.

10) The dividing baffle in two-compartment tanks shall extend from the bottom of the tank to at least six inches above the liquid line. The openings in the dividing baffle may be any shape but must have a minimum dimension of two inches and a total area of at least 12 square inches. The opening is to be centered in the baffle and at a point equal to 35 percent of the total liquid depth (30 percent liquid depth for cylindrical tanks) from the water level.

11) Septic tanks shall have an access manhole (a minimum 20 inch dimension) for each compartment. If the manhole does not extend to surface grade, a small diameter (at least 2-inch diameter) pipe shall extend to surface from the cover to mark the location of the manhole. This pipe shall not penetrate the lid of the tank. Inspection risers at least 6 inches in diameter (large enough to easily remove and replace the effluent filter) shall extend to surface grade, centered over the inlet and outlet tees. All below grade attachments to the tank, connections, riser extensions, and lid shall be water tight. When any opening larger than 8 inches extends to the surface, that opening shall be child and tamper resistant. Examples include lids weighing at least 65 pounds and locks, or anchors that are not removable without special tools.

12) The sewer line from the house to the tank, all fittings and pipe in the tank, all extensions to the surface from the top of the tank and the first 10 feet exiting the tank shall be schedule 40 pipe or heavier. Septic tanks shall be designed for at least a 20-year life. They shall be designed and constructed to withstand extremes in loads resulting from adverse conditions without excessive deflection, deforming, creep, cracking, or breaking. Change in shape shall be limited to 5 percent. Loads shall be based on 62.4 pounds per cubic foot for water and water-saturated soil. Top loads for design shall be 400 pounds per square foot plus 2,500 pound axle point load. Design shall be based on a 2 foot placement depth to top of the tank. If the tank will be placed deeper than 2 feet or subject

to vehicular traffic over the tank, a design by a Kansas licensed structural engineer shall be done for the specific conditions.

13) Refer to Table V-1 for minimum septic tank capacities

Special Considerations for Concrete Tanks

The anaerobic environment of a septic tank produces gases that combine with moisture to produce acids. Concrete above the liquid level is subject to corrosion and deterioration from these acids. This corrosion is best resisted by high quality concrete mix. Concrete septic tanks shall meet the following requirements, in addition to those above:

1) The concrete design mix shall have a compressive strength of at least 4,000 pounds per square inch at a 28 day cure. The water-cement ratio shall not exceed 0.45.

2) Baffles or other interior concrete units must be cast or built into the tank wall at the time the tank is constructed.

3) Air entrainment additives shall be added to 5 percent volume. Other chemical mixtures are encouraged to reduce water content, improve cement placement in forms, and for wet handling of incompletely cured concrete.

4) Concrete tanks and lids shall receive proper care during the hydration (hardening) period by: 1) monitoring and controlling temperature of the concrete and gradients (i.e. maintain 50-90 degrees Fahrenheit for conventional cure and up to 140 degrees Fahrenheit under low pressure steam cure) and 2) monitoring and controlling humidity to prevent adverse moisture loss from fresh concrete (i.e. prevent or replenish loss of essential moisture during the early, relatively rapid stage of hydration).

5) Reinforcing steel shall be placed as designed by a Kansas licensed structural engineer to ensure floor, wall, and top do not crack from moisture, frost, soil load, water loads, axle loads, or other stresses. Loads as specified above shall be used for the design condition. Reinforcing steel shall be covered by a minimum of 1 inch of concrete and shall be placed within ± $^{1}/_{4}$ inch.

6) Pouring the floor and walls of the septic tank at the same time (monolithic pour) is the preferred construction procedure. Very large tanks are often cast in 2 pieces and assembled in the field. All tanks shall meet the same structural strength standard as specified earlier. Two-piece tanks shall have permanently sealed, structurally sound joints and shall be water tested after assembly. A Kansas licensed structural engineer shall determine if the tank meets the strength specification.

7) In areas of high sulfate water (greater than 250 mg/L) more acid producing gases are likely and additional corrosion resistance is appropriate. Recommended measures include ASTM C150 Type II cement (moderate sulfate resisting), ASTM C150 Type V cement (highly sulfate resisting), or coating interior concrete surfaces above the water line. Coatings that provide additional protection of the concrete include asphalt, coal tar, or epoxy. The product used should be acid resistant and provide a moisture barrier coating

for the concrete. The product must not bleed into the water, risking groundwater contamination.

8) Manufacturers are strongly urged to follow guidelines and meet the standards of the American Concrete Institute, National Precast Concrete Association, and American Society for Testing and Materials. Manufacturers should identify and advertise their products which meet these applicable standards.

Special Considerations for Fiberglass and Plastic Tanks

1) All tanks shall be sold and delivered by the manufacturer, completely assembled.

2) Tanks shall be structurally sound and support external forces as specified above when empty and internal forces when full. Tanks shall not deform or creep, resulting in deflection more than 5 percent in shape due to the loads imposed.

3) Tanks, all below grade fittings, and connections including inlet and outlet pipe and risers shall be watertight.

SEPTIC TANK PLACEMENT SPECIFICATIONS

1) The vehicle setting the tank must not enter the absorption field area during the process of placing the tank, as heavy traffic compacts the soil.

2) Where natural soil is not suitable, tanks shall be placed on a bed of at least 4 inches of sand, pea gravel, or crushed granular noncorrosive material for proper leveling and bearing. Material shall be no larger than 2 inches in diameter and bed depth shall be at least four times the diameter of the largest material.

3) Access manholes should be at surface grade, but shall not be more than 12 inches below surface grade. Where the top of the tank must be more than 12 inches below surface grade, a watertight collar and extension riser shall be added as necessary to raise the cover. Inspection openings placed over inlet and outlet tees or baffles shall be at least 6 inches in diameter and extend to the surface. This simplifies locating the tank and makes it easy to inspect and clean the effluent filter, check the condition of tees or baffles, and measure sludge accumulation.

4) Septic tanks should not be placed into the water table (including perched or seasonal water table) because of the tendency of the tank to float. This is especially of concern when the tank is empty after being pumped; the displaced volume of the tank has a buoyant effect. Septic tanks should not be completely emptied if groundwater levels are significantly higher than the bottom of the tank. For existing tanks in any area subject to high water table or seasonally high water table, replacement tanks of plastic and fiberglass shall not be used unless precautions are taken to drain groundwater.

5) Septic tanks shall be watertight. An adequate test for this is to fill the tank with water and let it stand for 8 hours to allow concrete to absorb water and for plastic tanks to adjust. The tank is than topped off and an initial measurement is made with a hook gauge with Vernier scale, followed by another measurement an hour later. Any water loss

shows water leakage and the tank should be rejected. Observations of the outside of the tank can also give clues about leakage losses. Any trickle, ooze, or exterior wet spot is reason to reject the tank. Precast, one-piece tanks are best tested at the plant before delivery. Two-piece tanks that are assembled on-site must be tested following placement but before back filling.

6) The hole for the tank shall provide ample space around the tank that allows access for proper compaction. Backfill should surround the tank in uniform, compacted layers not exceeding 2 feet thick. Care must be taken during the installation and backfilling of fiberglass and plastic units to prevent damage to the tanks. The manufacturer's installation instructions must be followed, and usually includes filling the tank with water as it is backfilled. If the natural soil does not crumble easily, these tanks should be backfilled with sand. Medium to small-grained granular materials are the best fill around the tank's ribbing to provide consistent support. Because of potential soil collapse, it is unsafe and can be illegal for a person to enter a trench deeper than 5 feet without adequate shoring. Compaction should be done from the surface without entering trenches deeper than 5 feet.

7) Special care must be taken in bedding the house sewer, septic tank, and outlet line to prevent uneven settlement, resulting in cracked or ruptured pipe at the point where the inlet and outlet lines connect with the septic tank. Shorter pipe lengths at the inlet and outlet also help to minimize this problem.

REFERENCES AND ADDITIONAL READING

Corey, R.B., and E.J. Tyler. *Effects of Water Softeners on the Permeability of Septic Tank Soil Absorption Fields*, Champaign, Illinois, 1978.

National Small Flows Clearinghouse, Pipeline Quarterly, *Softener Use Raises Questions for System Owners*, Winter 2001, Volume 12, Number 1.

National Sanitation Foundation. *The Effect of Water Softener Waste Regeneration Brines on Individual Aerobic Treatment Plants*, July 1978.

National Small Flows Clearinghouse, Pipeline Quarterly, *Septic Tank Enhancements*, Fall 2003, Volume 14, Number 4.

Publications Regarding Basic Pretreatment – Available from K-State Research and Extension

Septic Tank Maintenance: A Key to Longer Septic System Life, MF-947

Why Do Onsite Wastewater (Septic) Systems Fail? MF-946

Publications Out of Print but Available from Extension Biological and Agricultural Engineering, 147 Seaton Hall, Kansas State University, Manhattan, Kansas 66506.

Household Product Disposal Guide, MF-965

Chapter VI
ENHANCED/ADVANCED TREATMENT

TABLES

FIGURES

INTRODUCTION

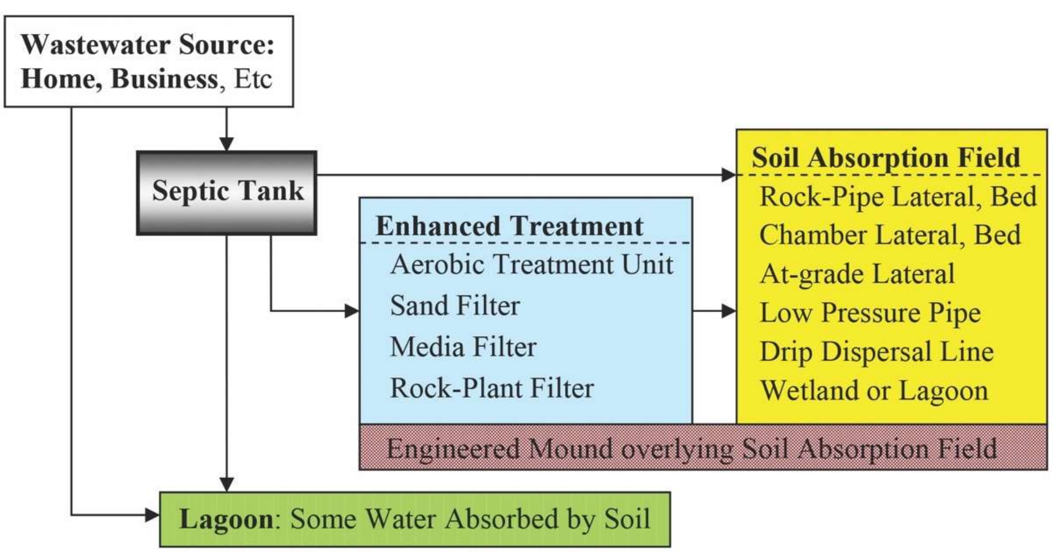
When suitable for the site and soil conditions, a traditional septic tank and soil absorption field is the ideal onsite wastewater system choice because of low cost, simplicity, no energy requirement, and low maintenance. Site limitations such as small lot, poor soil, high or perched groundwater, shallow soil depth to rock, or topography, may mean a traditional system is not a good or suitable choice. Other options include enhanced/advanced treatment; absorption field alternatives like pump-dosed, low pressure pipe or drip dispersal; lagoon; and off-site treatment.

Enhanced or advanced treatment units further treat the wastewater before it is discharged to the soil absorption field for final treatment. These components reduce the total suspended solids (TSS), biochemical oxygen demand (BOD), and stabilize the wastewater, and some also reduce nutrients. Treatment occurs by supplying oxygen to aerobic bacteria, which grow either in suspension or attached to a substrate. These bacteria consume dissolved and suspended organic wastes. Suspended growth is achieved by injecting air into the wastewater to mix and supply oxygen. Attached bacteria grow on a structure whether submerged, bathed, or dipped in wastewater.

Components that provide enhanced or advanced wastewater treatment are among those often termed "alternative systems." Alternative systems include aerobic treatment units (ATUs), sand filters, mounds, rock-plant filters, or other media such as peat, plastic foam, or textile that support attached bacteria growth. Alternative systems also include pump systems that distribute effluent to the absorption field through drip lines or low pressure pipe network.

Figure VI-1 illustrates where enhanced treatment fits with conventional onsite treatment components. Most absorption field options can be used with any alternative system or with septic tank effluent when it provides adequate treatment for the site and soil conditions. However, three alternative systems (engineered mound, unlined sand filter, and unlined wetland) are hybrids accomplishing both treatment and absorption.

Figure VI-1. How Enhanced Treatment Options Relate to Other Onsite Treatment and Soil Absorption Components



Enhanced treatment provides much of the wastewater treatment that normally occurs in the soil absorption field. An enhanced/advanced treatment unit ahead of the absorption field substantially increases the options for field design and a reduced organic load (BOD) may allow a smaller field. An enhanced treatment system completes much of the treatment before the wastewater is delivered to the soil absorption field. Effluent from an enhanced treatment component is still sewage, has considerable bacteria, and therefore, is not suitable for surface discharge. Surface discharge from any onsite system is illegal in Kansas so use of an appropriate absorption field is a viable option.

AEROBIC TREATMENT UNITS (ATUS)

Like other enhanced treatment options, aerobic treatment units (ATUs) depend on aerobic bacteria that require oxygen to decompose organic material in wastewater. Aerobic treatment typically produces a substantially higher quality effluent than is produced by a septic tank alone. ATU systems are frequently used with drip systems but this may be because many equipment distributors market both products and not because of any requirements. Sand filters and other media filters are equally appropriate with drip systems. The effluent from many rock-plant filters may not consistently be clean enough for use with drip systems.

ATUs are available in several different designs from numerous manufacturers. By design, an ATU may follow the septic tank or incorporate a “trash” tank to function as a septic tank. Figure VI-2 shows the typical configuration of two types of aerated tanks. The most common ATU design uses three chambers or tanks to treat sewage. The first chamber functions like a septic tank to remove solids and scum. Air is pumped in the second chamber to supply oxygen and mix the contents. Aerobic bacteria decompose the organic material producing an effluent much lower in biochemical oxygen demand (BOD). The final chamber slows the flow of the water so solids settle before the clarified effluent exits the tank. Some of these units also use a filter to retain solids in the tank and thus further improve effluent quality. ATUs without three chambers typically use a filter system to remove solids before effluent exits the unit.

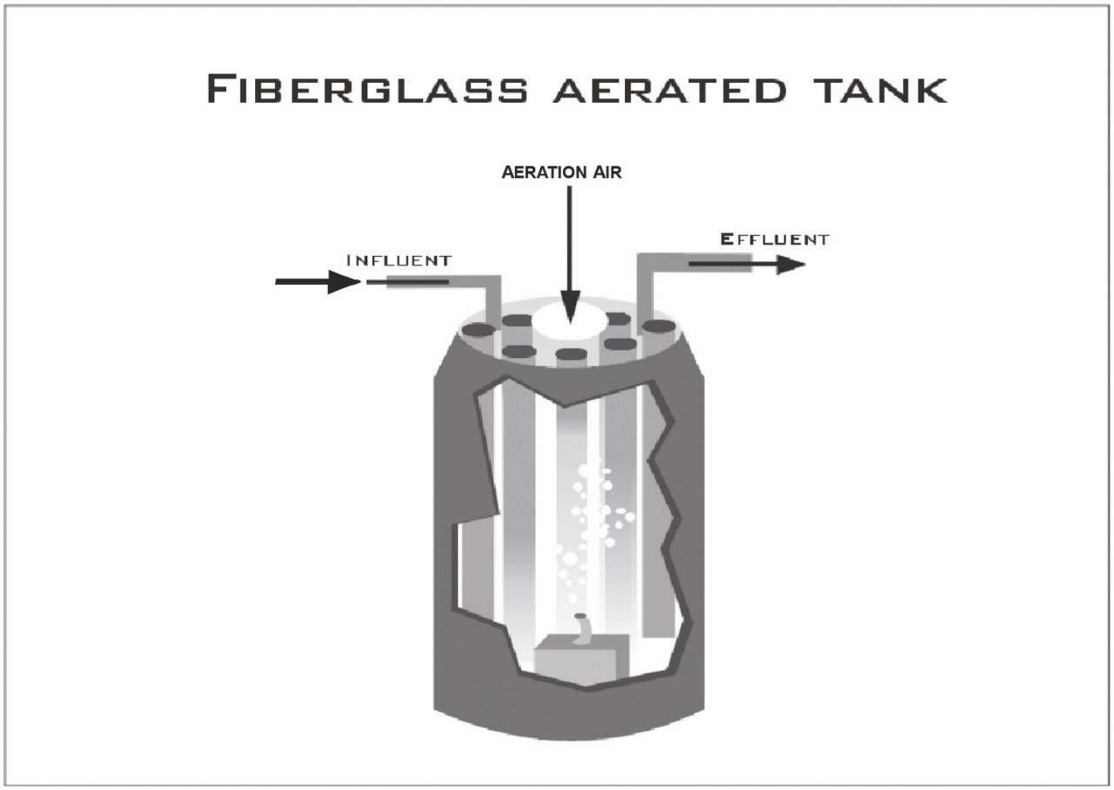
NSF International and ANSI have adopted Standard 40 for Residential Wastewater Treatment Systems. NSF and Baylor University have established testing protocols to evaluate the performance of ATUs. NSF Class 1 designation means that under a range of operating conditions representative of individual homes (including stress loading and interrupted use), the unit produced an effluent that averaged 25 mg/l or less of BOD and total suspended solids (TSS).

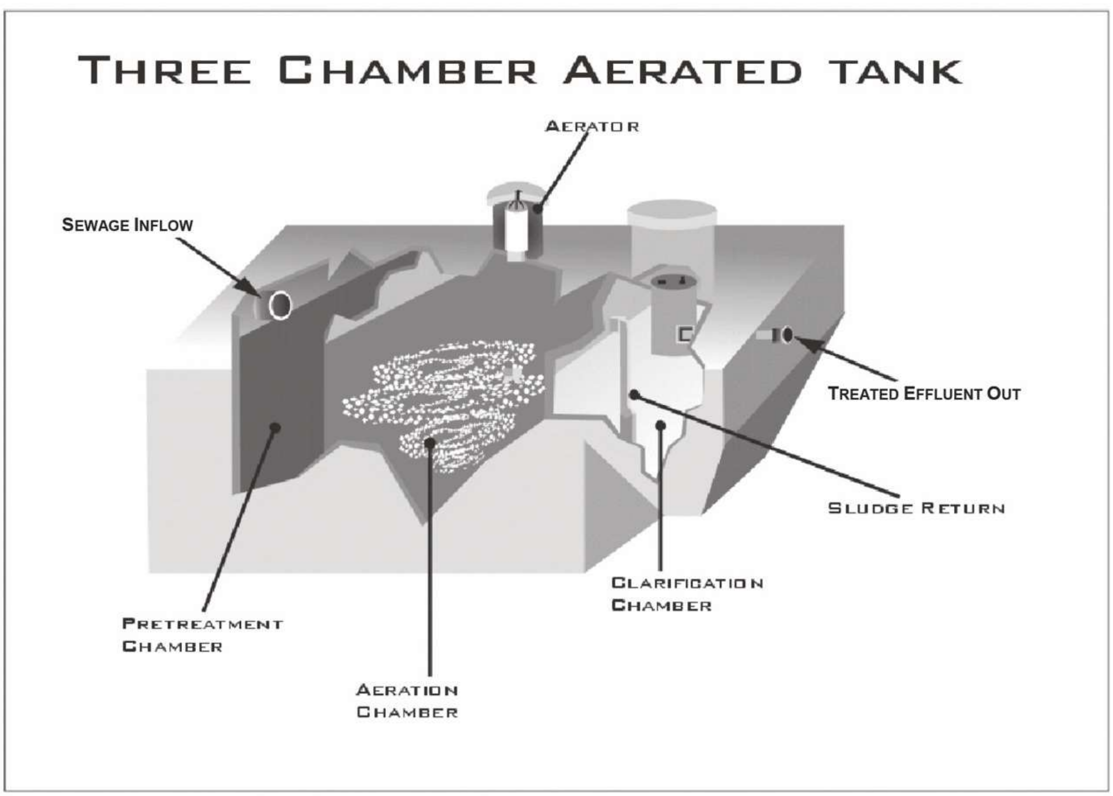
Maintenance for the first 2 years of operation must be provided by the manufacturer’s representative. Because of uncertainty of treatment results, only manufacturer’s models meeting Standard 40 as shown on the NSF web site at <www.nsf.org> are recommended. About 30 manufacturers market Class 1 units that meet this standard.

ATU DESIGN

ATUs are designed to handle a specific volume of flow and strength of wastewater. Aerated tanks are intended to treat typical domestic wastewater. High strength wastewater with a high BOD and/or TSS loading requires a special design. A typical average unit is designed to treat up to 500 gallons of wastewater per day. When the wastewater flow is more than 500 gpd, then a larger unit, a second unit, or special design features may be required.

Figure VI-2. Common Styles of Aerobic Treatment Units





The aerobic unit may provide a high level of treatment to remove BOD and TSS, however, the effluent requires further treatment to destroy or deactivate pathogens. The unit may be followed by any of the soil absorption fields shown in Figure VI-1. Soil absorption systems provide further treatment of the waste to destroy pathogens and in some cases, remove nutrients. Research has shown that because of changes in conditions small aerated tanks used for single-family residences do not produce consistent water quality. Surface discharge from these units is not legal in Kansas.

ATU Performance Evaluation

A well designed and maintained ATU produces an effluent which is much lower in BOD. This means that much less treatment is required in the soil absorption field. Additionally, aerobic treatment of organic material does not produce the odors characteristic of anaerobic treatment in the septic tank. With plenty of aeration, ammonia is oxidized to nitrite and then nitrate.

Microorganisms (or microbes) are responsible for the decomposition, as summarized in Table VI-1. For treatment to be successful, an environment must be maintained in the aerobic system that allows these microbes to thrive. Total suspended solids (TSS) removal by an ATU depends to a large degree on the design as well as operating conditions.

Table VI-1. Microbial Processes in Aerobic Treatment

Biochemical Oxygen Demand (BOD) Decomposition

$$\text{Organic Matter} + \text{Oxygen} + \text{Nutrients} \text{ -----}^{\text{microorganisms}}\text{-----> } O_2 + NH_3 + C_5H_7O_2 \text{ (new cells)}$$

Microbial Decomposition

$$C_5H_7O_2 \text{ (microbial cells)} + 5O_2 + N \text{ -----}^{\text{microorganisms}}\text{-----> } 5CO_2 + 2H_2O + NH_3 + \text{energy}$$

Nitrification – Conversion of Ammonia to Nitrite and Nitrate

$$2NH_3 + 3O_2 \text{ -----}^{\text{microorganisms}}\text{-----> } 2NO_2 + 2H + 2H_2O$$

$$2NO_2 + O_2 \text{ -----}^{\text{microorganisms}}\text{-----> } 2NO_3$$

Table VI-2 compares the average concentrations of septic tank effluent (the wastewater quality entering the ATU), ATU effluent, and two different sand filter effluents following different pretreatment systems. This data is based on typical household sewage treated in an aerated tank that receives regular maintenance and is operating properly.

Table VI-2. Performance Comparison of Effluent Water Quality for Septic Tank, ATU, and Sand Filters Following a Septic Tank and ATU System

Parameter	Septic Tank	Septic Tank and ATU	Septic Tank and Sand Filter[a]	Septic Tank, ATU, and Sand Filter[b]
BOD_5* (mg/L)	123	26	9	2-4
TSS (mg/L)	48	48	6-9	9-11
Ammonia-N (mg/L)	19.2	0.4	0.8-1.1	0.3
Nitrate-N (mg/L)	0.3	33.8	19.6-20.4	36.8
Orthophosphate (mg/L)	8.7	28.1	6.7-7.1	22.6
Fecal Coliform (#/100mL)	5.9×10^5	1.9×10^4	$(0.5\text{-}0.8) \times 10^3$	1.3×10^3
Total Coliform (#/100mL)	9.0×10^5	1.5×10^5	1.3×10^3	1.3×10^4

* Biochemical Oxygen Demand (5-day)
[a]Receiving septic tank effluent dosed at 5gpd/ft²; [b]Receiving aerobic tank effluent dosed at 3.5gpd/ft²
Source: Adapted from Kellam, Boardman, Hagedorn, and Reneau, *Evaluation of the Performance of Five Aerated Package Treatment Systems*, Bulletin 178, 1993, Virginia Water Resources Research Center, Virginia Polytechnic Institute and State University.

ATU Components

The wastewater treatment atmosphere is highly corrosive even when treated aerobically. All mechanical and electrical components must be protected from corrosion and water intrusion. The components of the aeration unit should be stainless steel or plastic. The motor housing should be mounted outside the tank or enclosed with watertight seals. Corrosion of the motor housing may eventually contribute to motor failure. The power supply to the tank should be grounded and all connections should be inside watertight junction boxes using water resistant wire nuts or other water-resistant method. All electrical wiring must have watertight connections and be done in accordance with the manufacturer's instructions and local wiring codes.

Aerobic treatment units are either buried or are otherwise protected from freezing. The aeration tank must be vented to the outside air, usually with an air tube on top of a riser or lid to bring in air which contains the oxygen. Easy access (riser to the surface) must be provided to the first compartment where the solids accumulate so that this chamber can easily be checked and pumped when needed. Some ATUs that have multiple compartments may also have an effluent filter at the outlet or in the line from the unit. Easy surface access (port) must be provided for service (cleaning) of the filter and any other components that require regular service.

The aerator provides a source of oxygen for the microbes and promotes mixing of the wastes being aerated. Mixing of suspended growth systems is essential so the microbes come into contact with both the organic material and the air and to keep them in suspension. The aeration compartment contains a mixed blend of particles (or floc) containing organic and inorganic solids and microbes that do the decomposition. In the final (or clarifier) chamber floc particles compartment contains a mixed blend of particles (or floc) containing organic and inorganic solids and microbes that do the decomposition. In the final (or clarifier) chamber floc particles settle to the bottom and some particles are returned to the aeration chamber. The returned floc particles keep the microorganism population high in the aeration tank providing more complete decomposition. Some ATU systems have only one compartment so the water must pass through a filter before exiting the tank. In these systems the floc accumulates on the surface of the filter so that the population of microorganisms is contained in the aeration compartment.

ATU Electrical Considerations

ATUs require an uninterrupted electrical supply to power the controls and aeration pump. The power source should be wired to a separate circuit in the home electrical panel. This prevents overloading the circuit, prevents the homeowner from unknowingly turning off power to the unit, and assures safety when working on the unit. The control box and all electrical connections for the aerobic unit must be watertight and must be outside the tank, above ground, or in a separate dry well. Because motor vibration in some aerobic units can wear and fray electrical wiring, it is important to carefully route wiring during installation to prevent unnecessary wear. During maintenance all wiring should be carefully checked for wear and realigned if necessary.

ATU Required Operating Conditions

An ATU must maintain an environment that is beneficial to the microbial population. The system should have a pH between 6.0 and 9.0 to keep the microbes healthy. Dissolved oxygen in the aerated tank should be a minimum of 1.0 mg/L. The actual dissolved oxygen will vary depending upon the loading, time of day, rate of oxygen transfer, and location in the tank. The tank will contain aerobic, facultative, and some anaerobic microbes. The accumulated sludge in the bottom of the tank will contain most of the anaerobic and facultative microbes.

The hydraulics of an ATU are similar to a septic tank. As flow enters the tank, wastewater in each compartment is displaced to allow the new wastewater to enter. The tank should have a total detention time of 24 hours or more, with at least 3 hours detention time in the final compartment to allow settling to occur. ATUs are very susceptible to hydraulic surges (high flow rates) that may wash solids out of the tank, reduce treatment efficiency, and can eventually cause a failure in the soil absorption field. Water conservation, though important for all in-ground onsite wastewater systems, is especially important for ATU Systems. Users with ATU systems should avoid high water use in a short period of time by spreading water using activities (laundry, bathing, showers, etc.) over a longer time period of the day.

An aerated treatment tank depends on a healthy population of aerobic microorganisms to remove pollutants. Sudden changes in waste characteristics (shock loading) such as pH, toxic chemicals, or the concentration of organic material may negatively affect the microbial population. A decline in the microbial population may cause a decline in the treatment efficiency of the system. An aerated tank should have a steady supply of organic wastes to keep the microbe population in the best condition. If the tank is not used, the microbial population begins to decline. If non-use continues for several weeks or months the microbe population may decline to a critically low level. When tank use resumes after a long idle period, it may take several days for the microbial population to become large enough to provide adequate treatment. Additionally, when the family returns after a vacation and runs several loads of laundry in a short period of time, the hydraulic surge may wash much of the bacteria out of the system. The homeowner should be informed about how the system works and be encouraged to use the system properly to maintain good treatment. Arranging for some use of the system during long absences helps ensure good operation when occupants return.

Harmful chemicals that change the pH of the tank or contain toxic substances may cause the microbial population to decline with a corresponding decline in treatment efficiency. Exclude toxic chemicals from the waste stream of ATUs just as in a septic system. Solids that do not readily decay such as sand, clay, cigarette butts, kitty litter, bones, and grit do not decompose and accumulate in the tank, reducing the tank's capacity to accumulate sludge. Grease and oil are not easily decomposed in an aerated system so should be excluded from the wastewater as much as possible. Inert materials or those slow to degrade, accumulate in the tank and increase the required sludge pumping frequency.

ATU Maintenance

Aerobic treatment units use mechanical and electrical components that require maintenance. Maintenance should include a check of overall operation, the aeration motor and pump, air lines, orifices, alarms and controls, and accumulation of debris in piping, shafts and filters. Hair, lint, and other debris must be removed from the aerator shaft. Accumulation of debris on the aerator shaft increases the load on the aerator motor and wear on the bearings and may cause a premature motor failure. The air intake vent must be open to provide air for the system.

Distributors of ATUs often provide service contracts for the system. Homeowners are strongly encouraged to keep a service contract on these systems. The tank should be equipped with an alarm to alert the owner when there is a failure of mechanical or electrical equipment. The alarm should be both visual and audio and must be placed so the homeowner can readily detect failing conditions. The homeowner should call the qualified, trained service provider when an alarm is activated.

In addition to mechanical equipment maintenance, treatment tanks must be pumped to remove solids, and filters, if present, must be periodically cleaned. The power supply to the system must also be kept operational so the tank has a constant supply of air.

ATU System Summary

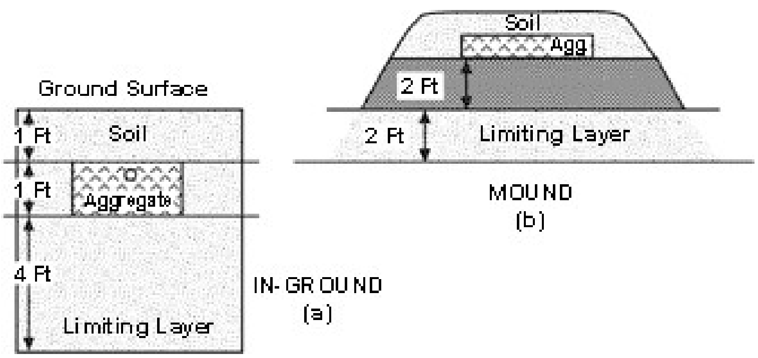
A well designed, tested, and manufactured ATU can achieve a higher level of wastewater treatment than is possible with a septic tank. However, to consistently achieve this level of treatment, the system must be properly installed, operated, and maintained. The homeowner is responsible for the operation of the system and must understand how to use it properly and respond quickly when problems develop. The system should be equipped with an alarm that automatically notifies the homeowner when problems exist. Good maintenance requires that the system receive routine checks and repairs by a qualified, trained technician. When all requirements are met, an aerated tank can provide effective treatment.

ENGINEERED MOUND SYSTEM

Traditional septic tank-absorption field systems require suitable soil and site conditions to adequately treat wastewater. Mound systems are only slightly different in principle from a wastewater treatment aspect. Mound systems are elevated absorption beds that utilize suitable sand fills to partially treat wastewater before it reaches natural soil. Mound systems are used to augment natural soil for complete treatment and disposal. Figure VI-3 demonstrates the cross section of a conventional soil absorption lateral and the mound system in relation to ground surface and limiting conditions.

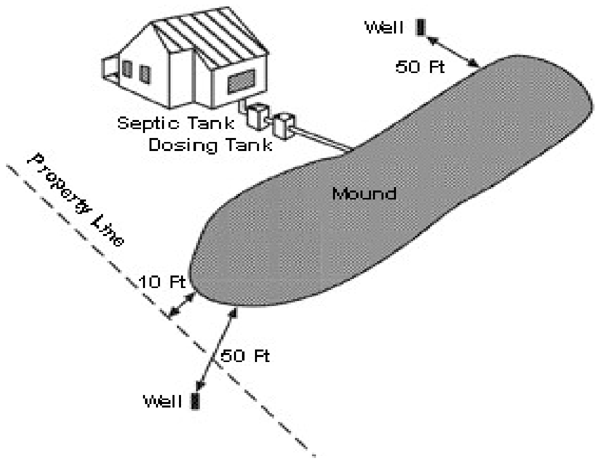
Figure VI-3. Cross Section of Traditional Soil Absorption Lateral

(A) and Mound (B) in Relation to Ground Surface and Limiting Condition (After Converse and Tyler, 1990)



A mound must be positioned in the landscape along the contour of the lot. Minimum separation distances of 50 feet from drinking wells and of 10 feet from property lines are required for the mound system, as shown in Figure VI-4. Mounds are long and narrow to ensure that wastewater can infiltrate the soil beneath and move away from the mound without surfacing. Ideally the mound should be as long and narrow as possible along the contour, but no shorter than is prescribed for the design linear loading rate. Constructing a mound shorter and wider than recommended, results in a risk of partially treated wastewater coming to the surface. Cost of an engineered mound increases with site slope. Design is dependent on the slope and slopes greater than 15 percent are normally not suitable for a mound.

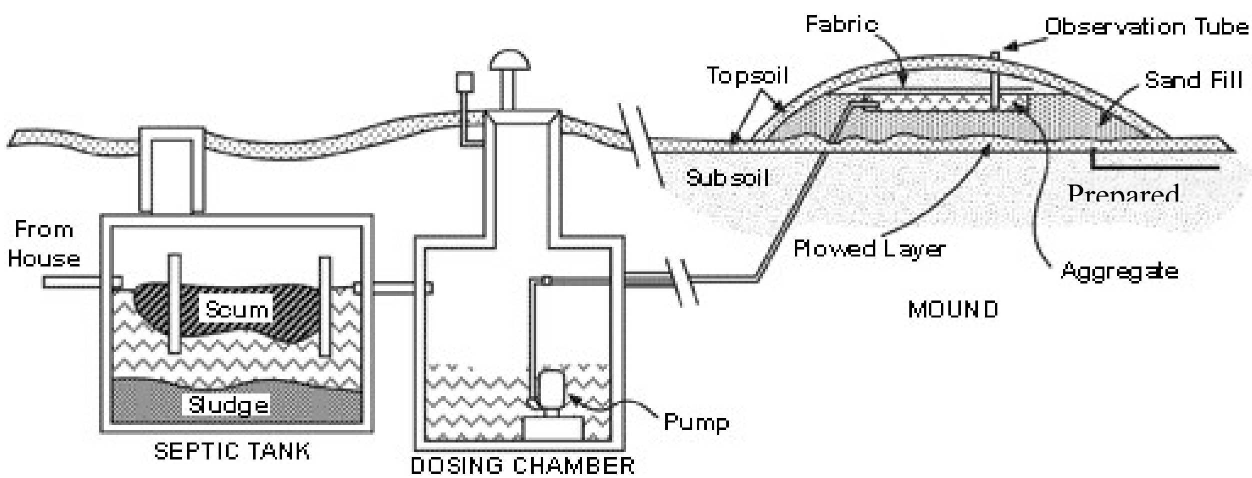
Figure VI-4. Minimum Separation Distances for the Mound System



A mound system consists of a septic tank, dosing tank with pump, distribution pipes, and mound, as shown in Figure VI-5. The septic tank allows the solids in wastewater to separate by settling or floating and to degrade. The septic tank effluent should discharge through an effluent filter to a dosing chamber (tank). The dosing tank is equipped with a pump to deliver the septic tank effluent through the distribution system in the mound. The distribution system normally consists of small diameter pipes and allows for low pressure, even distribution of effluent to the absorption area in the mound.

Figure VI- 5. Schematic of the Mound System

(Converse and Tyler, 1990)



Most of the pollutants are removed as the wastewater percolates through the sand fill in the mound. The natural soil beneath absorbs the partially treated wastewater that trickled through the mound and removes pathogens to complete treatment and dispersal. To enhance infiltration into the soil, the surface is roughened by tillage along the contour before the sand fill is placed.

MOUND DESIGN EXAMPLE

Designing a mound system is a site-specific process thus the following steps must be completed to fit the components of the mound to the features of the site. The configuration of the mound is based on the volume of the wastewater to be treated, the characteristics of the site, natural soil profile, and the depth to a limiting condition. These steps show the design procedure and an example of a mound design for a typical three-bedroom Kansas home is also included. The following 15 design steps described here are adapted from Ohio State University Extension, Bulletin 813. (Chen and Mancl, 2004)

Design Step 1. **Site and Soil Evaluation**

Conduct a site and soil evaluation as outlined in Chapter IV making note of the soil profile and the depth of the limiting condition; slope of the site; and the location of trees, etc. Mound systems are suitable for areas of Kansas with shallow depth to a restrictive soil layer, shallow bedrock, or seasonal high water tables. A minimum depth of at least 12 inches of unsaturated, permeable soil is a prerequisite for a mound system. The permeability of the soil must be at least 0.5 inch per hour (perc no greater than 120 minutes/inch) and no more than 20 inches per hour. Table VI-3 gives some recommended minimum and maximum criteria for mound systems.

Table VI-3. Recommended Minimum/Maximum Soil and Site Conditions for Mounds

Minimum depth to permeable restriction such as fractured or weathered rock	1 foot
Minimum depth to impermeable soil or rock	1.5 feet
Minimum depth to permanent or seasonally perched water table	1.5 feet
Minimum perc rate for soil horizons on the site (no greater than)	120 min/inch
Maximum site slope	15 percent

Before designing a mound system for a site, evaluate and record the site description and soil profile. The natural soil would not be reshaped. If the site meets the recommended soil and site criteria, establish the contour of the lot in and adjacent to the proposed mound area as shown on Figure VI-6. Measure and mark the required set back distances for wastewater systems. Mounds must be on the contour to maintain constant mound height and to ensure even distribution of effluent. This means that mounds typically curve to follow the natural soil surface contour.

Example:

A summary example of the soil and site information is presented here.

1) Soil Profile (summary of three soil profile excavations based on shallowest values):

    a) 0-7 inches: silt loam texture; moderate fine and medium angular structure; slightly hard / friable consistence

b) 7-24 inches: silty clay texture; moderate fine blocky structure; extremely hard / very firm consistence (layer of poorer drainage)

c) 24-30 inches: silty clay texture; common fine and medium distinct grayish brown and few fine distinct strong brown mottles (poor to very poor internal drainage); weak medium and fine blocky structure; extremely hard / very firm consistence; few fine black concretions

d) Greater than 30 inches: silty clay texture; few fine distinct strong brown mottles that increase with depth; very weak fine blocky structure grading to massive at greater depths; extremely hard / very firm consistence (very poor internal drainage)

2) Site slope is 3 percent or 0.03.

3) The suitable area available on the site is 180 feet along the contour and 50 feet parallel to the slope. Three medium-sized trees are near the mound area. A small tree just above the available area could be removed to prevent root interference with the mound fill material.

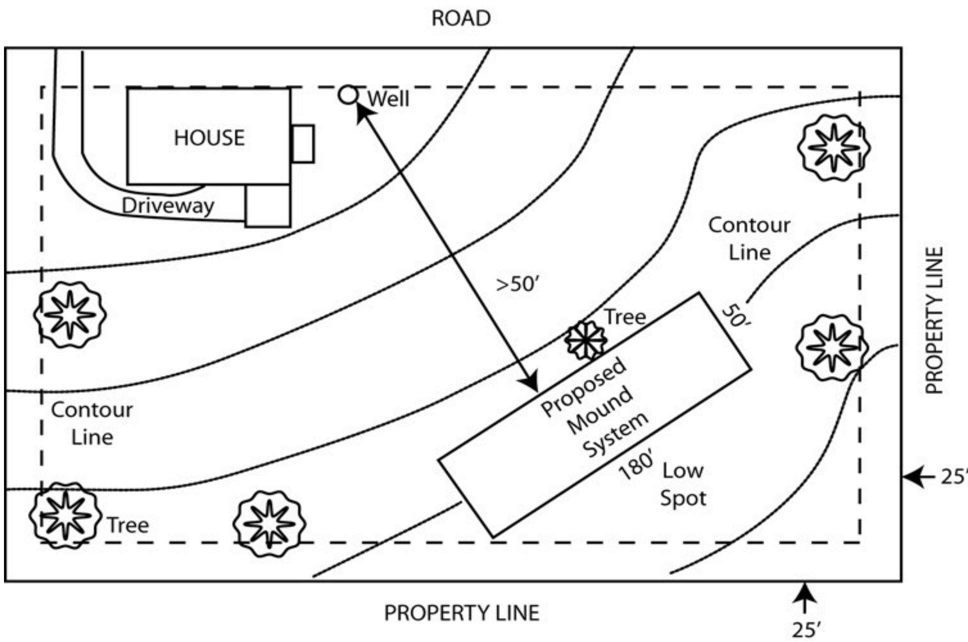
4) Depth to restrictive soil layer or limiting condition is 24 inches due to the silty clay texture with weak blocky structure that has poor drainage. Mottles below 24 inches indicate a seasonal high water table indicative of poor drainage.

Site slope = 3 percent or 0.03

Suitable area = 180 feet long (on the contour) by ***50 feet wide*** (with the slope)

Depth to restriction = 24 inches (layer of poor internal drainage)

Figure VI-6. Site Evaluation Example for Locating an Engineered Mound



Design Step 2. **Determine Wastewater Flow Rate.**

The wastewater flow rate for individual homes is estimated by multiplying the number of bedrooms by 150 gallons per day (gpd). This is based on 2 people per bedroom and 75 gallons per person per day as outlined in KDHE Bulletin 4-2. Other types of wastewater sources can be estimated from tables of typical flows.

Wastewater Flow Rate = 150 gpd/bedroom x number of bedrooms

Example:

Wastewater Flow Rate = 150 gpd/bedroom x 3 bedrooms

Wastewater Flow Rate = 450 gallons/day (gpd)

Design Step 3. **Select the Linear Loading Rate**

The linear loading rate shown in Table VI-4 controls the hydraulic loading along the contour and prevents overload. The rate controls the mound length. Based on soil and site evaluation, identify the nature of the limiting condition. In Table VI-4 a range of values is given, use the conservative value when possible. The space-limited value is less conservative and should be used only when the suitable area available is limited by the lot size and the site features.

The linear loading rate is selected from Table VI-4 using the rate for the limiting condition that corresponds to the site. Use the conservative value when space permits.

Table VI-4. Linear Loading Rates Based on Limiting Conditions

	Linear Loading Rate Range (gpd/linear ft)	
Limiting Condition	**Conservative Value**	**Space-Limited Value**
Solid bedrock	3	4
Impermeable soil layer	3	4
Seasonal high water table	3	4
Semi-permeable soil layer	5	6
Fractured compacted till	5	6
Creviced or fractured bedrock	8	10
Sand and/or gravel layer	8	10

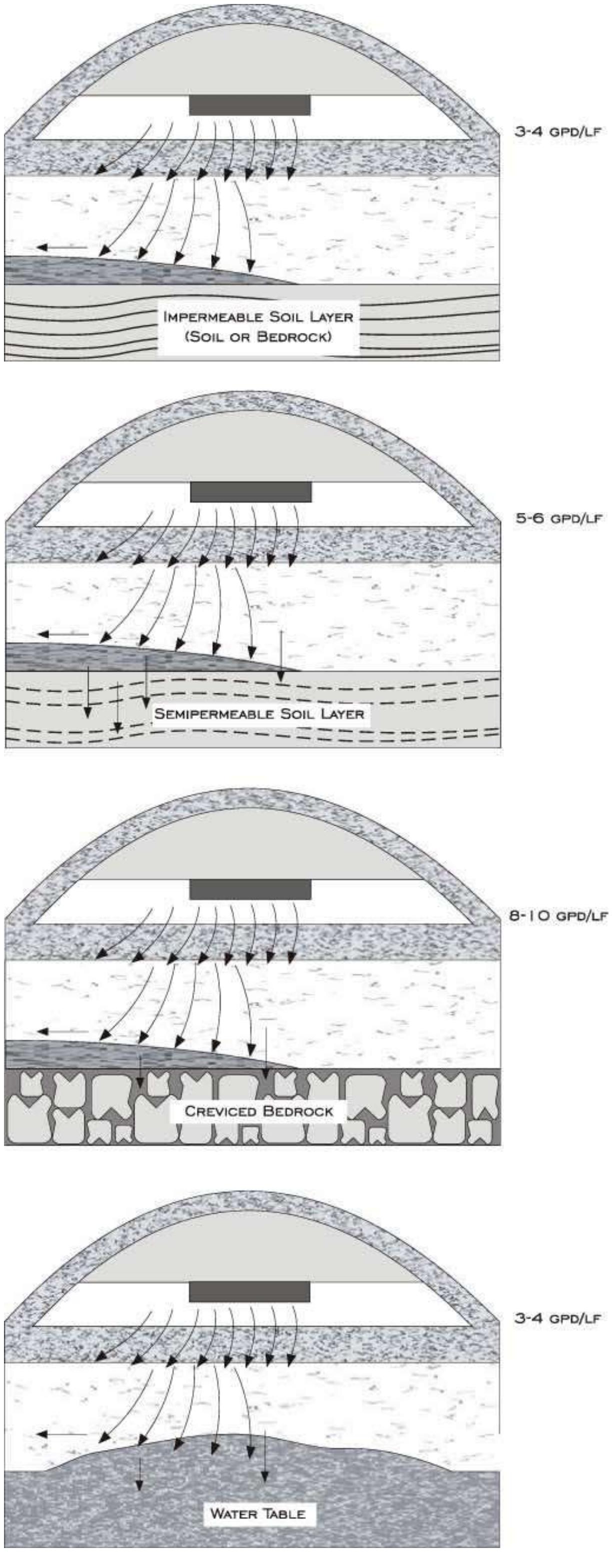
Note: The values in this table are the same values shown on Figure VI-7.

Example:

The soil evaluation revealed the limiting condition as a soil layer with fine texture and weak structure that has poor drainage. The soil mottles are an indication of a seasonal perched water table. The area available seems large enough to accommodate the conservative linear loading rate of 3 gpd/lf (Table VI-4) so this will be used.

Linear Loading Rate = 3 gpd/lf (the conservative value)

Figure VI-7. Linear Loading and Lateral Movement of Percolate Through Soil and Geologic Materials



***Design Step 4.* Select the Sand Fill Loading Rate**

The selection of sand fill material is critical to long-term performance of the mound system. The purpose of the sand fill is to accept effluent from the distribution system and provide much of the treatment of the wastewater before infiltration into the natural soil. Suitable sand is a type that can be loaded at a reasonable rate and will provide satisfactory treatment. Generally, the finer the sand the better the treatment but the slower the wastewater infiltration will be from the absorption bed. However, too fine sand cannot be loaded at an acceptable rate and may become severely clogged, which may result in failure of the mound system. Too coarse sand will allow effluent to pass through the mound with inadequate treatment.

Following the USDA Soil Textural Classification, coarse sand is suitable. However, this is subject to the following two conditions: (1) no more than 20% by weight is gravel (> 2 mm), and (2) no more than 5% by weight is silt and clay (< 0.053 mm). To achieve a fines content this low usually requires that the sand material be washed to remove the fines. Note: Request a sieve analysis report from the aggregate supplier for the proposed sand to verify the criteria specified here are met.

Concrete sand is produced by many sand and gravel quarries in Kansas and generally meets the criteria for the very coarse and very fine fractions. The fine aggregate specified by the Kansas Department of Transportation will meet the mound sand requirements. The specification is detailed in Section 703.02 of Aggregate for Portland Cement Concrete, Office of Construction Administration, 2002 Construction and Material Specifications. Although mason sand is also commonly available, it is finer sand than concrete sand and is not recommended. Limestone sand is not suited although it may meet size requirements. Limestone sand can dissolve over time, reducing the system's useful life.

Sand specifications are also given in terms of effective size and uniformity coefficient. When using these criteria, select sand with an effective size in the range of 0.15-0.30 mm, and with a uniformity coefficient in the range of 4-6. When the sand meets these guidelines, the recommended design sand fill loading rate is 1.0 gpd/ft^2 when the wastewater is typical domestic septic tank effluent. If the septic tank effluent has a higher than normal strength such as from a restaurant, the wastewater quality should be evaluated and the sand fill loading rate should be reduced accordingly. When treating higher strength wastewater, the sand fill loading rate should either be reduced, or additional pretreatment installed in order to achieve a waste strength comparable to domestic effluent before distribution to the sand fill material.

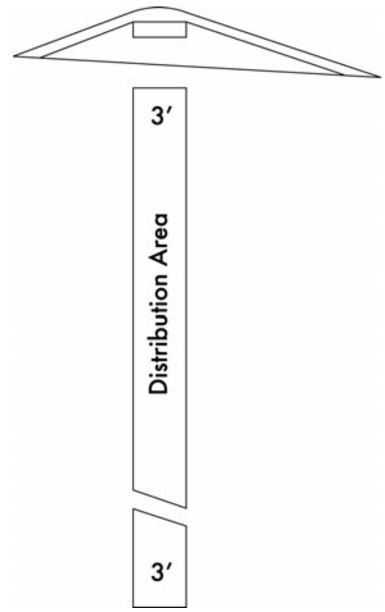
Sand Fill Loading Rate = 1.0 gpd/ft^2 (unless a sand is used that does not meet the specifications defined above).

Example:
The engineered sand fill specified for a mound will be used and the recommended sand fill loading rate of one gallon per square foot per day. (1.0 gpd/ft^2) will be used.

Sand Fill Loading Rate = 1.0 gpd/ft^2

***Design Step 5.* Determine the Distribution Area Width.**

The distribution area runs the length of the mound at the top of the sand fill as shown in the diagram to the right. The distribution area is where wastewater is applied at the surface of the sand fill material. It is similar to the bottom of a lateral trench. The distribution area width is obtained by dividing the linear loading rate from step 3 by the sand fill loading rate from step 4.



$$\textit{Distribution Area Width} = \frac{\textit{Linear Loading Rate (gpd/lf)}}{\textit{Sand Fill Loading Rate (gpd/ft}^2\textit{)}}$$

Example:

Distribution Area Width = (3 gpd/lf)/(1 gpd/ft²) = 3 ft

Distribution Area Width = 3 ft = 36 inches

***Design Step 6.* Determine the Distribution Area Length**

The distribution area length is obtained by dividing the wastewater flow rate (gpd) from step 2 by the linear loading rate (gpd/lf) from step 3 as shown in the following equation.

Distribution Area Length = Wastewater Flow Rate (gpd) / Linear Loading Rate (gpd/lf)

Example:

Distributon Area Length = (450 gpd)/(3 gpd/lf) = 150 feet

Distributon Area Length = 150 feet

***Design Step 7.* Select Basal Area Loading Rate**

Wastewater percolates through the sand fill by gravity. When the partially treated wastewater reaches the natural soil it cannot move as quickly through the soil as in the more porous sand above. The wastewater begins to spread out and flow downslope. The purpose of the basal loading rate is to assure that there is adequate area at the base of the mound for the water to spread out when it contacts the soil surface. The properties of the surface soil horizon determine the basal loading rate. However, when there is a less permeable layer within the top 2 feet of soil below the mound, a more conservative basal loading rate may be selected.

Choose the basal loading rate from Chapter IV, Table IV-4 (reproduced here for convenience as Table VI-5).

Example:

The surface soil layer (top 7 inches) is a silt loam texture with moderate granular structure. Because a mound gives better treatment (BOD=30), a suitable basal loading rate from Table VI-5 is 0.8 gpd/ft^2. However, because the internal drainage in the next lower soil layer is poorer and there is adequate area it is advisable to use a lower basal area loading rate. A rate of only 0.3 gpd/ft^2 is appropriate for a silty clay texture with moderate structure (BOD=30).

The Basal Area Loading Rate = 0.3 gpd/ft^2.

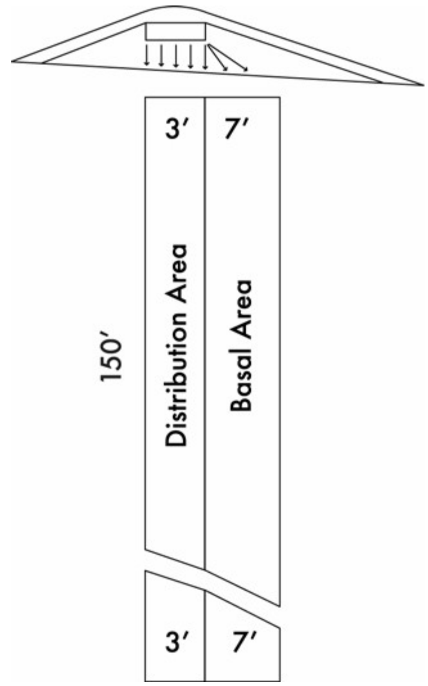
Table VI-5. Recommended Design Loading Rate for Various Soil Texture, Structure, and Effluent Quality

Texture	Structure		Hydraulic loading (gpd/ft^2)	
	Shape	Grade	BOD=150[1]	BOD=30[2]
Coarse sand, sand, loamy coarse sand, loamy sand	Single grain	Structureless	0.8	1.6
Fine sand, very fine sand, loamy very fine sand	Single grain	Structureless	0.4	1.0
Coarse sandy loam, sandy loam	Massive	Structureless	0.2	0.6
	Platy	Weak	0.2	0.5
		Moderate, Strong		
	Prismatic, blocky, granular	Weak	0.5	0.7
		Moderate, Strong	0.6	1.0
Fine sandy loam, very fine sandy loam	Massive	Structureless	0.2	0.5
	Platy	All grades		
	Prismatic, blocky, granular	Weak	0.2	0.6
		Moderate, Strong	0.4	0.8
Loam	Massive	Structureless	0.2	0.5
	Platy	All grades		
	Prismatic, blocky, granular	Weak	0.4	0.6
		Moderate, Strong	0.6	0.8
Silt Loam	Massive	Structureless		0.2
	Platy	All grades		
	Prismatic, blocky, granular	Weak	0.4	0.6
		Moderate, Strong	0.6	0.8
Sandy clay loam, clay loam, silty clay loam	Massive	Structureless		
	Platy	All grades		
	Prismatic, blocky, granular	Weak	0.2	0.3
		Moderate, Strong	0.4	0.6
Sandy clay, silty clay, clay	Massive	Structureless		
	Platy	All grades		
	Prismatic, blocky, granular	Weak		
		Moderate, Strong	0.2	0.3

[1] *typical septic tank effluent BOD concentration*
[2] *typical enhanced (advanced) treatment component effluent*
Source: *Table IV-4 page IV-7of the Environmental Health Handbook; reproduced here for user convenience.*

***Design Step 8.* Determine the Basal Width**

The basal area is critical for a mound because the wastewater that moves through the mound must be absorbed by the natural soil surface. To ensure that water will infiltrate, surface compaction must be avoided in this area. The mound basal area length and width should be outlined on the site and protected from construction traffic and equipment. (Note: The basal width is normally less than the mound side widths, which are required to provide a mound side slope as selected but no steeper than 3:1.). The minimum basal width is the linear loading rate (gpd/ft) divided by the basal loading rate (gpd/ft^2).



$$\textit{Basal Width} = \frac{\textit{Linear Loading Rate (gpd/lf)}}{\textit{Basal Loading Rate (gpd/ft}^2\textit{)}}$$

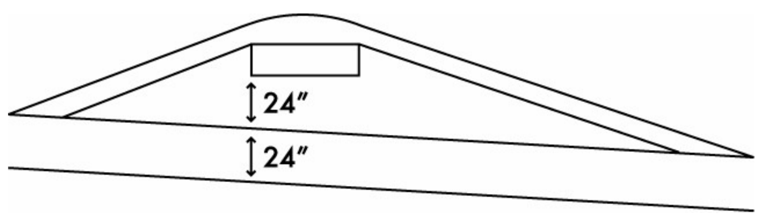
Example:

Basal Width = (3 gpd/lf) /(0.3 gpd/ft^2) = 10 ft

This basal width is 10 - 3 = 7 feet wider than the distribution area width.

***Design Step 9.* Determine Upslope Sand Fill Depth**

Bulletin 4-2 states 4 feet of suitable soil is required beneath soil absorption systems. The mound sand fill combined with the existing suitable soil must be at least 4 feet. The available suitable soil depth is obtained from the soil profile evaluation conducted within the proposed area, step 1.



The depth of required sand fill is determined by subtracting the available suitable soil on the site from the required 4 feet or 48 inches of aerated soil required in Kansas.

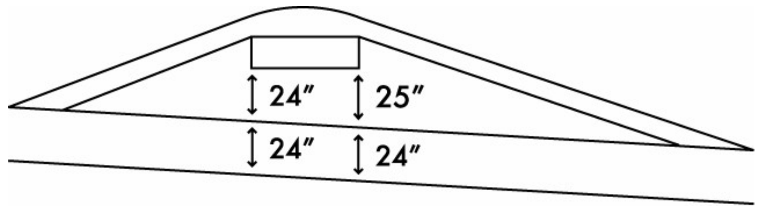
Example:

In the design example, the silt loam top layer (0-7 inches) and the silty clay with moderate structure second layer (7-24 inches) could be considered suitable. The deeper part of the soil profile is not suitable due to its silty clay texture and weak or massive structure. The soil profile shows 24 inches of suitable soil. The mound sand fill combined with the existing suitable soil must total at least 4 feet.
Upslope Sand Fill Depth = (48 inches) - (Depth of Suitable Soil to Limiting Condition)

Upslope Sand Fill Depth = (48 inches) - (24 inches) = 24 inches

***Design Step 10*. Determine Downslope Sand Fill Depth**

The bottom of the distribution area (small rectangle at the top of the mound) must be constructed level.



Therefore, sloping sites must have a deeper sand fill on the downslope side of the distribution area.

The depth at the downslope edge of the distribution area is the upslope depth plus the site slope times the width of the distribution area.

Example:

The site slope is 3 percent (0.03) for the design example (step 1). The downslope fill depth is obtained by adding the slope times the width and to the upslope fill depth.

Downslope Sand Fill Depth = (Mound Sand Fill Upslope Depth) + (Site Slope) x (Distribution Width)

= (24 inches) + (0.03) x (36 inches) = 24 + 1.08

Downslope Sand Fill Depth = 25.08 or 25 inches

***Design Step 11.* Mound Cover Depth, Distribution Area Depth, and Distribution Cap Depth**

A mound cover depth of 6 inches of soil is required to protect the mound side slopes, the sand fill, and to ensure proper performance. This soil cover supports grass roots needed for erosion control and also provides frost protection. Because the mound soil cover must have specific properties, it can be an expensive construction component. The preferred materials for a mound cover are sand loam, loamy sand, or silt loam. The soil must be adequate to support grass growth preventing soil erosion. Generally high clay soils are not suitable without significant amendments to improve properties. Do not compact the mound cover soil because the microbial community treating the wastewater entering the mound and the grass growing on the mound need air. Natural settling of the mound cover and cap will occur over time and will not interfere with mound operation.

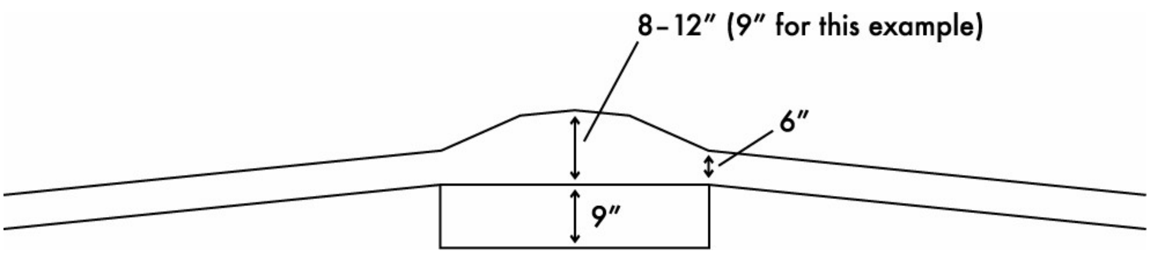
The distribution area fill should be clean, washed, coarse aggregate to surround and protect the distribution lines and assure good contact with the sand fill. At least 6 inches of coarse aggregate base should be beneath the distribution laterals, 1½ more inches of aggregate depth for pipe depth, and 1½ inch of aggregate covering the distribution laterals. Thus, the total aggregate depth should be 9 inches. The distribution aggregate should be covered with geotextile filter fabric to keep soil from working down into and filling voids of the distribution aggregate. In some areas chambers are used in place of aggregate for the distribution area.

A distribution area cap must cover the distribution area with adequater soil to drain water off the top of the mound and to provide freeze protection for the distribution area. This cap should be more than the 6 inches used for the mound cover but should be no greater than 12 inches deep. The wider the distribution area the deeper the cover will need to be. Often 8 to 10 inches is adequate.

Distribution Area (Aggregate) Depth = 9 inches

Mound Cover Depth = 6 inches

Distribution Cap Depth = 8-12 inches Note: the wider the distribution area the thicker the cap should be to ensure adequate slope for drainage.



Example:
Because the distribution area is narrow, the depth selected for the distribution cap was 9 inches. Other depths used for this example are as described in the discussion of this section.

Distribution Area (Aggregate) Depth = 9 inches.

Mound Cover Depth = 6 inches.

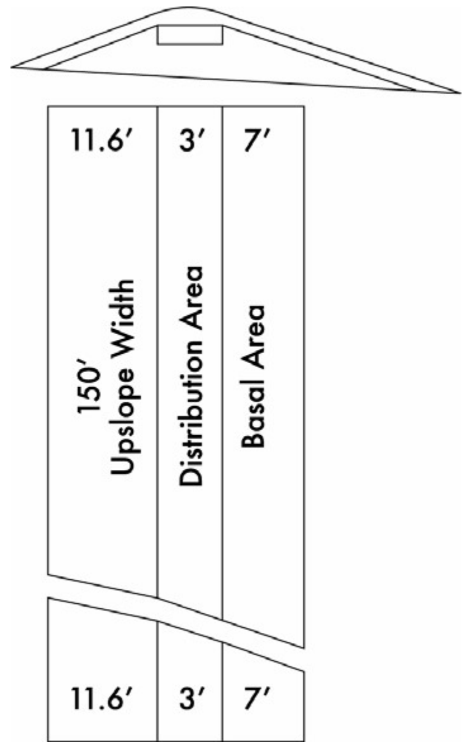
Distribution Cap Depth = 9 inches.

***Design Step 12.* Determine the Upslope Fill Width**

The mound side slope ratio (run:rise) should not be steeper than 3:1 for safe mowing, with 4:1 or flatter preferred. The larger the ratio, the flatter the slope. Flatter side slopes require more fill to construct resulting in a larger mound footprint, but generally blend better with the landscape. The mound footprint extends in all directions beyond the distribution area. On level sites the mound side slope ratio is used to calculate the distance the sand fill will extend to the sides of the distribution area. On sloping sites the upslope width intersects the site slope making the distance less than calculated using the side slope ratio. An upslope width correction factor must be used for the width adjustment. Upslope width correction factors are provided in Table VI-6 for a range of site slopes and mound side slope ratios.

Table VI-6. Mound Upslope Width Correction Factors

Site Slope, %	Mound Side Slope Ratios 3:1	4:1	5:1	6:1	7:1
0	1	1	1	1	1
1	0.971	0.962	0.952	0.943	0.935
2	0.943	0.926	0.909	0.893	0.877
3	0.917	0.893	0.870	0.847	0.826
4	0.893	0.862	0.833	0.806	0.781
5	0.870	0.833	0.800	0.769	0.741
6	0.847	0.806	0.769	0.735	0.704
7	0.826	0.781	0.741	0.704	0.671
8	0.806	0.758	0.714	0.676	0.641
9	0.787	0.735	0.690	0.649	0.613
10	0.769	0.714	0.667	0.625	0.588
11	0.752	0.694	0.645	0.602	0.565
12	0.735	0.676	0.625	0.581	0.543
13	0.719	0.658	0.606	0.562	0.524
14	0.704	0.641	0.588	0.543	0.505
15	0.690	0.625	0.571	0.526	0.488



Note: This table is based on the upslope width correction factor = 1/[1+(Mound side slope ratio, or run) x (Site slope as a decimal)].

Example:
For the design example a side slope ratio of 4:1 is used because that shape is easier to maintain (mow) than steeper sides slopes. Compared with larger ratios this ratio also minimizes the footprint of the mound and the quantity of fill materials required. However, slopes this steep (4:1) are not easy to mow so when possible it is desirable to use a slope ratio of 5:1 or flatter. The upslope correction factor from Table VI-6 for the 3 percent site slope and 4:1 side slope ratio is 0.893.

Upslope Fill Width = (Side slope ratio or run) x (Upslope sand fill depth + Aggregate depth + Mound cover depth) x (Upslope width correction factor)

= (4) x (24 inches + 9 inches + 6 inches) x (0.893) = 139.31 in

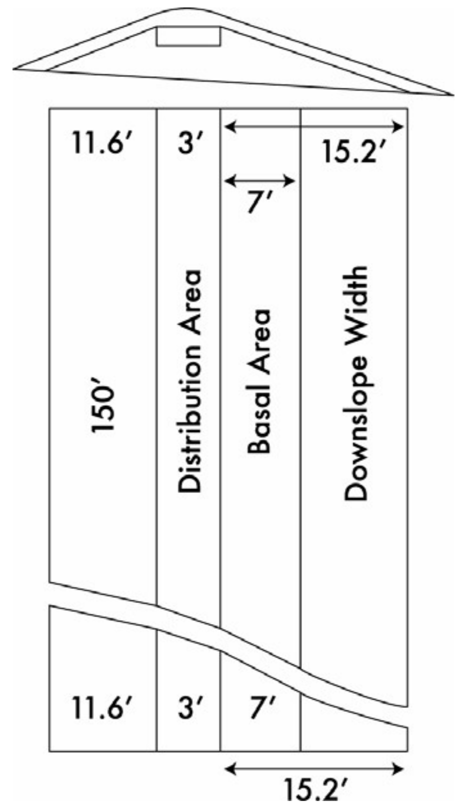
Upslope Fill Width = 139 inches or 11.6 feet

***Design Step 13.* Determine the Downslope Fill Width**
Since the site slopes away on the downslope side, a downslope width correction factor is required for the width adjustment. Downslope width correction factors are provided in Table VI-7 for a range of site slopes and mound side slope ratios. Note: Downslope width plus the distribution area width (Step 5) must be at least as much as the basal width.

Table VI-7. Mound Downslope Width Correction Factors

Site Slope, %	Mound Side Slope Ratios 3:1	4:1	5:1	6:1	7:1
0	1	1	1	1	1
1	1.031	1.042	1.053	1.064	1.075
2	1.064	1.087	1.111	1.136	1.163
3	1.099	1.136	1.176	1.220	1.266
4	1.136	1.190	1.250	1.316	1.389
5	1.176	1.250	1.333	1.429	1.538
6	1.22	1.316	1.429	1.563	1.724
7	1.266	1.389	1.538	1.724	1.961
8	1.316	1.471	1.667	1.923	2.273
9	1.370	1.563	1.818	2.174	2.703
10	1.429	1.667	2.000	2.500	3.333
11	1.493	1.786	2.222	2.941	4.348
12	1.563	1.923	2.500	3.570	6.250
13	1.639	2.083	2.857	4.545	11.111
14	1.724	2.273	3.333	6.250	50
15	1.818	2.500	4.000	10.00	xx

Note: This table is base on the downslope width correction factor = 1/[1 - (Mound side slope ratio, or run) x (Site slope as a decimal)].



Downslope Fill Width = (Side slope ratio or run) x (Downslope sand fill depth + Aggregate depth + Mound cover depth) x (Downslope width correction factor)

Example:
The design example uses the side slope ratio 4:1. The downslope correction factor for the 3 percent site slope and 3:1 side slope ratio is 1.136.

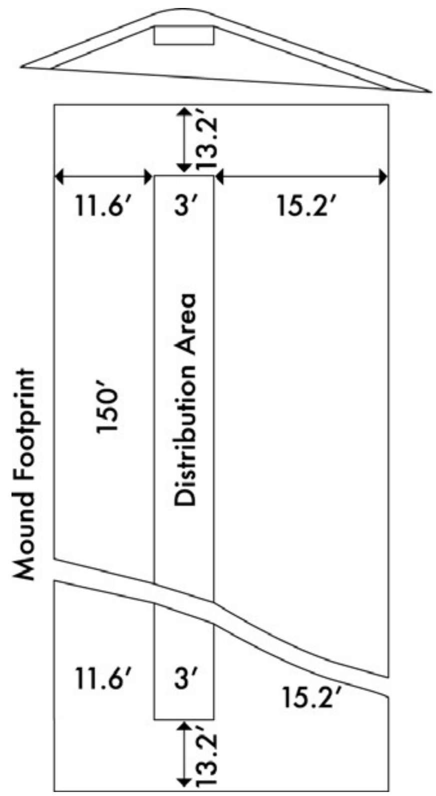
Downslope Fill Width = (4) x (25.1 inches + 9 inches + 6 inches) x (1.136) = 182.21 in

Downslope Fill Width = 182 inches or 15.2 feet

Design Step 14. **Determine the End Slope Length.**

The mound ends have the same slope as the side slope ratios used for the sides of the mound.

End Slope Length = (Side slope ratio or run) x (Average depth of sand fill under absorption area [average of Steps 9 and 1] + Aggregate depth + Mound cover depth)



Example:

The mound side slope is 4:1 for this design example.

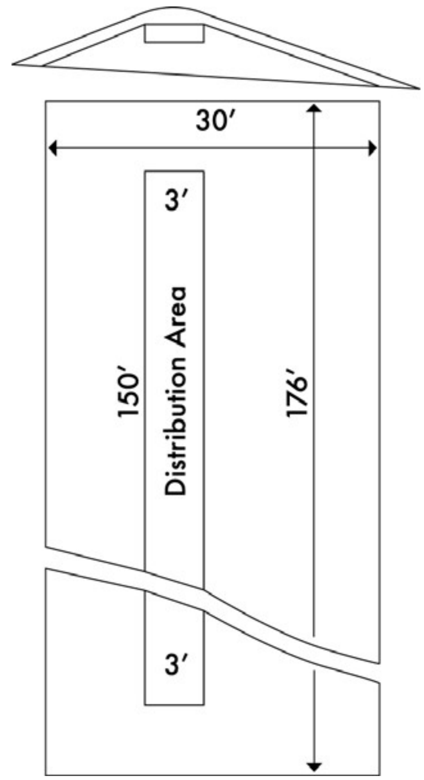
End Slope Length = 4 x ([24 + 25]/2 + 9 + 6 in)

= 158.2 in

End Slope Length = 158 inches or 13.2 feet

***Design Step 15.* Overall Mound System Length and Width.**

The overall length and width of the mound is also called the mound footprint and is the area covered by the completed mound. Add the end slope length (step 14) to both ends of the distribution area (step 6) to determine the overall mound length. Add the upslope fill width (step 12) and downslope fill width (step 13), to the distribution area (step 5) to obtain the overall mound width. Knowing both length and width of the mound, the footprint can be located on the site.



Overall Length = (Distribution area length) + (2) x (End slope length)

Overall Width = (Distribution area width) + (Upslope fill width)

Example:

Overall Length = (150 ft) + (2) x (13.2 ft) = 176.4 feet

Overall Length = 176 feet

Overall Width = (3 ft) + (11.6 ft) + (15.2 ft) = 29.8 ft

Overall Width = 30 feet

Stake out the mound so all parts are parallel to the contour. The length of this mound system (176 ft) will fit within the proposed site area (50 x 180 ft). However, wastewater is applied only to the distribution area (3 by 150 ft) which is smaller than the site area available. Because wastewater should not move into the ends of the mound to any appreciable extent in restricted space conditions it may be acceptable for the mound end to extend into the setback width (beyond the mound end location shown in Figure VI-6).

ENGINEERED MOUND DESIGN SUMMARY

Following the 15 design steps described above will result in the appropriate size for a mound to adequately fit site conditions. The volume of fill materials must still be calculated based on the dimensions obtained. Be sure the site plan and design specifications require that there be no trees in the mound footprint area. Because it is not acceptable to build a mound on a site that has been disturbed by the mechanical removal of trees, cut any existing trees flush with the ground surface. The remaining tree root system will then be covered by the mound. Avoid placing the distribution area directly above the remains of a tree.

In some cases, a valuable tree within the footprint near the edge of a mound could be preserved with a shallow retaining wall placed out several feet around the tree; using mound fill to the retaining wall. Do not attempt this on the downslope side of the mound because the toe could leak at this location. Soil mounded around the base of a tree may cause the tree to die.

RECOMMENDED CONSTRUCTION FOR MOUND SYSTEM

Because a large portion of mound system components are above-grade, some people say mound systems are easier to construct than conventional in-ground soil absorption systems. However, mound construction requires procedures and perhaps some equipment unique to its construction. Once the design has been completed and verified and the soil conditions are correct, construction is ready to begin. The most important things for a contractor to remember are outlined in the following 11-step procedure. It is strongly recommended that the following procedure be followed as closely as possible until the contractor has gained experience through installation of several systems. These construction steps are adapted from Ohio State University Extension, Bulletin 813. (Chen and Mancl, 2004)

***Construction Step 1.* Mark the Mound Site**

Lay out the proposed mound system along the contour of the lot in the area specified by the detailed soil and site evaluation. According to the design, outline and stake three areas: distribution area, basal area, and overall footprint of the mound.

***Construction Step 2.* Locate the Septic Tank and Dosing Tank**

Determine the septic tank and dosing tank locations based on the site layout. The tanks should be installed to the side or upslope of the mound.

***Construction Step 3.* Prepare the Mound Site**

Prepare the site for the mound. Mow grass to a maximum 2-inch height and remove cuttings from the mound location. Trees should be cut flush with the ground surface leaving the base and roots undisturbed. Construction should be delayed if the soil is too wet. Dig a trench from the dosing tank to the side or upslope of the mound. The trench is for the pressure pipe carrying septic tank effluent to the center of the mound. The pressure pipe should be installed with an adequate slope so septic tank effluent drains back to the dosing tank after the pump shuts off. The trench should be adequately bedded and filled with granular backfill to reduce settling.

***Construction Step 4.* Prepare the Soil Under the Mound**

Prepare the soil surface in the basal area. A chisel plow on a small tractor or special teeth fitted to a backhoe bucket can be used to scarify the soil surface. Scarifying the soil surface and breaking up the sod growing in the basal area will improve the contact of the mound sand with the natural soil. Avoid any traffic and equipment on the basal area or downslope of the mound. The basal area will be covered with a layer of sand that protects the soil under the mound from compaction during construction.

Construction Step 5. **Place the Sand Fill**

Apply the sand fill to cover the basal area and form the absorption area. Two methods are used to spread and shape the mound. In the traditional approach a backhoe moves sand to cover the basal area in the shape of the mound after the truck delivers sand to the upslope side. The alternative method is to use a truck equipped with a conveyor to distribute the sand over the basal area to the appropriate depth. This approach is especially suited to limited access sites. Spray paint markings on the ground to outline the basal area and use stakes to indicate the desired depth of sand at critical points to guide the operator in distributing sand to shape the mound.

Construction Step 6. **Place Absorption Rock**

Level the sand surface in the absorption area. Cut off the distribution main at least 4 inches above the sand surface and remove all bits of plastic and rough spots that can accumulate debris and clog the pipe. Place supports on the sand (sections of 6-inch pipe work well) to hold the distribution pipe at the desired level. Lay out the main, manifold, and laterals according to the designs. Cement all tees and joints to prevent leaks and pressure losses.

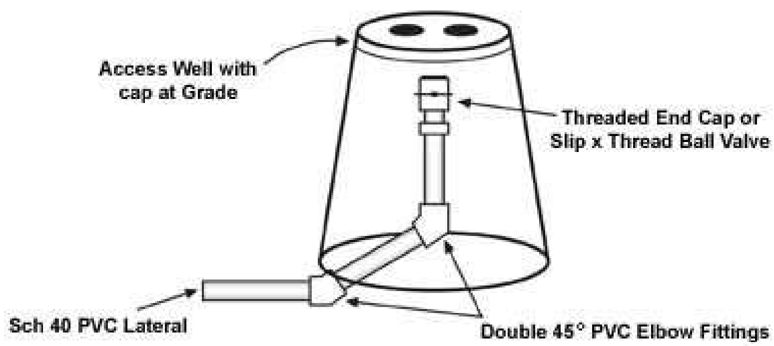
Construction Step 7. **Layout Distribution Laterals**

Distribution laterals are typically small-diameter pipe with small orifices (holes) spaced evenly along the top. The distribution orifices should be mechanically drilled at the shop with a drill press. Hand drilling is discouraged. Mark the hole positions evenly on the top of the laterals according to the design calculations. Drill the design-size holes with a sharp drill bit to help create clean holes and minimize rough edges. Put one of the same size holes in the bottom at the end of each lateral as a drain. Slide a smaller diameter pipe back and forth inside each pipe to knock off any burrs of plastic around the drill holes. The pipe size, hole size, and hole spacing should be carefully calculated, laid out, and marked in the shop to avoid mistakes in assembly. Consult with the designer about necessary adjustments during the construction to be sure this will not affect performance. Guidance for designing pump and distribution systems will be covered in Chapter X.

Attach turn-ups to the end of each distribution lateral pipe with a removable cap to allow accumulated debris to be flushed from the pipes. The turn-up is supported with gravel to accept the flushed wastewater and allow it to flow back into the mound for treatment. An irrigation valve box (Figure VI-8) works well to house the turn-ups so they can be easily located and accessed for regular maintenance. To facilitate maintenance a ball valve is often used with a threaded plug or cap. The squirt height for the plug or cap with the correct size hole should be recorded for all new installations. During maintenance the squirt height is measured to verify that the system is functioning as planned and installed.

Figure VI-8. Valve Box for Access to Flush Lateral Lines

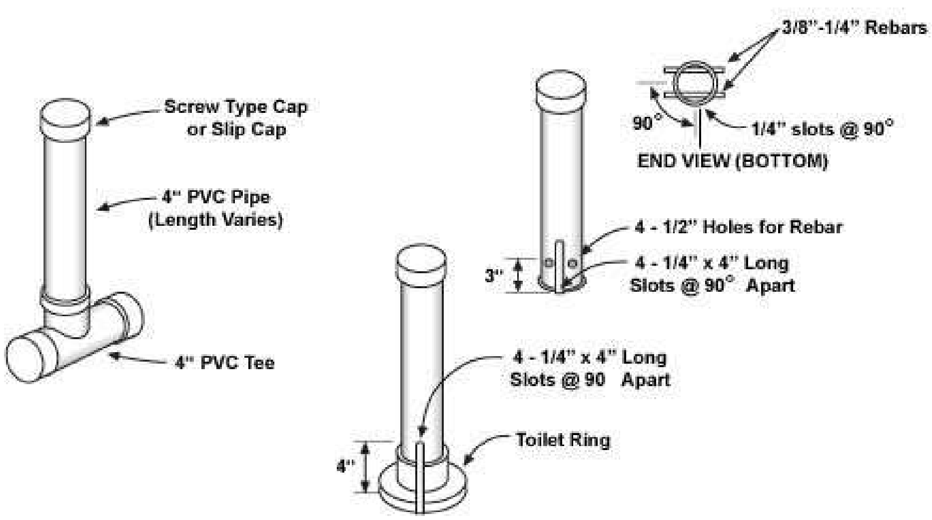
(not to scale)



Construction Step 8. **Install Observation Access**
Observation pipes extending from the absorption surface through the gravel to the top of the mound serve as a window and provide a convenient way to check the conditions and ponding of wastewater above the sand. At least two 4-inch observation pipes – one at either end of the distribution area – are recommended; three would be better. They are inexpensive to install at the time of construction. Three methods of anchoring observation pipes so they do not pull out are shown in Figure VI-9.

Figure VI-9. Three Methods of Anchoring Observation Pipes

(Converse and Tyler, 1990)



Construction Step 9. **Pressure Test and Cover the Distribution System**
Conduct a pressure test for each line to check for leaks, plugging, broken pipes, drainback, and to

record the squirt height of each line. The squirt height should be uniform for all distribution laterals. Cover the distribution system with clean, washed gravel. The holes on the top of the pipe must be shielded so they are not restricted by the gravel cover. A 4-inch perforated pipe slipped over the distribution pipe, or commercial deflectors make effective shields. Cover the gravel with geotextile fabric before placing the protective layer of soil on top of the mound. Chambers can also be used in place of gravel on top of the sand. The distribution laterals, as designed, are hung from the top of the chambers.

Construction Step 10. **Cover the Mound with Soil**
Cover the sand and gravel with an insulating layer of soil. Deliver soil cover material to the upslope side of the mound and cover the mound working from the upslope side. Never allow any heavy equipment on the area downslope of the mound before or during construction. On sloping sites, the treated wastewater must be able to flow downslope through the soil. Heavy equipment will cause unnecessary soil compaction and lead to bleed-out at the toe or downslope of the mound. Properly grade the upslope side of the mound to divert surface runoff around the mound. Stay on the mound while shaping the downslope side to limit soil compaction. A small bulldozer works well to shape the mound. Seed the soil cover of the mound to limit soil erosion as soon as the construction is completed. If it is late in the season, additional erosion control measures may be necessary.

Construction Step 11. **Complete and Deliver As-built Drawings**
Preparation of as-built drawings is strongly recommended for good record keeping. The as-built drawings should include actual mound system layout, elevations, benchmark, and start-up date. They should contain pertinent information needed for reference during service, especially the initial squirt height for each lateral. The drawings should be kept for personal records with copies provided to the owner and inspector. Photos make an excellent verification record.

MOUND MAINTENANCE

Maintenance-free wastewater treatment systems do not exist. All systems require some regular maintenance. Because mound systems have mechanical pumps, electrical controls, small diameter laterals, and orifices, they require semi-annual maintenance. Each inspection and maintenance should take a trained professional approximately 30 minutes to complete. For systems with great distances between pumps and the mound, it may take as long as one hour to complete the necessary inspection and maintenance.

Important inspection and maintenance tasks include:

- Make sure no trees or shrubs are planted on the mound. Tree roots may clog the distribution pipes.
- Avoid sprinkler systems and irrigation on the mound. Plant ground-cover vegetation that tolerates dry conditions, if necessary.
- Walk around the lot and look for landscape changes that could interfere with or damage the mound system.
- Walk downslope of the mound to check for signs of surfacing sewage.
- Locate and open each inspection port to check for ponding.
- Activate the pump and check alarms.

- Open valve box at the end of each lateral to open and flush lines to remove debris that may clog holes in the small lateral pipes.
- After the lines are flushed, measure the squirt height for each line and compare it to the initial test to check for orifice plugging, broken pipe, or other problem. Record the results of this pressure test each time maintenance is conducted.

MOUND SYSTEM SUMMARY

Mounds have a long history of use. When well designed, properly constructed, and adequately maintained they have a long service life. Mounds reliably provide high quality water to reach the natural soil surface under the mound. Mounds do not require a separate soil absorption system because the soil beneath the mound is the absorption field. Mounds are well suited to shallow soils and shallow or seasonally perched water tables. They are site specific so require a separate design for each site situation. The cost of engineered fill materials may make a mound more expensive than some other options. Because they have pumps, controls, and small diameter distribution pipes with orifices, they require more maintenance than traditional septic tank and lateral systems.

SAND FILTER SYSTEM

Sand filters have been used in wastewater treatment for many decades. The technology is used for single homes, clusters of homes, institutions, and small municipal systems. They have been used for discharging as well as non-discharging applications. Remember: In Kansas surface discharge from individual onsite systems is not permitted so a discharging system would only be an option for a cluster or a small community system that holds a NPDES permit.

Sand filters can be designed with several variations. All sand filters are designed and constructed to receive small, usually timed doses. This means that wastewater loading to the filter starts and stops at intervals. During the rest cycle wastewater seeps through the filter media while microbes provide the treatment and air is introduced before the next dose is applied.

Media is the material used in the bed of the filter. The media provides a degree of wastewater filtering or straining, but more importantly, provides a large surface area for the attachment of bacteria and other microorganisms that treat the wastewater. The media may range in size from sand to small pea gravel, depending on the design and operating conditions of the filter. The media must be within the size range specified in the design specifications to ensure that the filter will function properly. Other types of filters, similar to sand filters, utilize peat, foam, textile, or other material as media, and are discussed later in this chapter.

Sand filters may be designed and operated in either single-pass or recirculating mode. In a single-pass sand filter, the wastewater is applied to the top of the media and collected at the bottom for transfer to an absorption field. In a recirculating sand filter, the effluent from the media is split so part of it goes to the absorption field and the rest flows to the pump tank and is reapplied to the filter media. Typically, $^1/_3$ to $^1/_5$ of the effluent from the sand filter is sent to the absorption field and the remainder is recycled to pass through the filter media again. In general, single-pass sand filters are larger in surface area and use coarse sand media rather than small gravel typical of recirculating filters. Although all are operated intermittently, the term intermittent sand filter is often used to refer to single-pass systems.

Dosing can be based on either time or level of water in the pump chamber. Time-dosing applies wastewater to the sand media for a fixed amount of time (or dose volume) at fixed time intervals (dose interval) when float switches allow pumping to be done. Time-dosing gives more even distribution of the wastewater throughout the day but requires additional electronic controls. Even if time-dosing is used, the controls should be designed to override the timing and apply a dose if the level in the pump chamber rises too high, such as might occur when several loads of laundry are done in a short time period. Level-dosing applies wastewater whenever the water level in the pump or siphon chamber rises to a certain height and volume is not controlled.

Sand filters are usually used as the second step in wastewater treatment after solids in raw wastewater have been separated out in a septic tank. Effluent from a sand filter typically goes to a traditional soil absorption field. Over time, sand filters have proven themselves to be a reliable technology when properly designed, constructed, and maintained.

SAND FILTER COMPONENTS

Sand filters are constructed beds of sand or other suitable granular material, usually two to three feet deep. The filter material (called media) is typically contained in a liner made of plastic, concrete, or other impermeable material. Depending on the design, the sand filter may be situated above ground, partially above ground, or below ground, and the filter surface may be open or covered with soil. Septic tank effluent is applied to the filter surface in intermittent doses and receives treatment as it slowly trickles through the media. In most sand filters, the wastewater collects in an underdrain and flows by gravity or is pumped to an absorption field for final treatment and dispersal.

Sand filters are constructed and assembled on the site. Most materials are available locally, however, kits containing essentially all filter components, with the exception of the sand media, are also available. If the appropriate sand media cannot be obtained nearby, it must be shipped in, which will likely increase cost.

Suitable filter media can be purchased from aggregate companies or other suppliers. The media must be as clean and as uniform in size as possible to allow correct flow of wastewater. If the sand has too many small grains they will settle in the spaces between the larger grains, leaving inadequate space for the wastewater to flow. The media should be tested with a sieve analysis prior to use in the filter. The sieve analysis determines the amount of material that will pass through a mesh basket of a specific size.

Where appropriate sand media is not available or is too expensive, textile, foam, or peat media may be an alternative. A discussion of other media filters is included later in this chapter.

Sand Filter Operation

A few basic design, construction, and operating principles are common to every type of sand filter system. First, to prevent the sand filter from clogging, wastewater must be pre-treated in the septic tank to remove solids and scum. An effluent filter (or screen) is required in the septic tank as an additional step to ensure that no solids carry over to the filter media in times of heavy water use.

After the solids are removed in the septic tank, a pump equipped with an adjustable timing control doses the wastewater to the sand media in timed intervals. Applications are spaced intermittently to allow the sand media to drain between doses. This ensures that oxygen is introduced into the media between doses of wastewater. Oxygen is critical to the biological and chemical treatment processes taking place within the sand media.

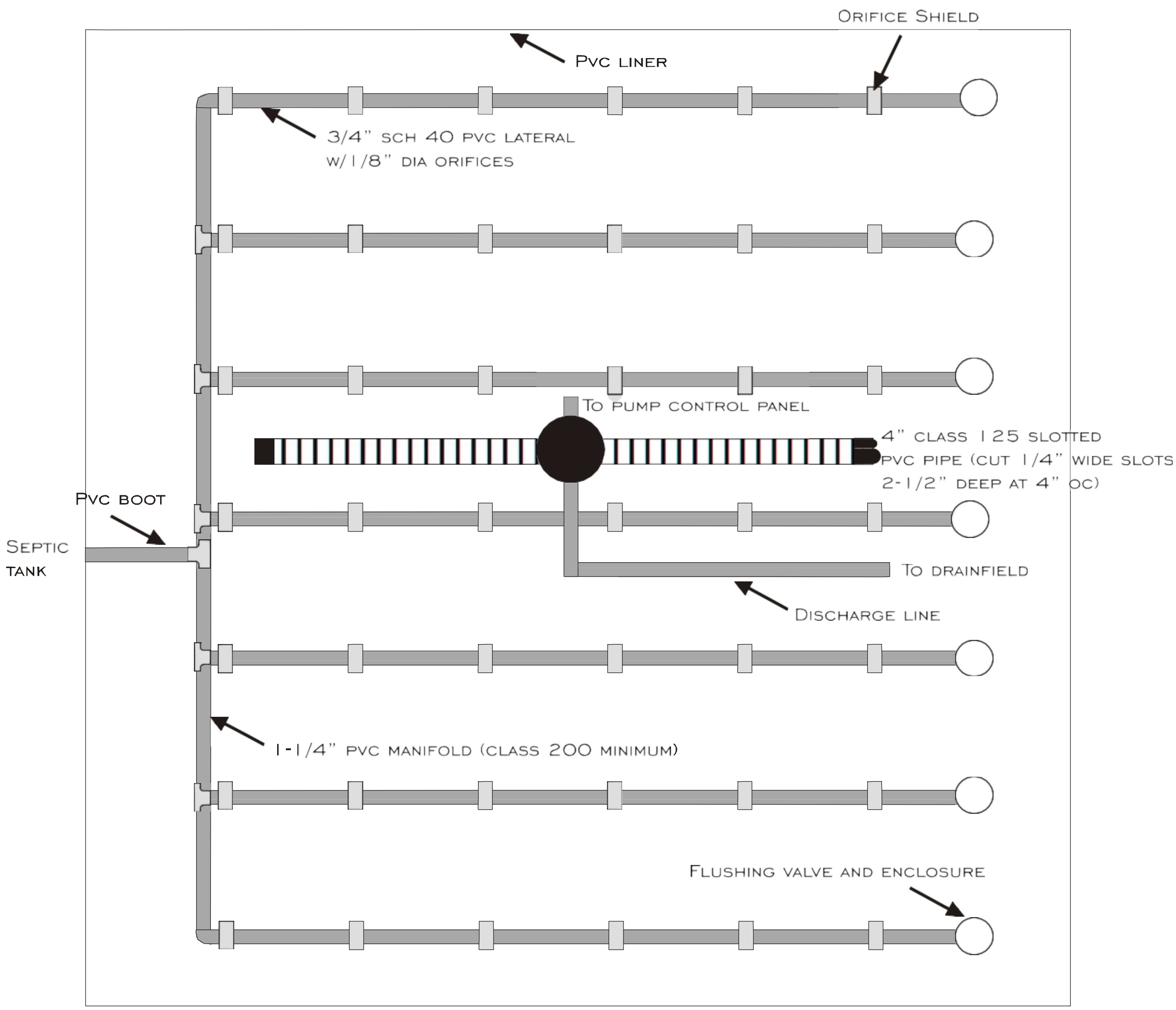
Historically, sand filters were designed to flood the complete media surface with a thin layer of wastewater. Modern designs distribute wastewater evenly across the sand media surface. This is often accomplished by metering it evenly throughout a network of low-pressure distribution pipes. Figure VI-10 shows a plan view of a typical sand filter. As the wastewater percolates slowly through the filter media, natural physical, biological, and chemical processes occur which provide treatment. Most treatment occurs within the first 6 to 12 inches of the sand filter surface.

As wastewater percolates through the filter media suspended solids adhere to the sand grain surfaces through a process called adsorption where negatively charged grain surfaces attract positively charged waste particles. Larger suspended particles are also trapped in voids between grains.

Sand filters accomplish much of the treatment through natural biological processes. Like the soil in every yard, sand filters are home to a variety of organisms, many of which contribute to treatment by consuming organic matter in the wastewater. The sand media serves as a substrate with abundant pore space to transmit oxygen essential to the organisms. Bacteria are the most abundant organisms in the filters, and they decompose most of the waste. Other beneficial microbes found in the filter media include protozoa and worms, which also contribute to treatment. Most organic matter is broken down by microbes in the filter.

After the filter media has matured, usually within a few weeks, a microbial layer, called a biomat is formed at the boundary of the distribution network and the sand media. This thin dense layer is the most significant part of the sand filter. This layer contains a high concentration of microorganisms including bacteria and protozoa that consume the organic material in the wastewater. Protozoa feed on the bacteria and help prevent the biomat from becoming so thick that it clogs the sand media. This balance between the various life forms and the physical and chemical processes taking place in the sand filter results in extremely efficient, natural wastewater treatment. However, these systems do have mechanical and electrical components that must have regular maintenance.

Figure VI-10. Plan View of Sand Filter Laterals and Drain



Single-Pass Sand Filter

Single-pass sand filters are constructed onsite and usually require an excavation about 3 to 4 feet deep. Single-pass (or intermittent) sand filter media has an effective size of 0.25 to 0.75mm. Before construction, a thorough site evaluation is needed to ensure the media bed will be level. The media bed must also be located to prevent inflow of surface water runoff. Generally, the entire media bed is contained in an impermeable membrane liner. A graded layer of washed gravel such as pea gravel is placed around underdrain pipes at the bottom of the media bed. The filter media is then placed on top of the layer of pea gravel. As with all sand filters, the depth of the media depends on the size of the grains and other factors, but normally ranges from 24-36 inches. Another layer of pea gravel is placed on top of the media bed, surrounding the network of distribution pipes. Geotextile fabric is then placed on top of the entire bed and covered with loam topsoil. A section view of a typical single-pass sand filter is shown in Figure VI-11.

Most single-pass sand filters are dosed frequently using a timer. After the wastewater percolates through the bed, it collects in the underdrains. From here it either flows or is pumped to a soil absorption field for final treatment. The hydraulic loading rate for single-pass sand filters is typically 1.2-1.5 gallons per day, per square foot. This is a relatively low rate compared with other sand filters, which helps to ensure the filter does not become overloaded or clogged. Due to this low hydraulic loading rate, single-pass sand filters usually require more surface area to treat the same amount of wastewater than recirculating sand filters. However, with efficient landscaping techniques, the space used for single-pass sand filters can be available for other aesthetic uses.

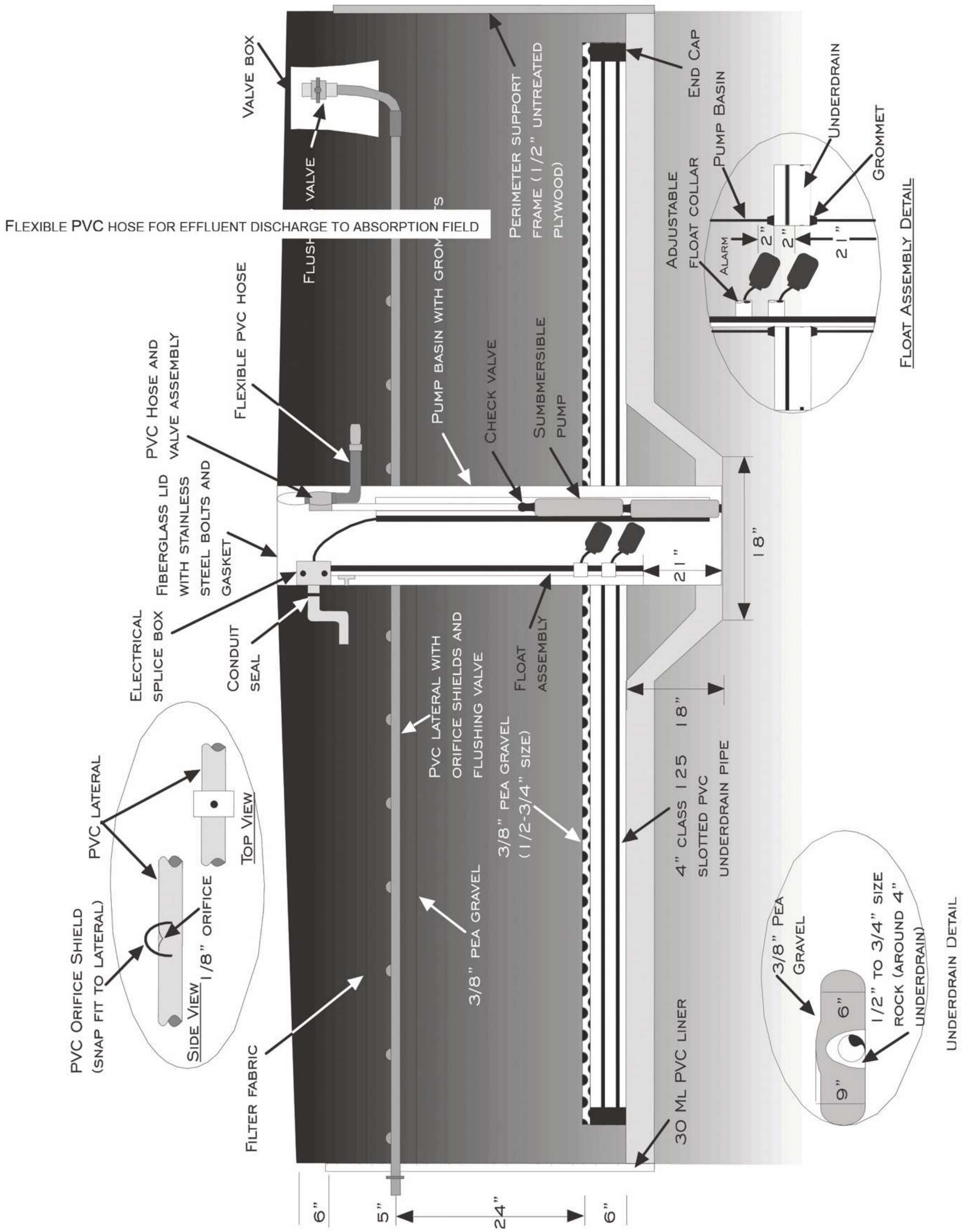
Recirculating Sand Filter

In a recirculating sand filter, wastewater flows by gravity from the septic tank to a dose tank, which is equipped with a pump, floats, and controls. Wastewater is then pumped to the filter media when it reaches a certain level in the tank or in timed doses. After the wastewater trickles through the media, it is collected in the underdrains. A flow splitter, either in the filter or dose tank, then directs a portion of this treated wastewater back to the dose or recirculation tank where it mixes with septic tank effluent and is returned to the filter media. The remaining filter media effluent bypasses the recirculation or dose tank and goes directly to the soil absorption field.

The recirculated sand filter effluent has a ratio of 3:1 to 5:1 when compared to effluent discharged to the soil absorption field. Weirs, moveable gates, and other devices are often used to direct part of the sand filter return flow to the recirculation tank and the remaining flow goes to the absorption field. A common way to divide flow is to use a tee in the return line from the sand filter underdrain that extends into the recirculation tank with the straight part going to the soil absorption field. A rubber ball in a screened cage rises with the water in the tank and plugs the tee when the tank reaches a certain level. When this happens, the remaining sand filter effluent is diverted to the soil absorption field.

Regardless of how flow is divided, the filter effluent and septic tank effluent are mixed in the recirculation tank so the wastewater applied to the sand filter is less concentrated than septic tank effluent. The wastewater also contains more oxygen than septic tank effluent, which helps eliminate odors.

Figure VI-11. Section View of Typical Single-Pass Sand Filter Showing Components



The recirculating sand filter media has an effective size of 0.8-3.0 mm, which is coarser than media used in single-pass sand filters and, therefore, less prone to clogging. Hydraulic loading rates typically are 3-5 gallons per day per square foot, which means that less area is needed to treat the same amount of wastewater than with single-pass sand filter designs. Recirculating filters require more energy and routine maintenance than single-pass sand filters. Unlike the single-pass sand filter that is covered with soil, recirculating sand filters are typically covered with small stones or a loose-fitting cover, which maximizes oxygen transfer and minimizes disturbance.

Disadvantages of recirculating sand filters are that they are more sensitive to cold temperatures and more prone to freezing than the single-pass filter that is regularly dosed with warmer septic tank effluent and protected by a soil cover. Sometimes this problem can be remedied by adjusting the dosing frequency and recirculation ratio or by providing the sand filter bed with an insulating cover.

Recirculating sand filters are more commonly used for treating wastewater from small communities, residential developments, recreational areas, shopping centers, or institutions. They can be used for sources generating up to 120,000 gallons of wastewater per day. They are usually constructed with two or more beds that can be operated in parallel or in series, which allows parts of the filter media to be rested while others are working. Some recirculating sand filters have removable covers that insulate from extreme cold weather, reduce odors, and minimize maintenance. Because odors are generated when septic tank effluent is dosed to the filter surface, the sand filter should be sited downwind from residences and businesses.

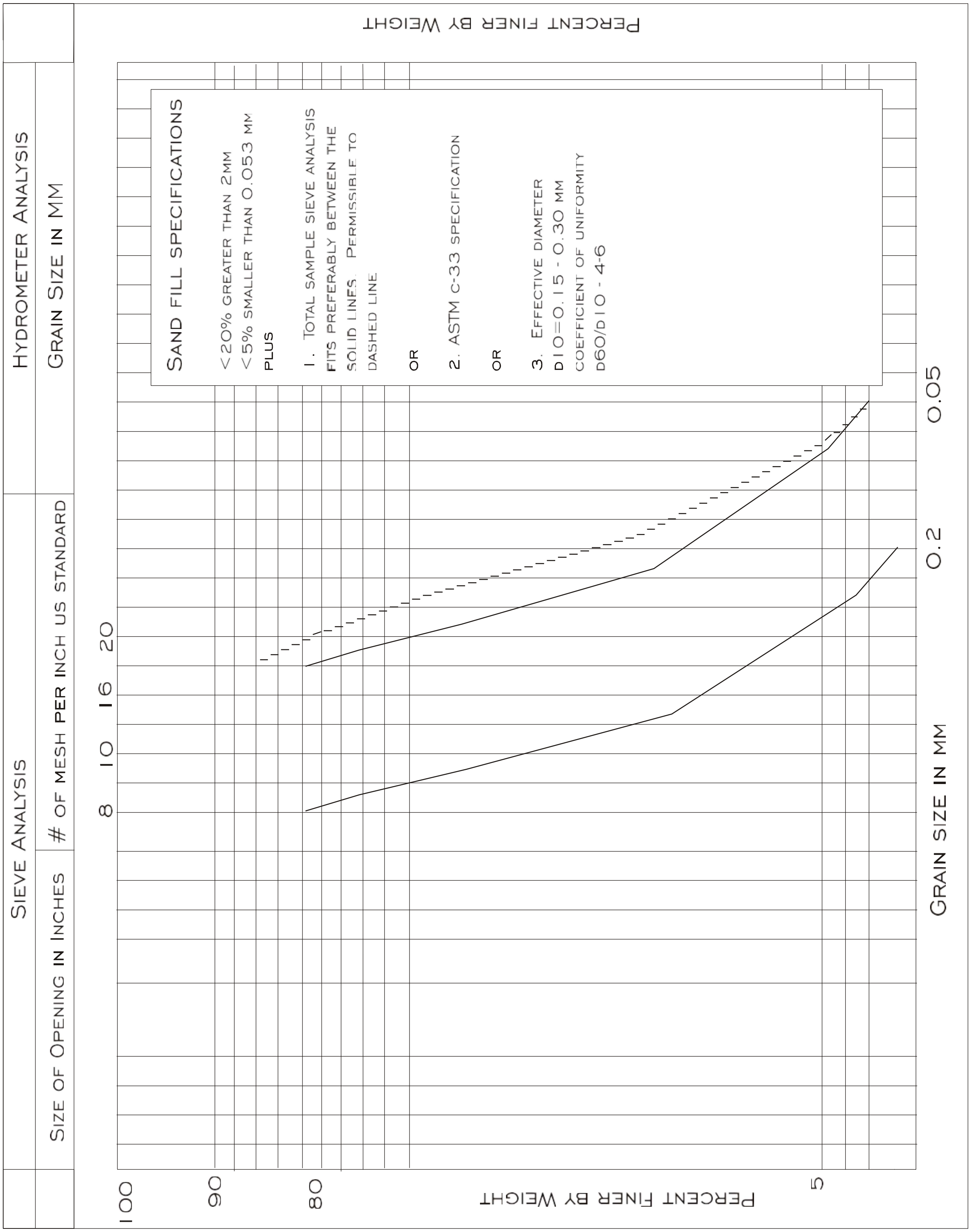
Sand Filter Media

The composition, size, uniformity, and depth of the media affect sand filter performance. In some areas where sand is not available locally, other materials, such as crushed glass, anthracite, garnet, mineral tailings, or bottom ash, may be used for filter media. Characteristics of the media’s composition, such as its solubility, acidity, and hardness, must be considered in the filter design.

The size and uniformity of the filter media also affects the performance of the sand filter. Grains should be relatively uniform in size to prevent clogging. The media should be neither too coarse nor too fine. Coarse media may allow wastewater to pass though the filter too fast and not receive adequate treatment. Fine media may slow passage too much, is prone to clogging, and can prevent good oxygen transfer to parts of the filter.

“Effective size” and “uniformity coefficient” are measurements used to express these characteristics. Effective sizes for sand filter media range from 0.25-3.0 mm in diameter. Both types of sand filters have specific media size range requirements. A uniformity coefficient of four or less is recommended for all filter media. Figure VI-12 shows example sand filter media sieve analysis of a coarse media for recirculating filter and fine media for a single-pass filter. It is extremely important that the media be washed to be free of fines. A qualified person, perhaps an engineer, should inspect the media for cleanliness before it is used as filter media.

Figure VI-12. Examples of Sand Filter Sieve Analysis



Sand Filter Loading

The organic loading rate depends on the strength of the wastewater. Know the concentration of wastewater before designing the system. Wastewater containing high levels of organic material can reduce the filter's effectiveness over time and increase the need for maintenance.

Hydraulic loading, or the amount of wastewater distributed over the media surface, must be uniform to ensure consistent treatment. Uneven distribution may cause one part of the media bed to be overloaded and wastewater may be flushed through the media without receiving adequate treatment. Wastewater dosed too frequently causes similar problems. Doses should be spaced to allow the media adequate time to drain and re-aerate.

Sand Filter Treatment Efficiency

Biochemical oxygen demand (BOD) and Total Suspended Solids (TSS) are common indicators used by regulatory agencies to assess wastewater treatment and the impact of discharge on the environment. BOD is a measure of the amount of oxygen microorganisms need to consume and break down organic matter, and is typically measured for 5 days. TSS is a measure of the amount of particulates suspended in the wastewater. Single-pass sand filters are capable of reducing five-day BOD and TSS in wastewater to 5 and 17 mg/L or less, respectively (see Table VI-2). Sand filters also remove many pathogens, such as viruses and harmful bacteria. One disadvantage of sand filters is that they are not very effective at removing phosphorus from wastewater. Single-pass filters oxidize nitrogen but are not considered effective nitrogen removers. Recirculating filters oxidize the nitrogen and return the effluent to the anaerobic dose tank resulting in some denitrification.

Sand Filter Operation and Maintenance

Most operation and maintenance requirements for single-pass and recirculating sand filter beds are relatively simple. Maintenance for some system components includes periodic inspection and service by a trained service provider. For example, electrical components, such as alarms, pumps, floats, and timers, need to be checked and serviced according to manufacturer's recommendations. Measurement of the septic tank sludge and scum depths should be done after the first year of installation and approximately every three years thereafter to determine when the septic tank needs pumping. Pipes, valves, and other system components need to be checked regularly, and screens and filters need to be cleaned.

Pumps used for onsite systems are often designed to last 10-25 years. In corrosive environments they deteriorate and are subject to wear. Electrical components deteriorate with age and use, so they will need to be replaced. As with all mechanical devices, regular maintenance of the system extends the useful life.

A key maintenance issue for a single-pass sand filter is to flush the distribution lines. It is important to clean accumulated solids out of the lines and keep the distribution orifices (holes) clear so that the effluent is spread uniformly over the sand media. Failure to perform line flushing will eventually cause non-uniform loading and clogging at the sand media surface (biomat) in areas of overload. Each distribution line typically has a cleanout assembly at the end for flushing. It is recommended that the distribution lines be flushed at least annually.

Sand filter performance is quite consistent over time. Operation and maintenance requirements are moderate; more than traditional septic tank lateral systems but less than many other enhanced treatment systems. In addition, overall treatment costs often compare favorably with other alternative systems.

Eventually, in some filters the biomat may become clogged. When this happens removing the top layer of sand or raking the surface to disrupt the biomat are options. However, in buried filters this is not a feasible option so temporarily removing the filter from service until the biomat breaks down is a possible option.

PEAT, TEXTILE, FOAM, AND OTHER MEDIA FILTERS

Under certain conditions, other types of media filters may be used in place of sand filters. These filters may be suitable for locations where sand media is not available or when onsite construction of a sand filter is not possible or practical. These filters are similar in function and design to a sand filter. However, a prepackaged media bed unit is typically used in place of a site built sand filter. The media used in the prepackaged unit may be a natural material such as peat, or a synthetic material such as textile. Other types use synthetic foam or some type of fixed film material such as small plastic balls as media. One disadvantage of the peat system is that the peat must be replenished and replaced over time. Replacement intervals are estimated to be seven to eight years.

Advances being made in alternative media filter design are occurring too rapidly to justify a detailed discussion of all these systems. The designer is advised to consult the latest manufacturers' information, research, or review articles. The basic operational principles for media filters remain similar or the same as sand filters. Septic tank effluent is intermittently dosed to the filter and treated effluent is discharged to a soil absorption system.

The textile filter operates in much the same way as a peat filter. The textile filter comes in a prepackaged module which is brought to the site and connected in series or parallel with other modules. The textile filter provides a large surface area for the development of a microbial population to assist in higher treatment efficiency. In addition, the textile media retains high porosity which helps maintain aerobic conditions. Some textile filters may contain a small ventilation fan to aid in keeping air available, so the media remains aerobic. The textile filters may be constructed as single pass or recirculating similar to sand filter designs. A higher level of treatment is achieved if the system is recirculating. Textile filters also require routine maintenance. The filter media may be cleaned and reused if clogging occurs.

ROCK-PLANT FILTER (VEGETATED SUBMERGED BED)

A natural wetland's ability to cleanse and treat contaminated water has been recognized for a long time. However, the use of small constructed wetlands (rock-plant filters) for treatment of wastewater from small sources – homes, businesses, and similar sources – is relatively new. The term "rock-plant filter" has been selected because, even though these systems use wetland plants and share some of the same natural processes as a natural wetland, they are man-made systems. In recent years the term "vegetated submerged-bed" has been adopted in the onsite industry.

Most rock-plant filters in the United States are located in the southeastern part of the country, but they are also used in Scandinavia and Canada. The first rock-plant filters in Kansas were installed in 1993. Changes in design specifications for use in Kansas have been based on monitoring of these systems. A publicly accessible system installed in 1995 is located at the Corps of Engineers swimming beach at the gathering pond below Milford Lake.

A rock-plant filter consists of a traditional septic tank, a lined treatment cell, and a soil absorption field. The lining of the treatment cell must be impermeable to prevent the loss of wastewater from the cell or allow the inflow of water during a wet season. Typically, a heavy plastic membrane or well-compacted clay is used. The absorption cell or field transfers the pre-treated wastewater to the soil. Several options can be used for the absorption field including: an unlined wetland using plants that can tolerate both wet and dry conditions, traditional rock and pipe or chamber laterals, or other soil absorption.

As with other enhanced treatment systems, rock-plant filters provide a substantially higher level of pretreated wastewater than traditional septic tanks. Plant roots serve as a structure for bacterial attachment and consume some wastewater nutrients. A significant amount of treatment by bacterial action in the rock bed continues even when the plants are dormant, resulting in little variation in effluent quality throughout the year.

Of the different types of enhanced treatment systems (such as sand filters and ATUs), the rock-plant filter is the only option that does not require electricity for operation. On sites where elevations and slope allow for gravity flow through the treatment and absorptions cells the operational expense is minimal. This system does require homeowner (or service provider) awareness and maintenance to monitor system performance and check that the plants are in good health. Specifically, any activity that results in large doses of chemicals like bleach, pesticides, antibiotics, lye, etc. will damage or kill both plants and beneficial microbes.

K-State Research and Extension publication, *Rock-Plant Filter Design and Construction for Home Wastewater Systems*, MF-2340 describes current ideas about designing and installing rock-plant filters for use in Kansas. The companion publication *Rock-Plant Filter Operation,*

Maintenance, and Repair, MF-2337 presents information about how to service and care for these filters for good, long term performance. This type of care is needed to assure that the treatment component will function as designed and intended.

REFERECES AND OTHER READING MATERIALS

Cited and Quoted References

Converse, J.C. and E.J. Tyler. 1988. *Inspecting and Troubleshooting Wisconsin Mounds*, G3406. Agricultural Bulletin, Rm 245, 30 North Murray Street, Madison, WI 53715.

Converse, J.C. and E.J. Tyler. 1990. *Wisconsin Mound Soil Absorption System: Siting, Design and Construction Manual*. Small Scale Waste Management Project, 240 Agricultural Hall, University of Wisconsin-Madison, Madison, WI 53706.

Converse, J.C. and E.J. Tyler. 2000. *Wisconsin Mound Soil Absorption System: Siting, Design and Construction Manual*. Small Scale Waste Management Project, 240 Agricultural Hall, University of Wisconsin-Madison, Madison, WI 53706.

Kansas Department of Transportation, Office of Construction Administration. 2002. Construction and Material Specifications.

Ohio Department of Transportation. 2002. *Construction and Material Specifications*. Office of Construction Administration.

Shutt, K., D. Vala, J.C. Converse, and R.J. Otis. 1989. *Locating and Landscaping the Mound System of On-Site Waste-Water Disposal*, G2940. Small Scale Waste Management Project, University of Wisconsin-Madison.

Tyler, E.J. and L.K. Kuns. 2000. *Designing with Soil: Development and Use of a Wastewater Hydraulic Linear and Infiltration Loading Rate Table*. Conference Proceedings – Onsite: The Future of Water Quality, National Onsite Wastewater Recycling Association, P.O. Box 1270, Edgewater, MD 21037-7270

Wisconsin, DOC. 1999. *Single Pass Sand Filter Component Manual for Private Onsite Wastewater Treatment Systems*. State of Wisconsin, Department of Commerce, Division of Safety and Buildings, SBD-10595-P (R.6/99)

OTHER READING MATERIALS

Powell, G.M., B.L. Dallemand, and J.M. Willingham, 1998. *Septic Tank Maintenance: A Key to Longer Septic System Life*. MF-947, Kansas State University Research and Extension, Manhattan, KS 66506.

Ohio Administrative Code, *Household Sewage Rules*, Chapter 3701-29. Ohio Department of Health, July 1977.

Powell, G.M., B.L. Dallemand, and K.R. Mankin, 1998. *Rock-Plant Filter Design and Construction for Home Wastewater Systems,* MF-2340, Kansas State University Research and Extension, Manhattan, KS 66506.

Powell, G.M., B.L. Dallemand, and K.R. Mankin, 1998. *Rock-Plant Filter Operation, Maintenance, and Repair*, MF-2337, Kansas State University Research and Extension, Manhattan, KS 66505.

Powell, G.M., B.L. Dallemand, and J.M. Willingham, 2004. *Selecting an Onsite Wastewater or Septic System*, MF-2542, Kansas State University Research and Extension, Manhattan, KS 66505.

Sievers, D.M., 1993. *Design of Submerged Flow Wetlands for Individual Homes and Small Wastewater Flows*, Special Report 457, Fall, Missouri Small Wastewater Flows Education and Research Center, Agricultural Experiment Station, College of Agriculture and Natural Resources, University of Missouri – Columbia, MO 65211.

Solomon, C., P. Casey, C. Mackne, and A. Lake. 1998. *Intermittent Sand Filters*, Fact Sheet WWFSGN104, National Small Flows Clearinghouse, West Virginia University, PO Box 6064, Morgantown, WV

Solomon, C., P. Casey, C. Mackne, and A. Lake, 1998. *Recirculating Sand Filters*, Fact Sheet WWFSGN103, National Small Flows Clearinghouse, West Virginia University, Morgantown, WV

USEPA, 2002. *Continuous-Flow, Suspended-Growth Aerobic Systems (CFSGAS)*, OWTS Fact Sheet 1, in Onsite Wastewater Treatment Systems Manual, EPA/625/R-00/008. Environmental Protection Agency.

USEPA, 2002. *Enhanced Nutrient Removal – Nitrogen*, OWTS Fact Sheet 9, in Onsite Wastewater Treatment Systems Manual, EPA/625/R-00/008, Environmental Protection Agency.

USEPA, 2002. *Enhanced Nutrient Removal – Phosphorous,* OWTS Fact Sheet 8, in Onsite Wastewater Treatment Systems Manual, EPA/625/R-00/008, Environmental Protection Agency.

USEPA, 2002. *Fixed-Film Processes,* OWTS Fact Sheet 2, in Onsite Wastewater Treatment Systems Manual, EPA/625/R-00/008, Environmental Protection Agency.

USEPA, 1980. Design Manual: *Onsite Wastewater Treatment and Disposal Systems*, EPA 625/. Environmental Protection Agency Office of Water Program Operations, Washington, DC 20460. Office of Research and Development, Municipal Environmental Research Laboratory, Cincinnati, OH 45268.

USEPA, 2002. *Recirculating Sand/Media Filters*, Technology Fact Sheet 11. Onsite Wastewater Treatment Systems Manual, EPA 625/R-00/008, Environmental Protection Agency.

USEPA, 2002. *Intermittent Sand/Media Filters*, Technology Fact Sheet 10. Onsite Wastewater Treatment Systems Manual, EPA/625/R-00/008, Environmental Protection Agency.

USEPA, 2002. *Vegetated Submerged Beds and Other High-Specific-Surface Anaerobic Reactors*, OWTS Fact Sheet 5, Onsite Wastewater Treatment Systems Manual, EPA/625/R- 00/008, Environmental Protection Agency.

WA State Department of Health, 1992. *Properly Managing Your Sand Filter System*, EB1670, Cooperative Extension, Washington State University, Pullman, WA.

PROTOCOL
INSPECTION OF NEW OR EVALUATION OF EXISTING ENHANCED TREATMENT UNITS

GOAL: Ensure the integrity of the enhanced treatment component to adequately treat wastewater, protect waters of the state from contamination, and dispose of human waste in a sanitary manner for the protection of public health.

POLICY: Inspection of a new or evaluation of existing enhanced treatment unit will be completed at the request of the landowner, contractor, lending agency, or other concerned party. The inspection of a new enhanced treatment unit shall occur before the unit is put into operation. The inspection shall address at least the evaluation points listed below. An assessment summarizing the inspection or evaluation shall be provided to all individuals who have legal interest in the outcome of the evaluation. A file of all original letters, data, supporting evidence and documents shall be maintained by the permitting agency.

PROCEDURE:

1) If the enhanced treatment unit is manufactured, refer to the manufacturer’s guidelines and instructions for specific standards applicable to the unit being inspected or evaluated.

2) All new enhanced treatment units should meet the design and construction guidelines from one or more of the following sources: the Environmental Health Handbook; K-State Research and Extension publications; publications of National Small Flows Clearing House, EPA, established equipment manufacturer, National Onsite Wastewater Recycling Association (NOWRA), or other credible source. Record which guidelines the unit meets.

    a) The electrical supply shall be served by a separate circuit that is only connected to the enhanced treatment unit component and related equipment.

    b) All electrical connections outside of buildings are made in a water tight enclosure or sealed in moisture proof materials. Existing electrical and mechanical components must show no evidence of corrosion, especially at connections. Any corroded parts or materials shall be replaced with new parts or materials.

    c) All wiring outside of buildings shall be in water-tight exterior conduit. Any conduit that penetrates a container which will have a moist or corrosive atmosphere (such as pump tank or septic tank) shall be sealed by caulk, a trap containing mineral oil, or other method. This prevents corrosive gasses from the container exiting through the conduit to the control panel or other location, and causing corrosion.

    d) The control panel should be easily accessible with tamper resistant closures. The control panel components should be clearly labeled and should include instructions about the purpose and adjustments of the various components.

e) All systems with a liquid pump should have a high water level alarm. The float should be lifted to activate the alarm, verifying that the alarm sounds and can easily be heard inside the house.

f) For all liquid pumps, lift the float that activates the pump to be sure it operates as designed and installed. While the pump is operating, check that water is reaching only the intended delivery point. Verify that there are no leaks in the delivery line. Lush vegetation near the septic tank, pump tank, or along the pipeline route may be evidence of a leak. If timers are used in the control panel, check that they are set in accordance with the instructions (a copy should be in the control panel).

g) Check for evidence of past malfunction or problems including: high water level in pump tank, wet conditions on ground surface, or lush vegetation in unexpected locations such as around pump tank or pressure lines to the field.

h) For existing systems, check water use records or obtain a statement signed by owner that there are no water leaks into drains (provide dye tablets to the owner or occupant to check for leaking toilets). This will prevent system overload from excess water.

i) Determine if there has been any change in activity such as a bedroom addition, home business, or home food production or preservation that would increase flows or change wastewater “strength”.

j) Look carefully for evidence of damage or openings where extraneous water may enter the system (down spout, sump pump, surface runoff, etc.)

Look for water treatment components that may add excessive volumes of wastewater exceeding the system design. This equipment could include automatic flushing filters, a whole-house reverse osmosis system, or similar types of equipment.

APPENDIX A. MOUND DESIGN COMPUTATION SHEET
(Domestic Wastewater Only)

Step 1.
Site and Soil Evaluation.

1. Site slope is _____________ percent, or percent /100 = ______________ (decimal).

2. The available area is _____________ feet length; _____________ feet width.

3. Depth to limiting soil condition is _____________ inches.

Step 2.
Determine Wastewater Flow Rate.

The **Wastewater Flow Rate** is _____________ gpd (_____________ bedrooms x 150 gpd).

Step 3.
Select the Linear Loading Rate (from Table VI-5): Linear Loading Rate _______ gpd/lf.

Impermeable layer or water table, 3 to 4 gpd/lf; Semi-permeable layer, 5 to 6 gpd/lf; Permeable or cracked rock layer, 8 to 10 gpd/lf.

Step 4.
Select the Sand Fill Loading Rate. Sand Fill Loading Rate is 1 gpd/ft^2.

As long as the recommended sand fill specifications is followed.

Step 5.
Determine the Distribution Area Width.
Distribution Area Width = Linear Loading Rate / Sand Fill Loading Rate.

Distribution Area Width is _____________ feet, or is _____________ inches.

Step 6.
Determine the Distribution Area Length.
Distribution Area Length = Wastewater Flow Rate / Linear Loading Rate

Distribution Area Length is _____________ feet.

Step 7.
Select the Basal Area Loading Rate (from Table VI-5).
The basal loading rate is based on the surface soil layer but may be reduced because of the underlying soil profile conditions.

The **Basal Loading Rate** is ____________ gpd/ft^2.

Step 8.
Determine the Minimum Basal Width.
Minimum Basal Width = Linear Loading Rate / Basal Area Loading Rate.

Basal Width is _____________ feet.

Step 9.
Determine Upslope Sand Fill Depth.
Upslope Sand Fill Depth = (48 inches) **-** (Depth to limiting soil condition).

Upslope Sand Fill Depth is _____________ inches.

Step 10.
Determine Downslope Sand Fill Depth.
Downslope Sand Fill Depth = (Upslope Sand Fill Depth) + (Site Slope as a decimal) x (Distribution Width in inches).

Downslope Sand Fill Depth is _____________ inches.

Step 11.
Select the Distribution Area, Distribution Cap, and Mound Cover Depths.

Distribution Area (Aggregate) Depth is 9 inches.

Mound Cover Depth = 6 inches.

Distribution Cap Depth is_____________ inches. Distribution cap depth range is 8-12 inches. The wider the Distribution area the deeper the cap should be to ensure good drainage of runoff.

Step 12.
Determine the Upslope Fill Width.

Upslope Width = (Side Slope Ratio) x (Upslope Sand Fill Depth + Aggregate Depth + Mound Cover Depth) x (Upslope width correction factor) from table below.

Upslope Width is _____________ inches, or _____________ feet.

Step 13.
Determine the Downslope Fill Width.

Downslope Width = (Side Slope Ratio) x (Downslope Sand Fill Depth + Aggregate Depth + Mound Cover Depth) x (Downslope width correction factor) from table below.

Downslope Width is _____________ inches, or _____________ feet. The Downslope Width plus the Absorption Area Width must equal or exceed the Basal Area Width.

Step 14.
Determine the End Slope Length.

End Slope Length = (Side Slope Ratio) x [Average sand fill depth (Upslope Sand Fill + Downslope Sand Fill) / 2] + Aggregate Depth + Mound Cover Depth).

End Slope Length is _____________ inches, or _____________feet.

Step 15.
Overall Mound Length and Width.

Overall Length = (Distribution Area Length, feet) + (2 x End Slope Length, feet).

Overall Length is _____________ feet.

Overall Width = (Distribution Area Width, ft) + (Upslope Width, ft) + (Downslope Width, feet).

Overall Width is _____________ feet.

Site Slope (percent)	Upslope Width Correction Factors					Downslope Width Correction Factors				
	Side Slope Ratios (run per unit of rise)					Side Slope Ratios (run per unit of rise)				
	3	4	5	6	7	3	4	5	6	7
0	1	1	1	1	1	1	1	1	1	1
1	0.971	0.962	0.952	0.943	0.935	1.031	1.042	1.053	1.064	1.075
2	0.943	0.926	0.909	0.893	0.877	1.064	1.087	1.111	1.136	1.163
3	0.917	0.893	0.870	0.847	0.826	1.099	1.136	1.176	1.220	1.266
4	0.893	0.862	0.833	0.806	0.781	1.136	1.190	1.250	1.316	1.389
5	0.870	0.833	0.800	0.769	0.741	1.176	1.250	1.333	1.429	1.538
6	0.847	0.806	0.769	0.735	0.704	1.220	1.316	1.429	1.563	1.724
7	0.826	0.781	0.741	0.704	0.671	1.266	1.389	1.538	1.724	1.961
8	0.806	0.758	0.714	0.676	0.641	1.316	1.471	1.667	1.923	2.273
9	0.787	0.735	0.690	0.649	0.613	1.370	1.563	1.818	2.174	2.703
10	0.769	0.714	0.667	0.625	0.588	1.429	1.667	2.000	2.500	3.333
11	0.752	0.694	0.645	0.602	0.565	1.493	1.786	2.222	2.941	4.348
12	0.735	0.676	0.625	0.581	0.543	1.563	1.923	2.500	3.571	6.250
13	0.719	0.658	0.606	0.562	0.524	1.639	2.083	2.857	4.545	11.111
14	0.704	0.641	0.588	0.543	0.505	1.724	2.273	3.333	6.250	50.000
15	0.690	0.625	0.571	0.526	0.488	1.818	2.500	4.000	10.000	

Chapter VII
SOIL ABSORPTION SYSTEMS

PROTOCOLS

TABLES

FIGURES

INTRODUCTION

A septic tank followed by an in-ground soil absorption system is the preferred on-site wastewater treatment method in Kansas. Surface discharge of effluent or wastewater or from any on-site wastewater systems is illegal in Kansas without an NPDES discharge permit. However, NPDES permits are not issued for individual on-site systems, and ultimately effluent from these systems must go into the soil or be evaporated. A wide range of options and products are available to distribute effluent throughout the soil for final treatment. In the case of lagoons, seepage and water surface evaporation are the mechanisms for dispersal. Soil beneath a mound or lagoon system is its own absorption field, thus no additional effluent dispersal mechanism is needed for these alternatives.

In a properly functioning septic tank, the composition of raw sewage changes. Solids settle to the bottom for later removal, or float to the surface and are partly digested. Septic tank effluent is still sewage with abundant pollutants and harmful microorganisms. Underground application of effluent in suitable soil at appropriate rates provides good treatment and is safe for the environment. When the absorption field is shallow (near the surface), plant roots will take up some of the nutrients, especially nitrogen, during active growth periods. This helps reduce nitrate movement through the soil to the groundwater. In soils with appreciable clay content, adsorption removes much of the phosphorous in the wastewater.

Inspection of the wastewater treatment system, regardless of the type chosen, is essential for a local permit to be issued. Suggested inspection protocols for both new and existing systems are provided on pages VII-29 and VII-32 later in this chapter.

KDHE Bulletin 4-2 specifies the need for four feet of suitable, aerated soil between the bottom of the wastewater absorption area and the shallowest restrictive layer. Four feet of soil helps ensure adequate treatment and removal of pollutants. As discussed in Chapter IV, *Site and Soil Evaluations*, restrictions such as an impermeable soil layer, high water table, rock, or other feature may limit downward water movement and adequate treatment.

Excessive phosphorous and nitrogen contribute to accelerated eutrophication and degraded water quality in surface water, especially lakes or ponds. Sandy, gravelly, or rocky soils are more limited in capacity to remove nutrients, contributing to excess nutrients at a lake's shore or branches from the main lake body. In these sensitive, ecologically critical areas, greater separation distances or designs that more reliably remove nutrients may be required.

An important consideration for an absorption field location is the possibility of future connection to public sewers. A home's plumbing should be designed to facilitate a future public sewer connection if central systems may be installed in the future. When public sewer service becomes available, the private system should be removed from service and properly abandoned. See the K-State Research and Extension publication *Plugging Cisterns, Cesspools, Septic Tanks, and Other Holes*, MF-2246, for additional information.

Choosing the Soil Absorption System

The most common effluent soil absorption system is a traditional septic tank followed by a lateral absorption field. Traditional absorption fields are well suited to deep, sandy and loamy (medium to coarse texture) soils. Soil profile layers must be moderate or well- drained and have adequate capacity to absorb and transmit water. On relatively flat sites, laterals of the same elevation are commonly supplied by a manifold or distribution box (also called a "D" box). Where surface slopes exceed 1½ percent, use of serial distribution laterals with drop boxes is strongly recommended. Individual absorption laterals should always follow the surface contour, be level, and have a uniform depth of cover, regardless of using a level or serial distribution system.

Advanced treatment, as discussed in Chapter VI, and/or alternative soil absorption systems are used when soil conditions are restrictive due to high groundwater, flooding, slowly permeable soil, shallow bedrock, or inadequate lot size. Alternative soil absorption systems provide fundamentally sound solutions when correctly designed, installed as planned, well managed, and adequately maintained. Consider long-term sustainability, installation and maintenance cost, availability of service, and continued use of the home, as well as public health hazards, environmental pollution, and prevention of nuisance conditions when choosing the system.

On-site wastewater system component features are chosen in respect to the suitability of specific site and soil conditions. Site and soil conditions are primary determinants in selecting the most suitable soil absorption system, as discussed in Chapter IV, *Site and Soil Evaluations*.

Lagoons, discussed in Chapter IX, may be a good choice when poor soil conditions make traditional laterals infeasible and space is available. Alternative soil absorption, as discussed in this chapter, may be an option when a lagoon is unfeasible or the site is unbuildable.

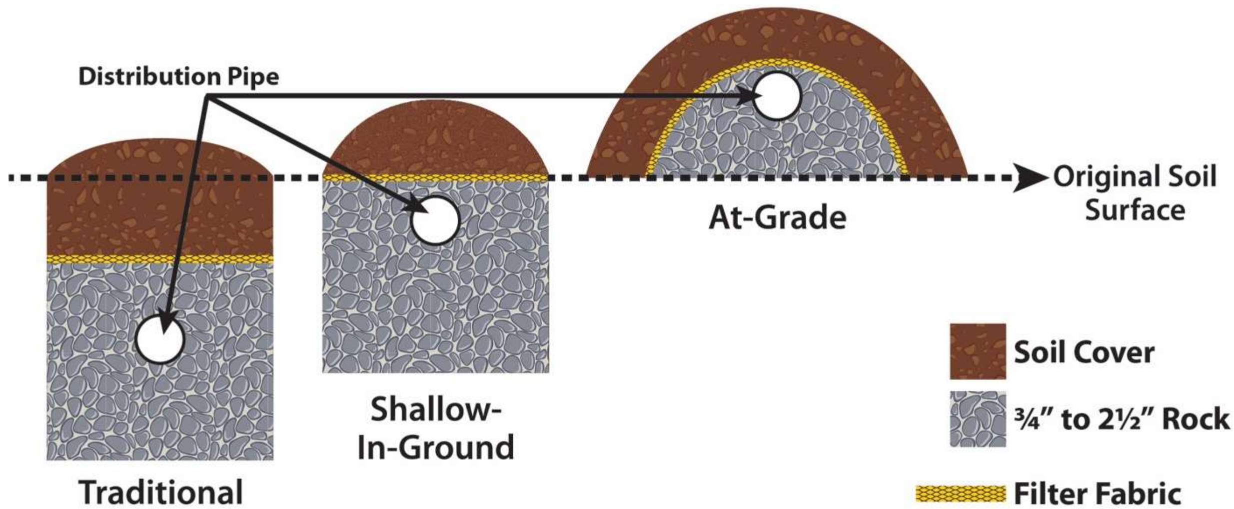
Design and construction must consider management for efficiency and regular service for long life with a minimum of problems. Use an experienced designer and/or installer for an alternative soil absorption system. Traditional tanks and laterals need only simple maintenance. Conversely, service of alternative systems requires knowledge of pumps, controls, timers, and their operation together. Regular field checks are essential. Choose a system that can be constructed properly, has maintenance access, and can be maintained locally.

Alternative Soil Absorption Systems

Alternative soil absorption systems include shallow in-ground, at-grade, bed, low-pressure pipe, drip, and mound systems. Mounds are also a treatment component and are discussed in Chapter VI, *Enhanced/Advanced Treatment*. Design and installation guidelines for alternative soil absorption systems are discussed in this chapter. Traditional, shallow, and at-grade systems, shown in Figure VII-1, are suitable for soil profiles with moderate or greater depths to restrictions. It is essential to know, understand, and comply with the local sanitary code.

Many bacteria and pathogens are filtered out as wastewater percolates through soil pores. Viruses may be adsorbed onto clay or organic particles where they can remain until they are inactivated by harsh environmental conditions. Soil particles also trap other chemicals, including phosphorus and ammonia (a form of nitrogen). Treatment processes are most effective when the loading rate does not exceed the soil's capacity to treat wastewater. Equal distribution of wastewater to the field aids both absorption and treatment.

Figure VII-1. Soil Absorption Options for Moderately Shallow Soil



EQUAL WASTEWATER DISTRIBUTION

All wastewater, both from a septic tank and from enhanced treatment components, must receive final treatment by the soil absorption system. Treatment works most efficiently when the loading is uniformly distributed among laterals and along their lengths. The principles to help achieve uniform distribution include the following:

- level bottom for all lateral trenches
- uniform depth with equal cover for all laterals
- equal distribution of wastewater among all laterals

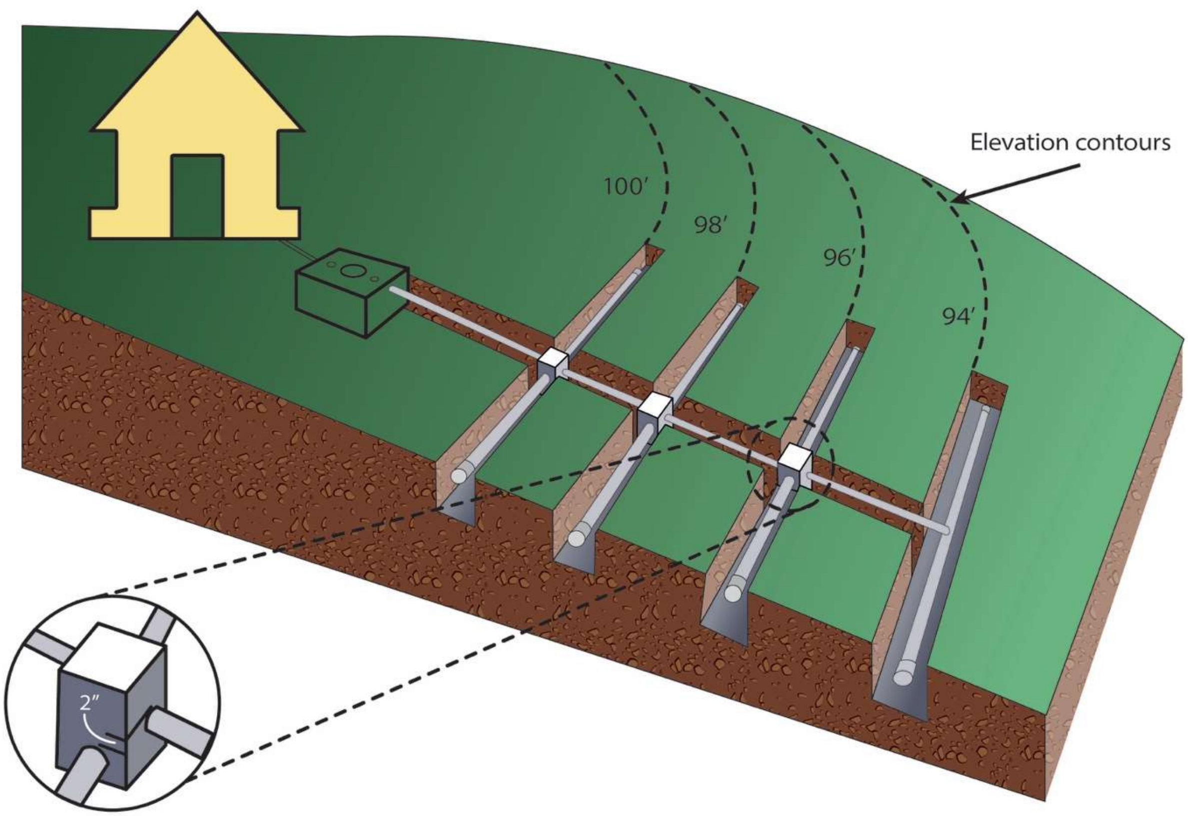
Uniform distribution is aided by the biomat and by intermittent low-pressure dosing of laterals, which is discussed in a later section. Effluent from a septic tank causes a clogging layer (biomat) to form within months at the soil/water interface in laterals. The biomat has a high concentration of microbes that filter suspended solids, such as organic matter and other microbes, from the effluent. Research shows as much as 90 percent of the treatment occurs in the biomat layer. As the biomat develops and becomes thicker, the absorption, or long-term acceptance rate, of the lateral is reduced.

When flow through the biomat is less than the wastewater load, backup into the structure or surfacing in the yard typically results and the absorption field is said to be failing. Saturated soil surrounding the laterals of failed systems limits the oxygen transfer needed for microbial decomposition.

Two types of absorption fields are commonly used. The most common is used for level sites (slope up to 1 percent) with all laterals the same elevation, and supplied by a distribution box or manifold. The other type is a serial distribution or step-down system where the next lateral is lower than the one above and is used when slopes exceed 1.5 percent. Type of soil absorption system, location, design, construction, and maintenance help minimize the chance of failure.

With gravity flow, it is extremely difficult to achieve equal distribution even when using a distribution box. The typical flow from a tank is just a trickle, which cannot practically be equally divided in the D box, even when it is carefully leveled and regularly checked. Flow levelers in each lateral of a D box help equalize flow when they are carefully adjusted several times a year. Thus, a D box or manifold pipe is only suitable for a level site with all laterals at the same elevation.

Figure VII-2. Typical Serial Distribution System for a Sloping Site



Even when flow is equally divided between laterals, wastewater still enters one end, and distribution along the lateral requires a level lateral and development of the biomat.

With the serial distribution or step-down system, the first lateral is filled and fully utilized before excess effluent overflows to the next lateral. Thus, the capacity of each successive line is utilized before flow reaches the succeeding lateral. With this system, to prevent capillary action from causing the soil above the lateral to be saturated, the invert of the overflow line should be at least 2 inches below the top of the lateral rock fill as shown in Figure VII-2.

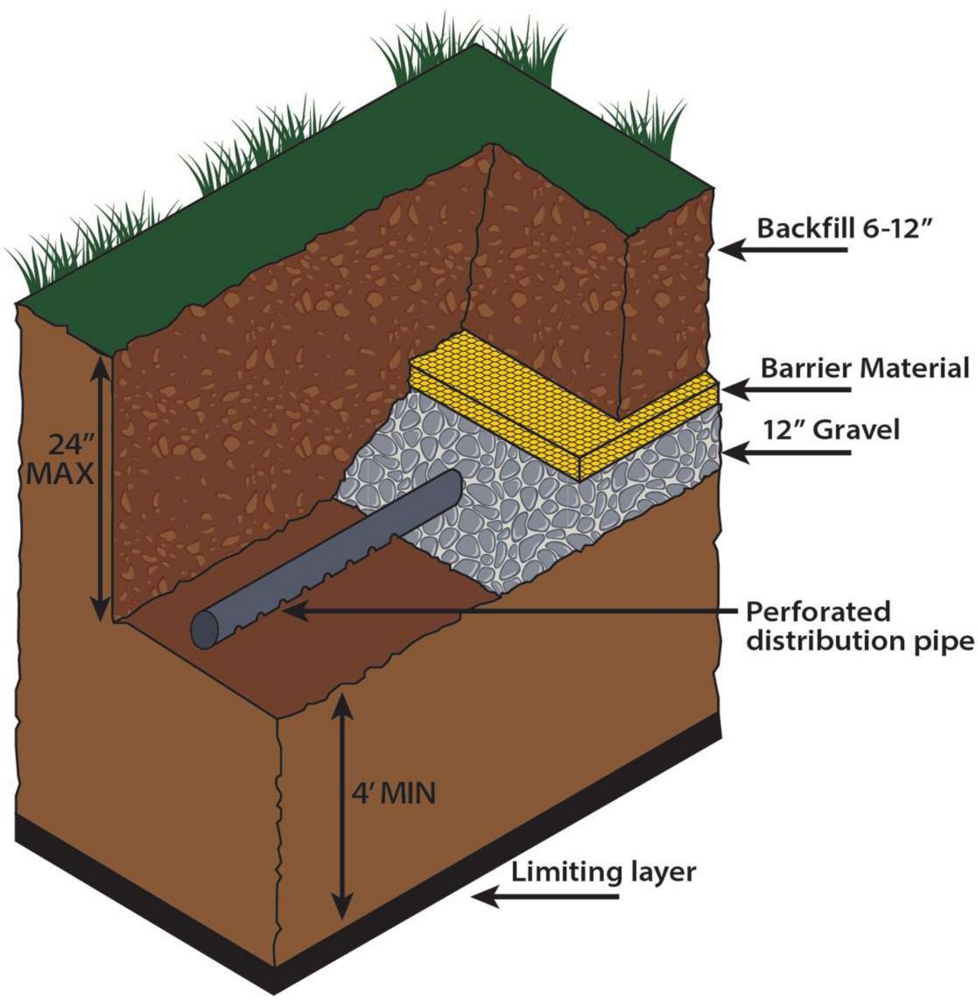
The most accurate way to achieve uniform distribution is by pressure flow. This has been done by small diameter, low-pressure pipes with small orifices; drip lines; and pressure manifolds delivering to gravity laterals. A pump or dosing siphon produces the pressure and hydraulic design assures it will work as required. As with all mechanical and electrical equipment, care of the system is important and maintenance (much more than for traditional laterals) is essential.

TRADITIONAL ABSORPTION FIELD

A traditional absorption field is a system of narrow trenches partially filled with a bed of clean gravel, crushed stone, or similar material surrounding perforated pipe, as in Figure VII-3. In place of gravel, gravelless components are available and are discussed in this chapter. Septic tank effluent is delivered to the field via the perforated pipe, and enters the gravel and then the surrounding soil.

Soil absorption fields should be sited far enough from wells, streams, and impoundments to minimize chances of contamination.

Figure VII-3. Traditional Rock and Pipe Absorption Trench



The design should plan for regular maintenance and construction must provide for easy access so service and repair can be efficient. Minimum and recommended separation distances for absorption fields from other facilities are given in Table VII-1. Also, it is always wise to plan for a replacement field in an accessible area of suitable soil.

In order to achieve minimum separation distances, site features may require pumping septic tank effluent to reach the most suitable soil absorption field location. In this case, as for all onsite systems, provide for easy access for maintenance and repairs during design and construction, including service of the septic tank by the septage pumper/hauler.

Once a soil absorption system has been sited, it is essential for contractors and the owner to understand the importance of preventing site improvements from interfering with the operation of the soil absorption field or replacement area. Driveways, walkways, additions to buildings, a swimming pool, or other improvements should never be constructed over or downslope of the absorption field or replacement area. Also surface water should always be diverted from the vicinity of the soil absorption field. Always avoid utility easements, because future installation or repairs of the utility may damage the field.

Table VII-1. Required and Recommended Separation Distances from Absorption Field

	Required Minimum	**Recommended Minimum**
Public Well or Pump Intake Line to Field	100	200
Private Well or Pump Intake Line to Field	50	100
Public Drinking Water Line to Field	25	50
Private Drinking Water Line to Field	10	25
Property Line to Absorption Field	10	50
House Foundation to Absorption Field	20	50
Surface Water or Water Course	50	100

**To meet these separation distances, a lot size of at least two acres may be needed. Always comply with local codes. These and other minimum distances are listed in Table IV-7 and KDHE Bulletin 4-2 Table 5.*

Pressure Distribution

Dosed low head pressure pipe is ideal to achieve uniform distribution of wastewater in soil absorption laterals. This dosed, or controlled pumped, distribution also provides the opportunity to do timed dosing with resting cycles. Dosing helps assure the soil stays aerated and helps limit thickness of the biomat. Pumping also allows the absorption field placement at a higher elevation than the septic tank, which maximizes the area and design options on sites. Because the biomat provides much of the treatment, maintain it; do not attempt to eliminate it.

A pressure distribution system has the advantage of enabling equal flow between all laterals and also along the lateral length. Regular maintenance is an essential component of pressure distribution. Annual maintenance must include the following:

- check components for damage and blockage
- clean all filters and screens
- clean distribution pipes and orifices
- test floats, controls, and pumps to verify they operate as designed; adjust as needed
- verify correct dosing times and volume

ABSORPTION LATERALS

Wastewater distribution in lateral fields by gravity depends on careful elevation control during construction and few solids in the effluent to limit clogging of absorption lateral pipes. Typically, a maximum gravity-fed lateral does not exceed 100 feet, and is preferred to be less than 60 feet. If a lateral is supplied from the center, total length shall not exceed 200 feet (100 ft to each side) and a maximum of 120 feet is preferred. Longer runs may be feasible when an effluent screen controls solids carry-over to laterals, elevation control is accurate, and there is regular maintenance. All laterals at the same elevation must be connected at each end with a level manifold or connector pipes to avoid dead ends.

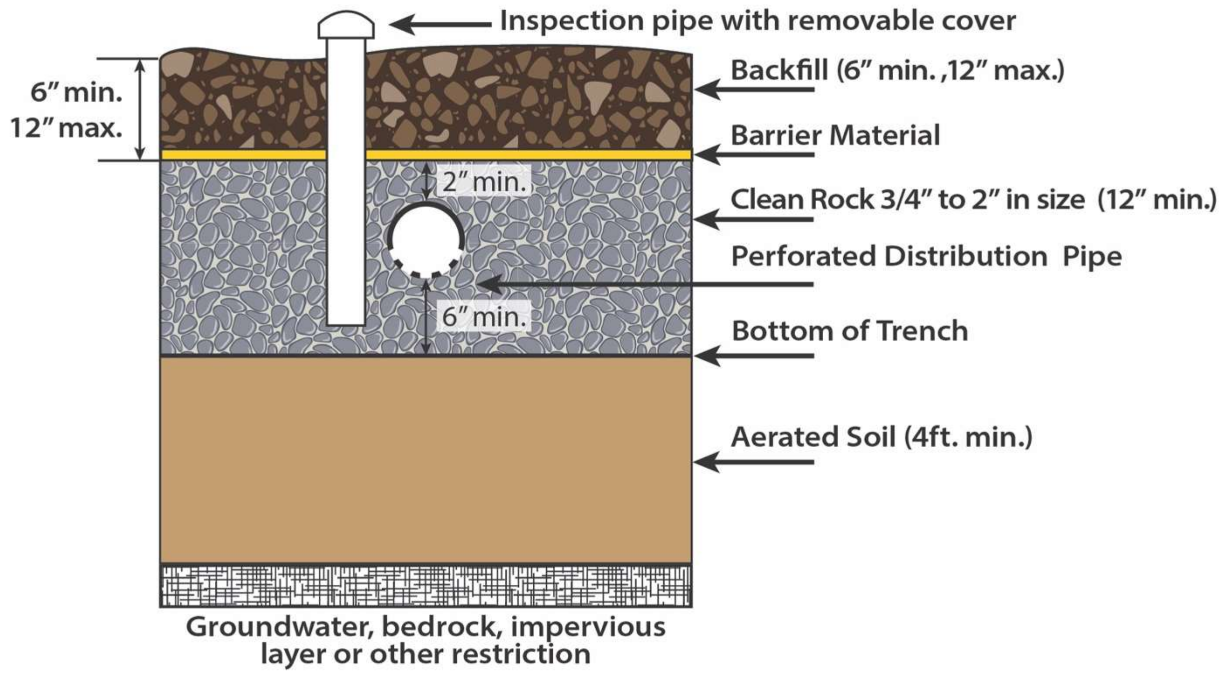
Absorption field area is dependent on two factors: wastewater flow and the soil loading rate discussed in Chapter IV, *Site and Soil Evaluations*. The wastewater flow is based on the house being fully occupied with two persons per bedroom. Thus, the wastewater design flow is based on the number of bedrooms at 150 gallons per day (gpd) per bedroom (75 gpd per person). The absorption lateral bottom area is obtained by dividing the wastewater flow in gpd by the loading rate in gallons per day per square foot (gpd/ft2).

Although absorption trench width may vary from 18-36 inches, 24 inches is the preferred width (see trench design in Figure VII-4). A minimum of 6 inches of gravel is placed under the 4-inch-diameter distribution pipe, followed by enough gravel to cover the top of the pipe by at least 2 inches. Soil cover over the trench should be at least 6 inches to provide adequate rooting depth for perennial grass, and no more than 12 inches to maximize water and nutrient use by vegetation as well as oxygen transfer to the lateral.

To enable aeration and promote plant uptake of water and nutrients, the lateral trench bottom should be as shallow as practical, but at least 18 inches deep unless additional cover is added over the lateral. The lateral should follow a level grade (on contour of the ground surface) rather than a straight line. On sloping sites, a step-down distribution arrangement is preferred. To maintain a level bottom on uneven site surfaces, trench depth may need to vary within a range of no more than plus or minus 2 inches of the average depth.

With shallow lateral depth, lateral lines may freeze during an extreme or prolonged cold period. Freezing is not usually a problem in Kansas for a carefully constructed system with ground cover that continues in daily use during the cold period.

Figure VII-4. Traditional Rock and Pipe Lateral



Freezing is more likely to be a problem when water stands in lines, and may be a problem when no water is used during a cold period. The lines should be designed and constructed to allow water to drain. Use of check valves or other features to retain water in the piping is not recommended unless the pipes are below the maximum frost depth.

When space permits, adjacent absorption laterals should be separated by at least six feet of undisturbed soil. Table VII-2 shows minimum spacing for a range of trench widths to achieve the 6-foot separation. When space is limited, the separation can be reduced, but this may make construction more difficult. Individual laterals should be constructed parallel to surface contours at uniform depth with a level trench bottom and curved to best fit the topography; avoid abrupt changes in direction.

Table VII-2. Trench Separation Distances

Trench Width (In.)	Minimum Distance Between Trenches (Ft.)	Minimum Distance Between Trench Centerline (Ft.)
18-24	6.0	8.0
24-30	6.0	8.5
30-36	6.0	9.0

Absorption Field Materials Guidelines

Perforated distribution pipe is commonly used and, where dosing is not required, 4-inch diameter pipe is standard. Typical designs for absorption laterals are shown in Figures VII-3 and VII-4, and a typical layout for serial distribution is shown in Figure VII-2.

Rigid PVC or corrugated polyethylene plastic pipe, meeting American Society for Testing and Materials (ASTM) standards D2729 and F405 or latest edition, respectively, is the minimum standard for use as gravity distribution lines. All materials used in the plumbing, wastewater line, and lateral fields shall meet standards specified by ASTM. In gravity flow lateral pipes, perforations are round, ½-inch diameter and are located at 4 and 8 o'clock positions on the pipe circumference with 6-inch spacing along the pipe. In no circumstances would slotted pipe be acceptable as the narrow slot openings plug easily.

Washed gravel or washed crushed stone is commonly used as the porous media for the trench. The media gradation shall be ¾ inches to 2 inches in diameter. Smaller sizes are preferred because they reduce masking of the infiltration surface. It is best to have a uniform size because more void space is created. Rock having hardness more than three on the Mohs hardness scale is required. Rock that can scratch a penny without crumbling or flaking generally meets this criterion. Larger diameter and smaller diameter material or soft aggregate such as calcite limestone are not acceptable and shall not be used.

Fines must be eliminated as much as possible to prevent clogging of the void space. Fines shall not exceed 5 percent by volume, so unwashed material is normally not acceptable. A test should be done to confirm the media is adequate. To test for fines, place five inches of material in a clear container. Fill the container with water and wash. Remove the washed gravel and let the fines settle. Five inches of gravel should produce less than one-quarter inch of fines.

The porous media must be covered with a non-woven filter fabric (at least 3-ounce nylon or 5-ounce polypropylene) before backfilling to prevent soil from sifting through the media.

Traditional untreated building paper or a 3-inch layer of straw are not recommended because they deteriorate over time and allow soil to work through the rock media material. Filter fabric (also known as geotextile, geotextile fabric, and landscape fabric) materials shall be fully permeable to air and water.

Geosynthetic aggregate media similar in size to the gravel and inert in wastewater may be used for laterals. Chunks of shredded tires can be a suitable substitute for rock. Ninety percent of the pieces should be ½ to 4 inches in size with no fines. Wire strands shall not extend more than ½ inch from the tire pieces.

When suitable rock or gravel is not locally available, is expensive, or access to the site is restricted, gravelless systems may be a suitable option for laterals. Gravelless options include chambers and large-diameter pipe.

Before using gravelless pipe, consult the local authority to identify requirements.

Field Construction Guidelines

Protection of the absorption field area should begin before any activity on the site. The site and soil evaluation identifies the best soil absorption area and a reserve area. All traffic, especially heavy equipment such as loaded trucks, should be kept away from the absorption fields by marking the site (fencing is preferred). Compaction from weight of such equipment can permanently alter soil characteristics. Excessive traffic from equipment or livestock can compact even relatively dry soils.

Construction of soil absorption field laterals when the soil is too wet causes compaction and smearing of the soil. This destroys soil structure, which greatly reduces the soil's capacity to absorb water and reduces treatment efficiency of the field. A test to determine appropriate soil moisture is to work the soil into a ball and roll between the hands. If it can be rolled into a ¼-inch- diameter rope shape without falling apart, it is too wet and construction should be delayed until the soil is dryer. Depending on season and rainfall, drying may take weeks or even months.

Before beginning construction, contours should be located using a surveyor, contractor, or laser level, and lateral locations should be marked on the contour by paint, flags, or stakes.

Lateral trenches shall not be excavated deeper than the design depth or wider than the design width.

Following excavation, the trench sides and bottom shall be raked to remove any smearing and graded to assure the bottom has less than 1-inch difference in elevation along the full lateral length, or in the complete field for a level system. The lateral pipe and rock cover shall not vary more than 1 inch in elevation along the lateral length when checked by a contractor, surveyor, or laser level.

When the trench bottom has been adequately prepared, it should be promptly filled with at least 6 inches of gravel, or, for a gravelless system, 6 inches from where the gravelless distribution line will be placed. Distribution pipes are carefully placed on the rock and leveled, with perforations aligned at 4 o'clock and 8 o'clock positions for all pipes. Rock is placed around and over the pipe to a cover depth of at least 2 inches. After rock and pipe have been placed into the trench, the filter fabric shall be placed to cover the rock and prevent downward soil movement. If gravelless chambers are used, the backfill along the sides should be compacted following the manufacturer's guidelines.

The lateral should be backfilled as soon as possible after inspection to prevent rainwater from filling it, sidewall collapse, and sediment washing into the trench. Earth backfill shall be carefully placed to completely fill the trench cavity. The backfill shall be mounded 2-3 inches (20 percent of the soil fill height) above the trench to allow for settling. If shallow in-ground or at-grade placement is used, topsoil must be placed between laterals as well as over the lateral to level the site. After settlement, the entire disposal area should be graded and seeded with grass. Heavy equipment should not be used to cover lateral trenches. Grading should be limited to handwork or very small equipment.

ABSORPTION FIELD INSPECTION

Inspection is one of the most important tasks associated with construction of new wastewater absorption fields and evaluation of existing wastewater systems. The sanitarian should inspect the absorption field after the materials have been placed but before the laterals have been covered. In most cases the sanitarian will do the inspection to evaluate whether the system meets minimum standards of the local code. This involves assuring components meet minimum requirements for type, quality of material, dimensions, and construction; the location meets setback distance and configuration requirements (slope, position, elevation); design and sizing have been satisfied; and construction meets requirements.

Existing systems must be evaluated using most of the same requirements used for new systems. Suggested protocols for evaluating new and existing systems are included together with inspection forms at the end of this chapter. A full inspection of an existing septic tank is only practical when it is empty, meaning the tank must be pumped, see Chapter V, *Septic Tanks*.

Evaluation of sludge and scum accumulation in the tank is the responsibility of the owner and is discussed in Chapter V. Figure V-5 depicts how measurements may be done.

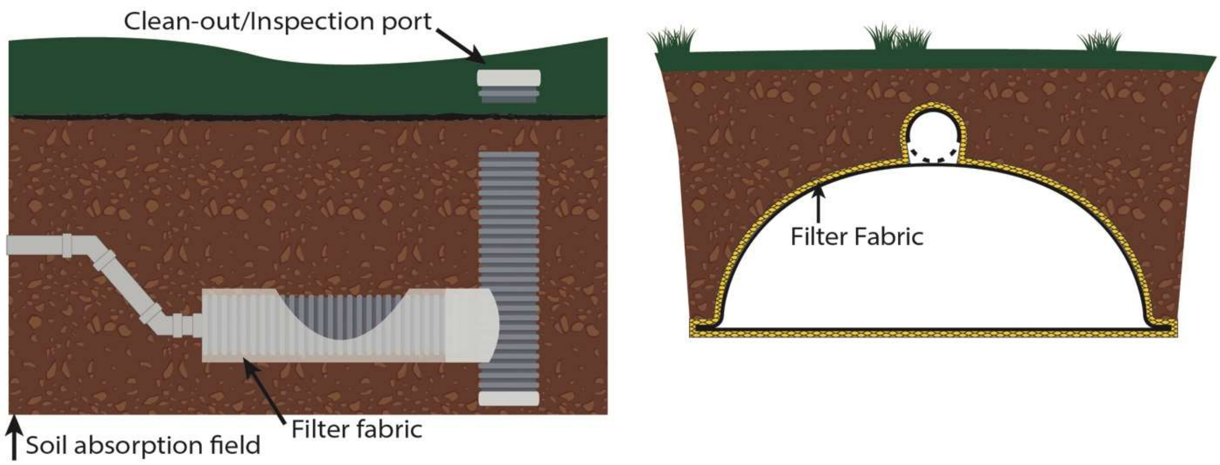
GRAVELLESS SYSTEMS

Gravelless systems typically have an open-bottom structure resembling half of a large-diameter pipe, to create an underground chamber to distribute and “store” effluent. Sidewalls are slotted with louvers to allow lateral movement of effluent. Figure VII-5 shows a typical gravelless chamber diagram. Chamber systems do not require piping to distribute wastewater within the lateral. Gravelless systems do not require rock or gravel to maintain an open trench for contact with the soil. Installation criteria emphasize the trench bottom must be level to allow for even distribution of wastewater. Lack of material in the trench means wastewater is in contact with a greater surface area on the trench bottom compared with a rock-filled trench, and that the effluent contacts the entire bottom surface and not just the voids between the aggregate materials. Absence of rock masks the surface, and thus less bottom area is required for chambers than for rock laterals, allowing for use of an increased loading rate.

Based solely upon use of gravelless systems, KDHE does not recommend a reduction in lateral area. Each local permitting authority should carefully consider any request for reducing the lateral area based upon industry claims, local experience, and available information. Manufacturer claims are typically in the 40-50 percent reduction range. Since 1995, Kansas health departments and local environmental protection groups have granted reductions ranging from 0-40 percent. When given, the most common reduction is 20-30 percent.

Reducing the absorption area for chambers should be done with caution. Wastewater permits typically contain a statement that owners are responsible for future performance of their wastewater system and will be required to make corrections in the case of failure, regardless of the cause of that failure.

Figure VII-5. Typical Configuration of Gravelless Chambers



Before using a gravelless system, the installer should be familiar with the manufacturer's limitations for the use of their system and all recommendations for installation. Some manufacturers recommend a maximum trench depth of 36 inches for their chamber. The type of gravelless system used depends upon factors such as: availability, site considerations, contractor preference, and cost. Some chamber designs allow lateral flexibility, allowing them to be more easily installed along the curved elevation contour of a sloped lot. Manufacturers make or imply claims of lateral reductions that vary by chamber design or model. This claim is based on the increased side-wall area of some designs by making the chamber narrower and taller. At present, KDHE recommends any reduction be based only on the amount of open bottom area for each design; it does not consider the extra sidewall "benefit." This is especially important when considering lateral field sizing between two or more brands and designs.

A small limitation to gravelless chambers is the impermeable top that may limit the evapotranspiration potential of the lateral field. This typically shows up during a dry summer when cool season grass is stressed or goes dormant, and there is a green strip on each side of the chamber but not over the top. In contrast, a rock pipe lateral will typically have green grass across the full width indicating water is available to the grass from the lateral.

A recent modification to gravelless lateral design is use of a narrow chamber (usually less than 24 inches wide) in a full 36-inch wide trench. Spaces on each side of the chamber to the trench sides are filled with clean rock or gravel as in rock laterals. Be sure the manufacturer's warranty is not affected before choosing to do this. The full 36-inch lateral width should be counted when calculating size of the resulting lateral field. Gravel in these laterals must be covered with filter fabric to prevent soil from filling rock void spaces.

Large Diameter Pipe

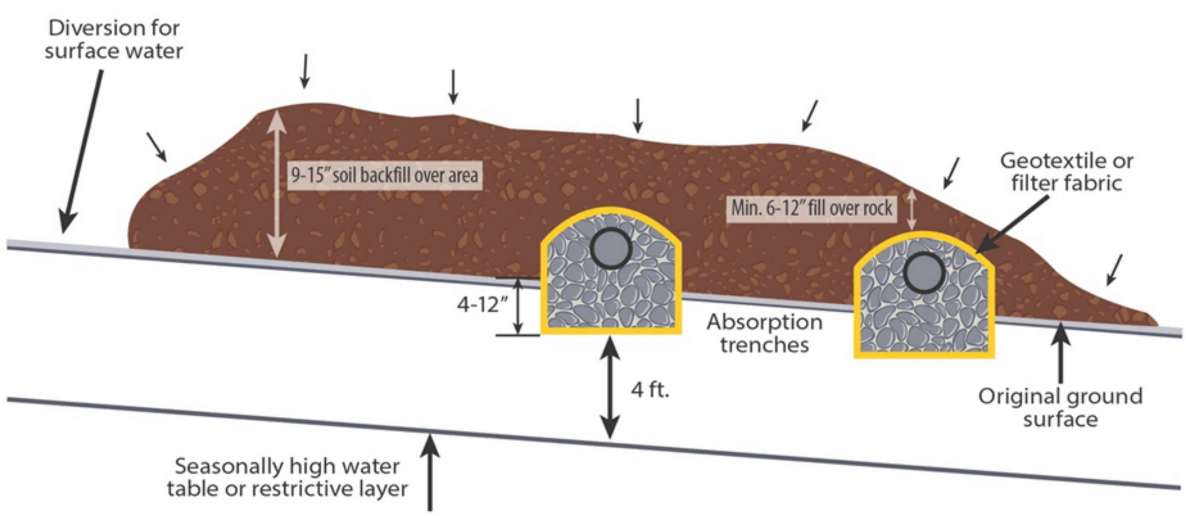
Another gravelless distribution option is large-diameter, corrugated perforated pipe. Manufacturers make this pipe in 8- or 10-inch diameter or larger, similar to distribution lateral pipe, except a larger size. Systems using this pipe have been widely tested by manufacturers, but relatively few tests have been conducted by independent researchers. No design criteria have been developed other than those provided by the manufacturer. The potential user is advised to follow the manufacturer's recommendations. The outside of the pipe is covered with geotextile fabric. Experience suggests this pipe may work better for fine-textured soils than coarse ones.

SHALLOW IN-GROUND LATERALS

A shallow in-ground lateral system is basically the same as conventional soil absorption laterals, except trench depth is often 6 to 12 inches, which is more shallow than a conventional lateral depth of 18 to 24 inches. The shallow in-ground design raises the laterals about a foot higher than in a conventional trench, increasing soil depth beneath the bottom of the laterals. This design variation is useful for sites having a reduced soil depth to a restricting layer (only 4 ½ to 6 feet instead of the normal 6 feet or more total depth for traditional laterals). It allows normal placement of the rock in a trench beneath and around the lateral pipe. The laterals and the space between them are covered with topsoil comparable to topsoil on the site. As with all rock laterals, it is essential that filter fabric cover the tops and sides of the rock that extends above the top of the trench. Figure VII-6 shows the lateral cross-section for shallow in-ground lateral systems. All other design criteria for this system would be the same as for traditional systems.

In the construction process, the vegetation should be removed from the soil surface to be covered with topsoil. The surface should also be roughened to a depth of 3 to 4 inches as described for mounds in Chapter VI. The contractor should be careful to avoid driving equipment over the absorption field site during construction because traffic on the site will compact the soil and reduces its capacity to absorb water. Mark the site to protect the field and consult with the contractor before beginning the installation. Construction should only be done when the soil is dry enough that when rolled between the palms the soil should not roll out to a rope shape less than ¼-inch in diameter without falling apart.

Figure VII-6. Typical Shallow In-Ground Absorption Bed and Lined Lateral Sections



AT-GRADE LATERALS

As the name implies, an at-grade lateral system is constructed on the natural ground surface; thus, no trench is excavated. This system is ideal for sites where the limiting condition provides only 4 feet of suitable soil below the surface. Protection of the original soil surface from disturbance by equipment during all phases of site construction is essential. The natural soil surface becomes the lateral bottom or soil absorption surface. The maximum site slope should be no steeper than about 6 to 1 (16 percent) to simplify construction, especially aggregate placement. This also enables use of normal construction equipment without excessive hand labor and helps ensure proper long-term operation.

Because water movement into the soil is essential to prevent lateral movement (especially on sloping sites) and seepage at the toe, which is at the natural soil surface, an at-grade system requires greater care during construction than traditional laterals. The soil must be dry enough that equipment does not cause either tracks or compaction. A good rule is that a ¼-inch soil rope cannot be formed without falling apart (soil cannot be rolled into a smaller rope shape). The site must be level along the laterals and the surface must allow water to infiltrate.

Construction of an at-grade system is similar in many respects to construction of a mound, except that no sand fill is used. Prior to installing an at-grade lateral line, all vegetation is removed. All grass, brush, and trees are cut just above ground level and removed; tree stumps are left in place. A tracked vehicle should be used in all phases of construction to help avoid soil compaction.

A level soil surface contour is laid out using a surveying level. Minor cuts and fills along the contour may be used to smooth surface irregularities. The soil surface under the laterals and at least 5 feet to the sides is roughened to a depth of a few inches by using the teeth of the excavator bucket or chisel plow, as is done for a mound (see Chapter VI). The lateral location is carefully marked using a contractor, surveyor, or laser-level to maintain a level grade.

Six inches of aggregate is placed on the prepared soil surface, following the marked contour. The distribution pipe is placed on the rock fill, again using the level to ensure the level grade is maintained. Additional aggregate is placed around and over the pipe covering it by at least 2 inches. Figures VII-1 and VII-7 show a cross-section of an at-grade lateral line for rock and pipe (chambers would be similar). On sloping sites, the pipe should be placed on the upslope side of the aggregate. The aggregate should have maximum side slopes of 1 to 1, minimum thickness of 1 foot (9 inches for low-pressure pipe), and maximum width at the soil surface of 3 feet.

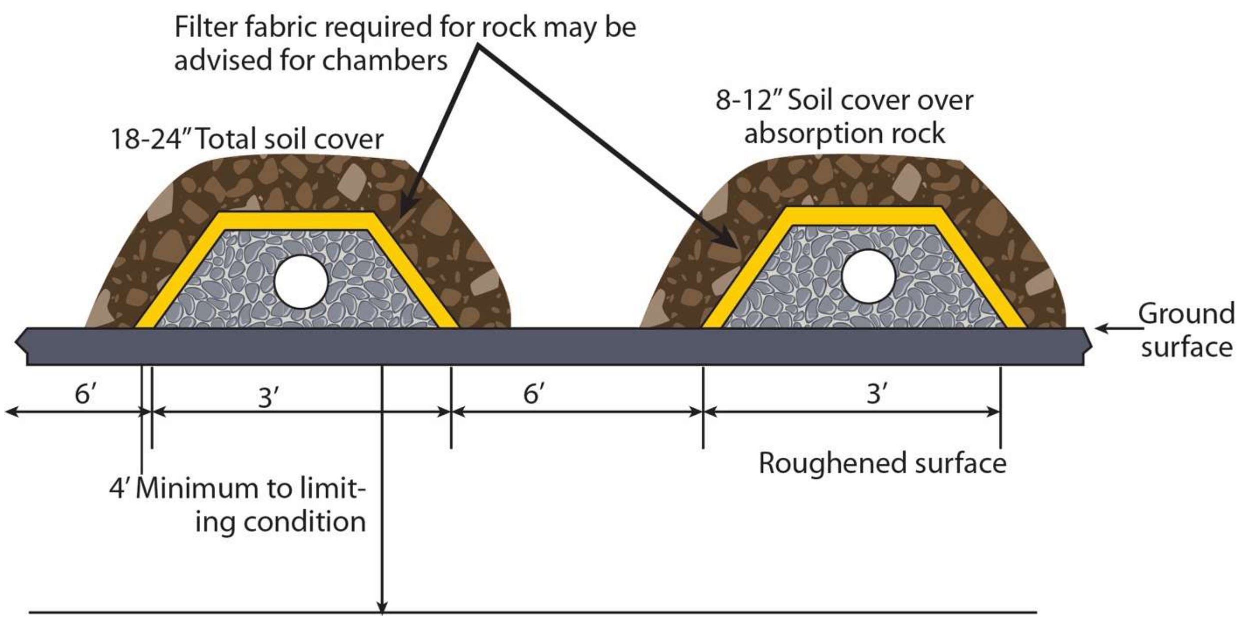
When laterals have been placed with at least one inspection pipe in each, the aggregate is covered with filter fabric as described earlier. Finally, the entire absorption area, including laterals and space between them, is covered with topsoil to a depth of 8-12 inches over the lateral aggregate. Properties of the topsoil used for cover should be similar to the natural topsoil of the site.

The loading rate and design procedures are essentially the same as for conventional laterals. On a level site, laterals would all be level and distribution pipe would also be level with the lateral ends connected by solid pipe. Standard minimum spacing between laterals is 6 ft as shown in Figure VII-7, the same as for a conventional lateral system. On sloping sites, a drop-box system may be used, but is only recommended for slopes up to 1 ½ percent. Low-pressure, dosed distribution lines are recommended for slopes exceeding 1 ½ percent.

A low-pressure distribution system using a few doses per day would be suitable for any site and is strongly recommended for all sloping sites. The improvement achieved by a pressure-dosing system will help assure a long, viable operating life. For sites with slopes exceeding 1 ½ percent, a pumped low-pressure distribution system is essential to assure even distribution of wastewater across the absorption field. When a pressure-dosing system is used on a site where laterals are at different elevations, care must be taken to equalize pressure, and thus equalize the loading rate for all laterals. A simple way of doing this is to put a gate or globe valve at the inlet to each lateral. A standpipe of clear plastic or a sensitive pressure gauge can be used to equalize the pressure when the system is installed. Once the pressure is set, the extra equipment can be removed until it is checked or needs to be reset. The following design example will help the reader understand the application of these principals.

Construction of an at-grade lateral field requires careful procedures. Small tracked equipment (such as a loader) should be used to reduce soil pressure during construction. The topsoil cover must be placed over the aggregate before equipment crosses it. It is best to conduct machine passes parallel with the laterals. Minimize machine traffic as much as possible.

Figure VII-7. Typical At-Grade Lateral Section (rock and pipe shown; chambers would be similar)



At-Grade Design Procedure

Designing an at-grade system is somewhat similar to designing an engineered mound, except that a mound may use a distribution bed while the at-grade system uses multiple laterals. The number of laterals depends on the maximum linear loading rate as discussed in more detail in the engineered mound section of Chapter VI.

Horizontal and Vertical Separation

Horizontal set-backs will be dictated by local code and should be followed for all soil absorption systems receiving septic tank effluent. Most codes have required separation distances between the bottom of the aggregate and the limiting soil condition, such as bedrock or high-water table. In Kansas, the minimum standard for vertical separation distance below the bottom of the absorption lateral is four feet. Thus, the at-grade system would only be suited to sites where there is at least four feet of suitable soil to a restriction.

Slope
The maximum slope on an absorption field site should not exceed 16 percent.

Linear Load Rate
The linear loading rate is defined as the amount of effluent applied (gallons) per day per linear foot (gpd/lf) along the natural contour. The mound section of Chapter VI (p VI-12) has more discussion about linear loading. Table VI-4 and Figure VI-7 illustrate general limiting soil and site conditions and suitable research based linear loading rates. Design linear loading is a function of the soil and geologic material that allows effluent to move vertically through the profile and laterally downslope away from the absorption area. If movement is primarily horizontal, a low linear loading rate (3-4 gpd/lf) is extremely important. If the flow is primarily vertical, then the linear loading rate can be higher, but still should be limited to a maximum of 8-10 gpd/lf. A linear load rate greater than 10 gpd/lf may result in a very wide absorption area, especially when the soil surface limits infiltration into the soil.

Soil Loading Rate
The soil loading rate is based on the surface soil layer that is in contact with the aggregate or the most restrictive layer within 2 feet below the surface. For an at-grade system, the aggregate is in contact with the natural soil surface. Refer to Table IV-4 in Chapter IV for recommended loading rates for various soil texture and structure conditions.

System Configuration
The system configuration must meet the soil site criteria and should typically be laid out along the contour and narrow parallel with the slope. A system that is too wide may leak at the downslope toe or at any toe on a level site. Other factors, such as oxygen transfer and exchange beneath the absorption area, are also affected by the width of the system. If there is not sufficient length along the contour, but there is sufficient distance along the slope, more than one at-grade system can be used to achieve the desired or required effective absorption area. As for all lateral fields, a terrace should be installed on the upslope side to prevent upslope runoff from entering the field area.

Effective Absorption Area
The effective absorption area is that which is available to accept effluent. The effective length of the absorption area is the actual length of the aggregate along the contour. The effective width on sloping sites is the distance from the distribution pipe to the downslope toe of the aggregate, and on level sites it is the total aggregate width.

Total Length and Width
Once the effective length and width of aggregate/soil contact area is determined, it is

necessary to add about 6 feet to each side and at the end of the absorption area to shape the cover soil into the existing soil surface. Greater widths are acceptable if additional landscaping is desired. Recommended maximum slope for the sides of the absorption area cover is 4 to 1 (4:1), but flatter is more desirable.

Pressure Distribution

To assure uniform effluent distribution and to avoid leakage at the toe, pressure distribution is recommended for dispersing effluent in at-grade systems. With site slopes greater than 12 percent, pressure distribution should always be used. Pressure dosing distributes the effluent evenly along the lateral through the small-diameter orifices. After it is dosed, the water moves vertically downward through the aggregate to the soil surface. As effluent comes into contact with the soil, it will move laterally (downslope on sloping sites and in all directions on level sites) as needed to infiltrate the soil. The pressure distribution network configuration will vary depending upon the size and dimensions of the absorption area. For level sites with absorption laterals up to 3 feet wide, a single lateral pipe in the center along the system length will suffice. Though not recommended, a wider absorption bed could be used on a level site. For a bed, equally spaced lateral pipes fed by a center manifold are used.

On sloping sites, the distribution network may consist of a single perforated pipe on the upslope edge of the aggregate lateral with a center feed preferred. The lateral pipe is installed nearest the upslope edge and water will move downslope by gravity. Multiple laterals, spaced parallel and 6 feet apart, as shown in Figure VII-7 and supplied by a short manifold, are recommended when the linear loading allows more water than a single lateral can supply.

Cover

After the aggregate, distribution pipe, and observation tubes have been installed, a synthetic geotextile fabric (or filter fabric) is placed over the aggregate. Approximately one foot of soil cover is placed on the fabric and extended/tapered to a distance of at least six feet beyond the aggregate edge. The surface is seeded with perennial, cool season grass to control erosion and maximize evapotranspiration

At-grade Design Example

Because an at-grade system involves more detailed site-specific design than traditional laterals, an example is presented here to help readers understand the design steps and calculations.

Information given:

- Typical three-bedroom house with standard features and no unusual uses
- Soil and site criteria
  - Site slope is 8 percent in proposed absorption field area
  - Proposed absorption area is 175 ft along the contour and 30 ft with the slope
- Soil profile description
  - 0-12 in. silt loam; 10YR 2/1 color; moderate, blocky structure; friable consistence

- 12-24 in. silty clay loam; 5YR 3/1 color; moderate, blocky structure; firm consistence
- 24-48 in. silty clay; 10YR 5/3 color; strong, blocky structure; very firm consistence
- 48 plus in. silty clay; massive structure; very restricted drainage; many medium, prominent mottles indicates a seasonal perched water table in this zone

Design Step 1

Determine the design flow rate (DFR). Because this is a typical three-bedroom house, use 150 gallons per bedroom per day (based on occupancy of two people/bedroom) to calculate the design flow rate. Use: 3 x 150 ***DFR = 450 gpd***

Design Step 2

Select the linear loading rate (LLR) based on evaluation of the sites soil profile. Because the profile consists of a permeable surface soil horizon over a slowly permeable subsoil horizon with a seasonal perched water table, the subsurface flow must be primarily horizontal with negligible vertical flow below 4 feet. Since the slope is moderate, a narrow lateral is most appropriate. The perched water table and very restricted drainage in the area necessitates a low LLR as discussed in the engineered mound section of Chapter VI. Therefore use: ***LLR = 4.0 gpd/lf***

Design Step 3

Choose the soil loading rate (SLR) for laterals on the site based on the properties of the soil layer that is the infiltrative surface. Use Table IV-4 (page IV-7) for selecting the appropriate SLR that matches the soil conditions. Because this is a silt loam texture with moderate structure and friable consistence, use the value: ***SLR = 0.6 gpd/ft2***

Design Step 4

Determine the required width (W) of the absorption surface. This is obtained first by dividing the linear loading rate by the soil loading rate to find the effective width (EW) or

EW = LLR / SLR

On a level site or one with very slight slope (less than 12 percent), the effective width (EW) is the required width (W) of the aggregate. On a sloping site, aggregate upslope of the distribution pipe is not effective for infiltration. On slopes, total aggregate width must be about 1.5 ft wider to support the upslope side of the distribution pipe network and to allow for the natural slope of the aggregate. When the width is more than 4 feet, it should be divided into multiple laterals with a separation space between them to approximate standard lateral spacing. Using the linear loading rate of 4 gpd/lf and the soil loading rate of 0.6 gpd/ft2 from steps 2 and 3, then:

EW = 4 gpd/ft / 0.6 gpd/ft2 = 6.7 ft **and** ***W = 6.7 + 1.5 ft = 8.2 ft.***

To maintain the desired narrow lateral, this would best be done using two laterals with a six-foot spacing between them so each lateral would be ***EW = 3.4 ft*** **and** ***W = 3.4 +1.5 ft = 5 ft.***

Design Step 5

Determine the required length (L) of the absorption area by dividing the design flow rate (DFR) by the linear loading rate (LLR) as follows.

L = DFR (gpd) / LLR (gpd/lf)

For this at-grade example, the design flow rate is 450 gpd from step 1 and the linear loading rate is 4 gpd/lf from step 2, so the required length is

L = 450 / 4 = 112.5 use 113 ft.

Thus the effective absorption area is 113 ft by 3.4 ft times 2, or 768 square feet.

Design Step 6

Determine the system configuration that best fits the site. Once the effective width and length of the absorption area are determined, the designer must determine if and how it will best fit on the site. When there is not sufficient length along the contour on the site, it may be possible to divide the absorption area into multiple zones. The required length of the absorption area is less than the available 175 ft along the contour so it fits the site.

Design Step 7

Determine the height of the lateral. Design for a minimum of 6" of aggregate beneath the distribution pipe and about 2" covering the pipe. Using small-diameter low-pressure pipe, the aggregate would be 9 to 10 inches deep. The aggregate will taper to zero at the edges. Place synthetic fabric over the aggregate and 8 inches of soil cover over the fabric. Total fill height over the lateral above the original grade will be about 1.5 foot at the distribution pipe and taper to zero at the edges of the dispersal field.

Design Step 8

Determine the total length (TL) and total width (TW) of the absorption field by adding the sloping fill to each side and each end of the absorption area. This allows the soil cover to slope gradually from the top of the soil covered lateral to the natural surface. A standard 5 feet can be added to each side and each end of the area. However, it is preferable to calculate the upslope and downslope width additions using design steps 12 and 13 in the engineered mound section of Chapter VI, pages VI-19 and VI-20, respectively. When desired, wider slope widths can be used to achieve flatter slopes for landscaping purposes.

TW = absorption width (W) + upslope width + downslope width

TW = 2 x (lateral width) + space between laterals + upslope width + downslope width

= (2 x 5) + 6 ft + (4 x 1.5 x 0.76) ft + (4 x 1.5 x 1.47) ft

TW = 10 + 6 + 4.6 + 8.8 = 29.4 ft; use 29 ft.

TL = absorption length (L) + average of upslope and downslope widths.

Simply adding the upslope and downslope widths together is the same as two times the average of these widths.

TL = 113 + 4.6 + 8.8 ft = 126.4 ft; use 126 ft.

Total width and total length calculated in this step are less than the 175 ft length and 30 ft width of the available area for the wastewater system. Thus, no adjustment in the system design is needed.

Design Step 9

Design a pressure distribution network. Because the absorption laterals are relatively narrow and on a moderate slope, a single distribution line along the length of each lateral is adequate. The distribution line would be located 3.4 ft upslope of the aggregate downslope toe. On a level site, the distribution pipe would be located in the center of the lateral aggregate. The pressure distribution will be designed according to the procedure discussed in Chapter X, *Pumps and Hydraulics*.

At-Grade System Construction

Construction Step 1
Check for proper soil moisture prior to construction. When the soil can be rolled between the hands to form a rope shape ¼-inch in diameter without falling apart, it is too wet for construction. Do not begin construction until the soil dries out.

Construction Step 2
Cut all grass, brush, and trees as close to the soil surface as practical. Do not remove tree stumps. Rake clippings and loose organic debris from the absorption area. Avoid heavy vehicle traffic, especially over and downslope of lateral absorption areas. Using a contractor or laser level, mark the level lines for the lateral locations.

Construction Step 3
Bury the force main (or delivery pipe) from the pump tank to the upslope side of the absorption area, ideally prior to roughening the soil surface. Bring the pipe in at a right angle to the absorption area and connect to the upslope end of the manifold, the line connecting to all laterals. Avoid traffic on the tilled area, especially beneath and downslope of the laterals.

Construction Step 4
Working from the upslope side to avoid compaction of the absorption area and downslope side, roughen the soil surface using the teeth of the backhoe. If a backhoe is not practical, use a chisel plow at a 4- to 6-inch depth. Avoid doing this step if the soil is too wet as identified in Step 1. If compaction or ruts occur in the upslope or downslope area during construction, re-till the compacted or rutted area. Minimize subsoil disturbance beneath and downslope of the absorption area.

Construction Step 5
Install at least one observation tube in each lateral to observe the condition at the infiltrative surface. Use two observation tubes for long laterals fed from a center manifold. Observation tubes are usually 3- or 4-inch PVC pipe extending from the infiltrative surface (aggregate – soil interface) to a few inches above the ground for easy access. They should be placed at points approximately one-quarter and three-quarters along the length of the absorption area. The observation tubes provide easy access to verify that effluent is reaching the area and to detect any ponding. The bottom six inches of the observation tubes must have perforations (holes or slots) in the sides to allow ponded effluent to enter.

Observation tubes must be anchored securely. A toilet flange, tee, or reinforcing rods through the pipe can be used as illustrated on Figure VI-9, page VI-25 in Chapter VI.

Construction Step 6
Place a 6-inch depth of lateral aggregate on the level contour in the designated tilled area. Work from the upslope edge of the system being careful to avoid compaction of the absorption or adjacent areas. A conveyor mounted on a truck or a mixer tank on a truck have been used to deliver the rock.

Construction Step 7
Place the distribution network pipe level along the length of the absorption lateral aggregate and

connect it to the distribution manifold pipe. On sloping sites, place lateral pipe as close as practical to the upslope edge. On level sites, place lateral pipe in the center of the aggregate. Place aggregate to the sides and cover the distribution pipe with at least 2 inches of rock.

Construction Step 8
Place the geotextile fabric to completely cover the lateral aggregate surface. Where needed, trim or fold back the fabric so it does not extend more than 2 inches beyond the edge of the aggregate.

Construction Step 9
Cover laterals to a depth of 8 to 12 inches over the absorption rock with topsoil having properties similar to natural topsoil on the site. Where multiple laterals are used, the soil cover must fill the space between laterals so no depression remains to collect water. Taper the soil fill on all sides of the absorption area lateral to the design distance from design step 8 above, or at least 5 feet. Finish grading around the system to divert surface runoff away from the upper edge and away from the site.

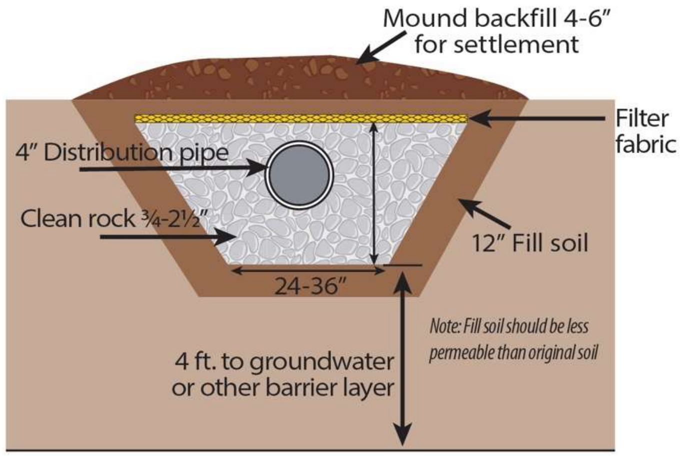
Construction Step 10
Immediately after construction, seed permanent cool season grass over the entire disturbed area and mulch the site for erosion control.

SOIL LINED LATERALS

Some sites may have such coarse soil (sand and/or gravel) that water may infiltrate and percolate too rapidly through the profile. The biomat may not form, or would form slowly, and not be consistent throughout the area. There is little chance of failure because of surfacing or backup in the facility. However, coarse soils are not suitable for traditional gravity absorption systems because they may produce inadequate treatment and do not protect groundwater. Alternative absorption designs are recommended for coarse-textured soils that provide inadequate treatment. A finer textured soil lining across the bottom and sides of the lateral has been used to slow infiltration and help distribute the wastewater evenly. A lined lateral works with gravity distribution and has the low maintenance of a traditional lateral system. The key to the successful longevity of lined laterals depends on the lining selection. As water moves from a fine-textured soil to an underlying coarser one, the fine-textured soil must be nearly saturated before water can move into the coarser material. This means the fine-textured soil will be continuously wet, and this may cause changes in soil structure and low oxygen transfer. A good lining might be a sandy soil with little structure that is not too permeable. It would not be as subject to damage by continually wet conditions and would have some spaces for oxygen transfer. Of course, the lateral must be over excavated by at least a foot in depth with sloping sides to allow placing the lining.

Some of the lining soil should be mixed with the top several inches of the natural soil to avoid an abrupt transition. Place at least a foot of the lining soil on the bottom and sides of the lateral as shown in Figure VII-8.

Figure VII-8. Soil-Lined Lateral Cross Section

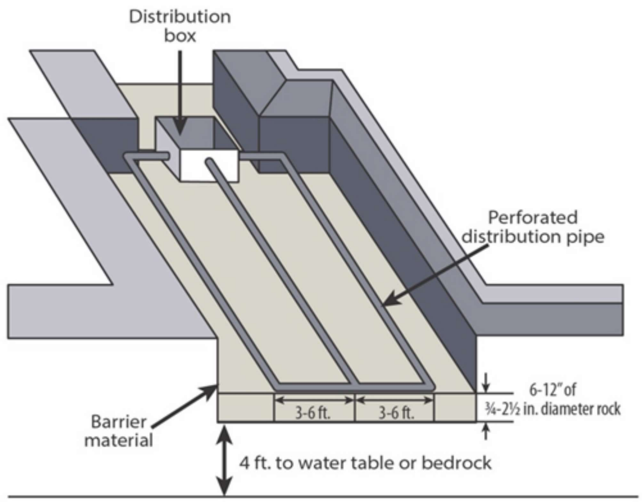


Other suitable alternatives could also include an enhanced pretreatment component and/or time-dosed pressure distribution. Using enhanced pretreatment reduces the amount of treatment the soil needs to do. Time-dosing maximizes wastewater contact with the soil enabling treatment. These alternatives require considerably greater attention to maintenance as well as greater detail during design and construction. In rural areas, it may be difficult to find service providers who can provide maintenance that is essential for alternative treatment or alternative absorption systems.

ABSORPTION BEDS

Absorption beds are typically much wider and shorter than laterals and contain multiple distribution pipes as shown in Figure VII-9. The primary advantage of absorption beds is that less surface area is required for a bed than for a traditional lateral absorption field. However, a lateral system is preferred because it provides a greater sidewall area with increased absorption surface and oxygen transfer under the laterals is much improved compared to the bed. A bed should only be installed on a level site for an existing home. The site should not be leveled to permit the construction of the bed. Laterals are more easily adapted to the contour of the land surface and can be used on steeper sites. Laterals may be constructed with less damage to the soil structure. Absorption beds are not recommended for permanent systems following a septic tank because of inferior treatment and shorter life expectancy compared to laterals.

Figure VII-9. Typical Absorption Bed Layout



A major limitation of a wide soil absorption area is that oxygen transfer is inadequate to the middle of the area under the bed. As a result, the soil often becomes anaerobic (septic) beneath the bed and treatment efficiency is substantially reduced. With oxygen more limited in areas away from the edges, the biomat growth becomes thicker and of a different consistency. With a thicker biomat growth, percolation through the bottom of the bed is proportionately reduced. The long-term outcome can be such low long-term acceptance rates that the bed system ultimately fails. For this reason, absorption beds are discouraged in favor of laterals no wider than 3 feet.

A bed system may be suitable for locations where central sewers are not presently available but are expected in the near future. When beds are used for dispersal of septic tank effluent, a larger bottom area is recommended than would be used for laterals. Recommendations vary widely and some state and local codes or regulations prohibit absorption beds because of deficiencies of this option. In Kansas when beds are used for septic tank effluent, a 50 percent greater bottom area is recommended.

Comparing 600 square feet of lateral trench 2.5 feet wide with a 900 square foot bed 20 feet wide shows slightly more total bottom plus sidewall area for laterals. The lateral system would have 4 trenches each 60 feet long making a total length of 240 feet. Using a rock depth of 1 foot the lateral system would have 600 square feet of bottom and 500 square feet of sidewall area for a total of 1100 square feet. The bed system would be 20 feet by 45 feet and would have 900 square feet of bottom area and 130 square feet of sidewall for a total of 1030 square feet. Thus, even when a bed is 50 percent larger, the laterals have more absorptive surface (bottom plus sidewall) and would be expected to have better aeration. The lateral system would be expected to provide better treatment and greater absorptive capacity through a longer life.

An at-grade bed system is very similar to at-grade laterals and can be used for level sites when soil conditions similar to those for at-grade laterals exist. Low pressure, time-dosed distribution should always be used for an at-grade bed system. The design of this type of system would have many similarities to a mound system design.

SUBSURFACE DRIP DISPERSAL

Subsurface drip dispersal (SDD) is a method of applying effluent to the soil at very low rates, and that may be used in place of traditional soil absorption systems. Drip systems are well-adapted to sites that have a severely limited soil absorption capacity, shallow soil, or a very restricted area for soil absorption. Drip systems typically receive enhanced treatment effluent from an aerobic treatment unit (ATU) or another pretreatment component. Drip lines are placed quite shallow (no more than 8-10 inches) and can easily be installed around trees, shrubs, and other landscape features with minimal disturbance to them. For more information about subsurface drip systems, please refer to KDHE's Subsurface Drip Dispersal Bulletin.

REFERENCES AND READING MATERIAL

Publications Soil Absorption Systems and Related Topics

Available from K-State Research and Extension, Distribution Center, 34 Umberger Hall, Manhattan, KS, 66506-3402, https://bookstore.ksre.ksu.edu/ (search by title or number).

Onsite Wastewater Publications

Environmental Health Handbook, 2nd Edition, on KDHE web site at https://www.kdheks.gov/nps/lepp/EHH.html

Get to Know Your Septic System (Onsite Wastewater Treatment), MF-2197, October 2000

Minimum Standards for Design and Construction of Onsite Wastewater Systems, KDHE Bulletin 4-2 (also K-State Research and Extension, MF-2214), November 1997

Plugging Cisterns, Cesspools, Septic Tanks, and Other Holes, MF-2246, July 1998

Selecting an Onsite Wastewater or Septic System, MF-2542, August 2004

Septic Tank Maintenance: A Key to Longer Septic System Life, WMS 18-947, January 2018, on KDHE web site at https://www.kdheks.gov/nps/lepp/download/KDHE_SepticTankMaint-MF-947-FINAL.pdf

Site and Soil Evaluation for Onsite Wastewater Systems, WMS 18-2564, March 2018, on KDHE web site at https://www.kdheks.gov/nps/lepp/download/KDHE_SiteSoilEvalOnsiteWW-MF2564-Final.pdf

Soil Compaction Problems and Solutions, AF-115, July 1996

Subsurface Drip Dispersal, KDHE Bulletin, June 2020

Why Do Onsite Waste\water (Septic) Systems Fail?, MF-946, November 2005

Your Wastewater System Owner/Operator Manual, S-90, September 2004

Available from MidWest Plan Service, 122 Davidson Hall, Iowa State University, Ames IA 50011, phone 800-562-3618, web address www.mwps.org

Residential Onsite Wastewater Treatment Systems: An Operation and Maintenance Service Provider Program, Consortium of Institutes for Decentralized Wastewater Treatment (CIDWT), January 2006.

PROTOCOL
INSPECTION OF A NEW ONSITE WASTEWATER (SEPTIC) SYSTEM

GOAL: Ensure system integrity to protect drinking water supplies, to prevent contamination of ground and surface water of the state, and to treat and disperse human waste in a sanitary manner to protect public health and meet state standards.

POLICY: Evaluation of the installation of a new wastewater system (pretreatment and soil-absorption field) will be completed as requested when the necessary paperwork has been completed and essential fees paid by the landowner, contractor, lending agency, or their representative. The inspection shall address all evaluation points listed here and will occur before the backfill of the underground portions are completed. An assessment report summarizing the inspection shall be provided to all persons who have legal interest in the outcome. A file of all original documents including letters, data, supporting information, etc. shall be maintained by the administrative agency.

EVALUATIONS:

1) Septic tank: verify the tank condition and that dimensions, capacity, manufacturer, and model are approved by KDHE, and meet state and local standards for septic tanks.

    a) Check to ensure tank manufacturer's name, phone number, month and year of manufacture, capacity, and model are displayed on the tank. Verify this model meets state minimum standards and is approved by KDHE.

    b) Check the tank for possible damage from handling.

    c) Using a contractor's or carpenter's level, check to see that the tank is set level on a gravel base in the excavation as specified in EHH, Chapter V, Septic Tanks.

    d) Check to see that the tank access ports and manhole risers meet all requirements. Ensure access ports and manholes extend to surface grade for easy access, and are watertight.

    e) Check dimensions of length, width, and depth below outlet invert, and verify tank capacity.

    f) Check distance to the bottom of inlet and outlet tees, or baffles from the bottom of the tank.

    g) Check the effluent filter (if present) to be sure it is easily accessible for service via riser at the surface.

    h) Use a contractor's or laser level to measure and record elevations of the sewer pipe where it exits the building, inlet to the tank, outlet from the tank, and absorption-field lateral(s). Verify the slope on the sewer pipe from the house to the tank is 1/4-inch per foot or 2 percent. Verify the elevation difference from the tank inlet to the outlet has a minimum 3-inch fall.

i) It is appropriate to verify the tank is water-tight by filling it with water and measuring loss over several hours.

2) Other tank related items

a) Inlet and outlet pipes of the tank meet minimum standards (Schedule 40), and are properly installed, adequately supported, and are either securely connected to Ts or terminate on the outlet side of the baffle.

b) Two-way cleanouts are provided every 100 feet along sewer lines that exceed 100 feet in length and carry solids from the building to the tank. It is easier to clear clogs when these cleanouts are no more than 100 feet apart.

c) Two-piece tanks are joined with an approved sealant so the joint does not leak, and is grouted inside and outside to make a smooth durable finish.

d) When the soil cover over the tank exceeds 12 inches, extension risers to the ground shall be installed over all openings. When tanks have multiple compartments, each one must be accessible for service and inspection. The manhole for each compartment must have a minimum dimension of 20 inches and should be centered.

e) When backfill is complete, use a probe to verify fill around tank is adequately compacted.

3) Absorption field area - verify field condition, dimensions, and capacity, and that quality of materials used meets minimum standards. If conditions are suitable (sufficiently dry, no compaction, and no traffic), proceed to verify the following:

a) Measure and record for each lateral — length, width, and undisturbed distance between laterals.

b) Approved perforated distribution pipe or chambers are used for all laterals.

c) Material separation (filter) fabric covers aggregate and meets the required minimum.

d) Inspection ports (observation pipes) installed appropriately in laterals as required.

e) Fill around piping, distribution box, manifold pipe, and drop boxes is compacted.

f) If a subsurface perimeter drain is used, measure and record the separation distance from absorption field, depth, length of drain lines, and location of lines and outlets.

i. Check and record the following elevations (where possible, use the pipe invert):
ii. Check elevation of distribution manifold pipe at each lateral tee or elbow, and at least one point between. Elevations should vary no more than ½ inch or 0.05 feet.

g) Check lateral trench and distribution pipe (elevation of trench bottom, top of distribution pipe, and top of rock). For trenches shorter than 50 feet, check at least two locations. For trenches longer than 50 feet, check at least three locations.

Note: It is difficult to check elevation of a trench bottom after rock has been placed. Recommend requiring contractor to make a record of trench-bottom elevations and having inspector make a random check for minimum depth of rock under pipe.

h) Ensure absorption field area with length, width, and all setback distances is defined, and has been protected during house and septic system construction on the site.

Additional requirements for stepdown (serial) distribution system.

- Determine that drop-box (or crossover pipe used in place of preferred drop-box) inlet invert elevation is at least 1 inch higher than the overflow invert, and lateral outlet inverts are at least 3 inches below overflow invert.
- Top of the gravel in laterals is 2 inches above that of the drop-box overflow invert elevation.
- Check drop-box or crossover pipe elevations as follows (use the pipe invert when possible or top of pipe when it is the same diameter): drop-box inlet invert, trench lateral pipe outlet invert, overflow pipe invert, and top of lateral gravel.

4) Measure and record setback or separation distances as follows: (Note: make drawing of system layout on the site, including measurements, and calculate square footage of absorption and reserve field.)

a) Septic tank to building foundations (existing and planned buildings)

b) Septic tank to all existing (and unused) wells or planned new water well locations

c) Absorption field to existing (and unused) wells or planned new water well locations

d) Absorption field to buildings (existing and planned)

e) Absorption field to property line

f) Absorption field to any surface water or water course

g) Absorption field to important topography features such as a drop-off

h) Reserve absorption area available for replacement of existing system in the event of failure or expansion. Also, verify all setback measurements for the reserve area.

PROTOCOL
EVALUATION OF AN EXISTING ONSITE WASTEWATER (SEPTIC) SYSTEM

GOAL: Ensure system integrity to protect drinking water supplies, prevent contamination of the ground and surface water of the state, and treat and disperse human waste in a sanitary manner to protect public health and meet state standards.

POLICY: Evaluation of an existing septic tank and soil absorption system will be completed at request of the landowner, lending agency, complainant, or other interested party. The inspection should address the evaluation points listed below. An assessment describing the evaluation should be provided to all individuals who have legal interest in the outcome of the evaluation. A file of all letters, data, supporting evidence, and documents shall be maintained by the administrative agency.

EVALUATION:

1) Obtain all known information about the system from the file, property owner, contractor, and/or complainant. Supplement this with all available information from other readily available sources, especially the County Soil Survey (web soil survey).

2) Conduct a visual survey of the site. Note any discharge areas, effluent surfacing, or evidence of previous effluent surfacing. Note any odors, wet soil, vectors, and damaged or burned vegetation.

3) Locate the point where the household sewer pipe(s) leaves the house. This can be aided by the following:

    a) In the basement, trace the sewage pipes to the point where they exit the house.

    b) Where there is no basement or where household sewer lines are not visible, locate the household sewer stack vent on the roof; it is often above the pipe exit.

    c) Look for a cleanout just outside of the house foundation.

4) Locate the septic tank and absorption field using the office file, information provided by the property owner, grass patterns, and surface depressions. If possible, verify the location with a probe. Radio operated tank location devices may also be used to locate septic tanks.

5) All household wastewater must enter the septic tank. The only exceptions are potable water, backwash of potable water filter (including water softener recharge), or air-conditioner condensation. Roof drains and sump pump must never enter the wastewater system. These can be surface discharged.

6) Perform a dye test, if necessary, to verify source of surfacing flow. Monitor the absorption field and surrounding area, including nearby streams, tilled fields, ditches, and embankments for surfacing of dye. There shall be no discharge of wastewater to the ground surface, or any surface in the absorption field area or downslope from it.

7) Septic tank evaluation

   a) Record tank construction, size, condition, and if possible, age from records. If necessary, determine tank size from measured dimensions or from tank pumping records.

   b) Record the last date the system was pumped and the name of the septage pumper/hauler. If the tank has not been pumped within the last three years, pumping is required.

   c) Open the tank and observe the contents. If the water level is below the outlet pipe invert, suspect leakage — this represents a cause to replace the tank.

   d) When tank is pumped, inspect its condition and components — baffles, tees, and effluent filter, and check that lids are in place and in good condition. Measure and record the dimensions, construction, and size of the tank.

8) Using visual indicators and probe, attempt to locate absorption field and verify length, width, number of laterals, and total square feet. Probe for rock/gravel and observe vegetation changes to help identify lateral locations.

9) If a map of the system on the site does not already exist, sketch a map of it showing locations, setbacks, and dimensions. Clearly show date and mark that this is based on field probing and may not be accurate.

10) If necessary, obtain the required registration permit application and fee from the owner and properly record this in the county files.

11) To complete the evaluation, avoid any written statement regarding expectations for future performance. Remember to compare all conditions with local code, state minimum standards, and recommendations. The evaluation should note any inconsistencies and state whether the system was in active use and the number of users at the time of evaluation.

12) Notify owner and other interested parties in writing of final evaluation and of any necessary course of action.

13) File copies of all pertinent information with the local permitting agency.

Chapter VIII
WATER CONSERVING TOILETS AND HOLDING TANKS

TABLES

INTRODUCTION

During the last several decades within the onsite wastewater industry, most of the emphasis has been on systems handling waste carried (or flushed) by water. However, non-water or very low water options are also available to handle human waste, but have not received as much attention. Non-water options include: vault privy toilet (modern outhouse), composting toilet, incinerating toilet, and portable toilet unit. These systems are only suitable for handling feces, urine, and toilet paper, plus organic kitchen wastes in some composting toilets. Yet sometimes a no- or low-water use system is not the most feasible option. In unusual circumstances or as a last resort, a holding tank may be a viable and a logical choice. This chapter summarizes information about options that involve little or no water flushing, holding tanks, and greywater systems.

Since the 1970s, a growing number of people are concerned that Kansas water resources are becoming over used. Irrigation of crops, power production, and to a lesser extent landscaping are the major consumers of water. Water used to carry wastes, though a small part of the Kansas total, can locally be an important part of high water use. Water used for the toilet can be reduced to less than a quart per flush. Composting, incinerating, and privy toilets work quite well without water. Greywater used for cleaning can easily be collected and treated by a separate wastewater system and, under the right conditions with an appropriate design, effluent can be used to water the landscape. The options discussed here are gaining in importance as water becomes more scarce and costly.

PRIVY OR OUTHOUSE

A “privy” is a small building separate but usually near a dwelling, often referred to as an “outhouse”, used for disposal of body wastes (feces and urine). It typically serves an individual home but may also serve a remote recreational area. The term “latrine” suggests communal use for groups such as for a camp, school, or military unit. A modern latrine may have flush toilets but in primitive locations it generally will not. The terms privy, outhouse, and latrine are often used interchangeably.

A privy can either be a “pit privy’ which is unlined or at least has an unlined bottom, or a “vault privy” which is set over a watertight tank. A pit privy is designed to allow the liquid wastes to seep into the soil (where most of the treatment occurs). The vault privy tank is often made of concrete similar to a septic tank, but plastic or fiberglass vaults are also used. Some county codes contain a section on privies. If there is no local code, the horizontal and vertical separation distances in KDHE Bulletin 4-2 should be used for guidance. In 1974, KDHE published official privy plans as Environmental Health Bulletin 4-3, *The Sanitary Privy*. Today pit privies are not considered suitable for legal use in Kansas because of unsanitary conditions so this bulletin is no longer current. Class V well regulations apply to all facilities with the capacity to be used by 20 or more persons per day and where the waste goes into the soil rather than into a central sewer system. All Class V wells should be registered with KDHE.

A vault toilet, as the name implies, has a water-tight container that retains wastes. Regular maintenance is essential to remove the accumulated waste. A well-designed and maintained vault toilet is legal, a suitable option, and much more sanitary than a pit privy. Septage from a vault toilet is much like septage from a septic tank and must be treated similarly. Because vault toilet septage has a much higher concentration of solids, handling will be different.

Odor-Free Toilet – The Modern Vault Privy

The United States Forest Service (USFS) is probably the world's foremost authority on the topic of sanitary privies. They supported a successful, multi-year project to develop a nicer vault toilet facility dubbed the Sweet Smelling Toilet (SST). The keys to success are location, design, and construction of the privy. Principles include: air flow moves down the toilet riser (seat) and up the vent stack at all times and materials used do not absorb odors and are easy to clean.

SST Design features include (Cook and Land, 1996):

1) 12 to 14 inch diameter black vent stack extending from vault to 3 or more feet above the highest part of the roof. The stack ideally located on the south side creates a strong upward air flow which lowers the pressure in the water tight vault and draws air in the riser. This air flow exhausts most of the odor into the atmosphere where it is dispersed.

2) The vent stack is uncapped and unscreened when possible.

3) A small (120 sq. in.) wall or door vent faces the prevailing winds (locate vent near the floor if wind is fluctuating).

4) The roof on the toilet portion of the structure is well insulated.

5) A manhole access to the vault is usually located near the vent stack and the vault floor slopes toward this access to make pumping the vault easier.

6) In units with multiple risers, a separate tank and a vent stack are used for each riser.

7) Maintenance should include regular pumping; frequent disinfectant cleaning of the inside and outside of the riser, the riser lid, and the floor; and assuring that the vent stack is free of any material that would reduce air flow, including spider and insect webs.

PORTABLE TOILET UNIT (PTU)

A portable toilet unit (also known as (aka) porta-potty, portable sanitation unit, portable toilet, etc.) is a portable privy with small self-contained, watertight tank. These are supplied and maintained by private service companies. Common uses for these units are at construction sites, seasonal use areas, and events drawing many people to areas that are not adequately supplied with toilet facilities. These units are quite nice and pleasant to use, when regularly serviced and cleaned. Service providers use reference tables to determine the number of PTUs needed for an event based on the length of the event and the projected number of participants. PTU use has expanded greatly in the last two decades and is a 1.5 billion dollar per year industry utilizing 9,400 trucks to service 1.4 million toilets.

COMPOSTING AND DRYING TOILETS

Composting toilets use aerobic decomposition of organic matter by bacteria, fungi, molds, and other organisms to transform waste into a relatively dry, nutrient-rich humus material called compost. Composting toilets generally consist of a toilet unit with seat, a composting tank or tray, a vent with a fan, and an access port for compost removal. Dry, high carbon, organic material such as sawdust, leaves, bark, or straw clippings may need to be added to provide bulk and to aid compost organisms.

The composting process takes place in a holding chamber in the presence of oxygen, for rapid aerobic decomposition. A warm, well-ventilated container with a diverse community of microbes breaks down waste materials and produces an odorless nutrient-rich organic material. Waste materials can be excrement, urine, toilet paper, and readily decomposable vegetable by-products. A well-managed composting process reduces waste volume by 80-90 percent. With good care, these composts produce temperatures of 120-130 degrees F, high enough to destroy most pathogens. Nitrogen and phosphorous are conserved and concentrated in the compost product. Under limited conditions, compost can be applied to land as a nutrient-rich fertilizer.

Commercially made composting toilets, available from several manufacturers, come in two general types. Large, passive units have large compost tanks and few or no moving parts. They rely on size to hold waste materials for the long time periods necessary for natural composting. They do not use mechanical heaters or mixers. A basement, crawl space, or other excavation is required for a large compost tank. Small, active systems are self-contained units that fit easily into a typical bathroom. They rely on electrical heating with mechanical ventilation and mixing to speed up the compost process. The input of external heat and mechanical power can reduce the size and initial cost of the unit. However, maintenance costs are increased because of energy consumption.

INCINERATING OR EVAPORATING TOILET

Incinerating toilets use an energy source (electric, natural gas, or propane) to burn toilet wastes at 1400 degrees F, resulting in an ash residue that is disposed of as solid waste. A paper bowl liner is applied for each toilet use to protect the bowl and to reduce cleaning. The liner and waste are dropped into a holding container. The waste is incinerated after 2-4 “flushes”. The units require an external energy source, a vent pipe, and perhaps an odor control device. Because of the energy used, they have a significant operating cost and thus are typically not a good choice for long term continuous use.

HOLDING TANK

A holding tank is a watertight tank that holds discharged sewage. It must be pumped to remove sewage from the site to an approved treatment system. The high cost of frequently pumping the tank makes this an expensive and less desirable option. A holding tank is the least desirable solution for problem soil and site conditions but may be an option for a small lot with little or no suitable soil for a traditional absorption system.

Local codes typically allow holding tanks only for an existing residence or commercial establishment. Do not consider a holding tank as an option for a new business or year-around residence, except as a temporary solution when a central sewer system is approved for construction and will be completed in just a few years. If sewers are planned for the future but financing and construction are not already approved, another solution should be found.

A holding tank can be a suitable option for systems that are expected to have very small flows such as those at part-time, seasonal, or recreational facilities. Often, a holding tank is used as a low-cost repair to make a failing system code compliant. A holding tank might also be used where the lot shape or size is so restrictive that a properly designed and sized traditional or alternative soil absorption system cannot be installed. A holding tank can also be an excellent way to handle excess flows from a system that has marginal capacity, experiences seasonal failure, or has temporary overloads.

When used to contain excess field flows, the holding tank should be placed so only the flow that cannot be absorbed by the soil system will flow into it instead of discharging to the surface. This may be done with a drop box structure that allows overflow to run into the holding tank.

When used in this way, the soil absorption system handles most of the flow and the holding tank collects only the excess resulting from large wastewater flow or extended wet weather.

Holding Tank Installation

Locate the tank where it is easily accessible for a pump truck during all weather conditions.

Take steps to minimize the chances for nuisance spills from accidents during pumping. Placement of a holding tank will be similar to a septic tank and must be on firm soil capable of supporting the weight of a full tank. A holding tank must comply with the same setback regulations required for other onsite systems. The tank must not be placed below or into the water table, as the tank will float when empty and some can even float when nearly full. A tank should have a minimum two-week storage capacity and should have a reserve capacity of an additional week to allow for possible emergencies or delays in pumping the tank.

The holding tank should be equipped with an access manhole extended to the ground surface for easy access when pumping. The manhole lid should be watertight and be made of heavy cast iron material that can be locked or otherwise secured to prevent unauthorized access. It is also strongly recommended that the holding tank be equipped with an audible and/or illuminated high-water alarm that is activated when the tank is approaching its full capacity.

Holding Tank Operation

When a holding tank is used, carefully plan for and install water-conserving appliances and fixtures. Adjust water-use habits to minimize wastewater production and the cost of service. An additional water meter is recommended to separate water usage for domestic purposes from irrigation water. When domestic use is monitored, the user has better information for scheduling tank pumping and determining the amount hauled. For those who make a commitment to reduce water use, it is amazing how little water is really essential. Average water-use through the winter months can be used to estimate on average the frequency for pumping the holding tank.

SEPARATE GREYWATER SYSTEM

Questions are often asked about handling, treating, and use of greywater separate from blackwater. Blackwater is typically defined as the sewage that comes from the toilet and sometimes includes the kitchen sink. Greywater is all other wastewater from the home.

Wastewater systems of some older homes were designed to send the blackwater to a small septic system or cesspool and to surface discharge greywater. Surface discharge of any sewage including greywater has not been acceptable in Kansas since 1997.

Untreated greywater is still sewage and contains bacteria – including fecal coliform or E. coli especially in laundry and bath water. These bacteria are commonly found in the digestive system of warm-blooded animals and their presence indicates fecal contamination with a corresponding high risk of pathogens being present. Greywater contains dirt, grease, soap, detergent, bleach, and other household chemicals depending on activities in the home. Greywater from the kitchen is often as high (or higher) in biochemical oxygen demand (BOD) compared to blackwater, and may contain pathogens. Because the wastes from the kitchen sink are more like toilet wastes this source is sometimes included with blackwater.

Dirty laundry, under normal circumstances, contains pathogens. The risk of harmful bacteria in laundry increases any time there is sickness. For these reasons it is a health risk (and in Kansas illegal) to have surface discharge of greywater. Bulletin 4-2 specifies greywater must be treated by an approved onsite wastewater system or be discharged to a permitted central sewer system.

In general, greywater is perceived as being relatively clean and low in nutrients or other pollutants. While it is true that greywater contains relatively little nitrogen (most of the nitrogen from a home is found in toilet wastes), greywater can contain significant amounts of BOD, phosphorus, and total suspended solids (see Table VIII-1).

Table VIII-1. Comparison of Some Greywater and Blackwater Characteristics

Parameter	Greywater	Blackwater
Source and flow	Wastewater from all sources except the toilet including: sinks, laundry, bath, shower, etc; usually about 70 percent or more of household total.	Wastewater flow from only the toilet; usually about 30 percent or less of household total.
BOD or organic load	Generally higher BOD concentrations; organics are easier to break down	Usually lower BOD concentrations; organics are more difficult to break down
Fecal bacteria	Greywater contains considerable fecal bacteria. It must be considered a potential disease source.	Blackwater contains higher fecal bacteria concentrations and is a serious disease source.
Nitrogen	Normally contains only about 10 percent of total nitrogen; has much lower concentration.	Typically contains about 90 percent of total nitrogen; has much higher concentration.
Phosphorus	Typically contains about half of the household phosphorous load; a lower concentration than blackwater.	Typically contains about half of the household phosphorous load; a higher concentration than greywater.
Treatment needs	Greywater must receive adequate treatment before reuse; cannot be surface applied or surface discharged.	Reuse of blackwater, except subsurface irrigation of windbreaks and grass, is strongly discouraged.

Source: Adapted from handout by J. Howard Duncan, 26 March 1992.

Separating greywater from blackwater after a house is constructed is usually difficult and expensive. However, houses that are already plumbed this way or houses just being or to be built are candidates for a separate greywater collection system. Using composting or incinerating toilets is more feasible if greywater is already handled separately or can easily be separated from blackwater. The Ruck System® uses a septic tank and an aerobic filter for blackwater which is then blended with greywater that has passed through a separate septic tank. The Ruck System can reduce nitrogen and phosphorous going to the soil absorption field.

Biochemical oxygen demand (BOD) in greywater may equal or exceed the BOD content of blackwater. This is primarily because of food waste and grease from kitchen drains. Total suspended solids (TSS), also from kitchen flows, may equal those found in toilet wastes and can far exceed toilet flows when a garbage disposal is used.

In a typical residence, greywater contains about half of the phosphorus (P) from a typical home. However, because of greywater's greater volume, the phosphorous concentration is less than in blackwater. Concentration and total P load in greywater directly relates to the use of detergents containing phosphate. Although some states prohibit the sale of phosphate detergents, Kansas does not. However, today most detergents contain less phosphorous than they did just a couple of decades ago.

CHOOSING WATER CONSERVATION / MANAGEMENT OPTIONS

Several options with very different characteristics for water conservation and management are presented and discussed in this chapter. Because the options are so different and information comes from different sources, choosing between them can be especially challenging. Table VIII-2 summarizes some parameters of interest and characteristics that might be important to the decision maker. Additional information is available through internet searches, dealers, and installers for each of the water conservation and management options identified in this chapter.

Additionally, new options will likely become available in the future. The user is encouraged to search out information about the parameters most important to him or her.

In addition to differences in types of equipment, there are also differences in the knowledge, experience, and skills of suppliers and installers. Complications can arise when the equipment dealer has had no previous experience with the equipment or because of location is not able to install the equipment they sell. It is therefore advisable to obtain customer referrals for the unit you are considering. A buyer should confirm that the chosen dealer and/or installer will do quality work by talking to a few previous customers. Be sure to ask about problems and how those problems were resolved.

Table VIII-2. Comparison of Selection Parameters for Different Water Conserving Options

Parameter	Vault Toilet (Privy)	Composting Toilet	Incinerating Toilet	Holding Tank	Greywater System
Best Use	Short term (camp, cabin, recreation); where no water or power are available	Must save water; very strong desire to save water; reuse nutrients; more sustainable; protects environment	Short term or limited use; no water but power available	Very small lot; temporary need; little use	Dry area and limited water; reuse for subsurface landscape watering
Initial installation cost	Low for regular unit; moderate for odor-free unit	Moderate to high; may require special construction	Low to moderate	Low	Moderate for new construction; typically high for existing home
Annual operating cost	Low	Low	High energy: cost is proportional to use	Very high: cost is proportional to use	Low to moderate
Labor	Very low	High; daily or weekly action	Moderate or high	Low to moderate	Low to moderate
Strengths	Very simple; no water needed; no wastewater produced; reliable	No or little water used; inside; save & reuse nutrients; environmentally sensitive	No water needed; inside	Normal bathroom plumbing; low initial cost; limited or temporary use	Possible beneficial reuse of water; normal home plumbing appearance
Limitations	Outside separate from house; must be pumped occasionally; primitive	Management is essential; requires a greywater system	Management is essential; requires a greywater system; high energy use	Must limit water use; tank must be pumped regularly; septage must be properly disposed	Requires same treatment as blackwater; yard reuse must be subsurface

REFERENCES AND READING MATERIALS

Ayres Associates through CH2M Hill, *The Monroe County [FL] Sanitary Wastewater Master Plan; OWTS Technology Assessment No.2: Non-Water Carriage Toilets*, November 10, 1997.

Barnstable County (Cape Cod) MA, Department of Health and the Environment, *A Compendium of Information on Alternative Onsite Septic System Technology in Massachusetts*, June, 1997.

Barnstable County MA (Cape Cod) Department of Health and the Environment, Alternative Septic Systems Information Center.

Barnstable County MA, Title 5 Correspondence Course: A Self-Paced Tutorial designed especially for Board of Health Members (6 Modules). This course is based on the Massachusetts Department of Environmental Protection TRAINING MANUAL FOR THE STATE ENVIRONMENTAL CODE, TITLE 5.

Bennett, Dick, 1995. *Graywater: An Option for Household Water Reuse*, in Home Energy Magazine Online, July/August 1995.

Cook, Briar, 1991. *In-Depth Design and Maintenance Manual for Vault Toilets*. United States Department of Agriculture, Forest Service, Technology and Development Center, San Dimas, CA. July.

Cook, Briar and Brenda Land, 1996. *Guidelines for Selecting an Odor-Free Toilet*. United States Department of Agriculture, Forest Service, Technology and Development Center, San Dimas, CA. August.

Gelt, Joe, 1993. *Home Use of Graywater, Rainwater conserves Water - and May Save Money*, University of Arizona, Water Resources Research Center, Arroyo Newsletter, Tucson, AZ, Summer 1993.

Kansas Department of Health and Environment, *Environmental Health Bulletin 4-3: The Sanitary Privy*, 1974 Topeka, KS.

Land, Brenda, 1995. *Remote Waste Management*. United States Department of Agriculture, Forest Service, Technology and Development Center, San Dimas, CA, May.

Makel, William, Gary Hoshide, and James Kautz, 1995. *Cleaning Recreation Sites*. United States Department of Agriculture, Forest Service, Technology and Development Center, San Dimas, CA. December.

New Mexico Cooperative Extension. 1994. *Safe Use of Household Greywater*, Guide M-106. New Mexico State University, Los Cruses, NM.

Portable Sanitation Association International (PSIA) Bloomington, MN 952-854-8300 or 800-822-3020. www.psai.org>.

Rosenbaum, Marc. *Converting "Waste" into Nutrients - Treating Household Organic Waste.*

Roley, Bill. *Home and Community Water Management* in Sustainable Cities - Concepts and Strategies for Eco-City Development, Edited by Bob Walter, Lois Arkin, and Richard Crenshaw.

United States, Department of Agriculture, 1995. *Toilet Vent Stack Maintenance*, Forest Service, Technology and Development Center, San Dimas, CA, July.

USEPA, 1999. *Water Efficiency Technology Fact Sheet: Composting Toilets*, EPA832-F-99-066, Office of Water, Washington, DC, September.

USEPA, 1999. *Water Efficiency Technology Fact Sheet: Incinerating Toilets*, EPA832-F-99-072, Office of Water, Washington, DC, September.

Chapter IX
WASTEWATER POND (LAGOON)

PROTOCOLS

TABLES

FIGURES

INTRODUCTION

A septic tank followed by an in-ground soil absorption system is the preferred on-site wastewater treatment system when site and soil conditions are suitable. However, when the soil is too impermeable for an in-ground system and adequate area exists, a lagoon may be an option. Soils with high clay; poor drainage; seasonal perched water table; or platy, very weak, or massive structure are typically poorly suited to soil absorption but often well suited to lagoons.

A properly designed, constructed, and maintained lagoon will treat wastewater, protect human health and the environment, and can be inconspicuous. It is important to remember, however, that a wastewater lagoon treats raw sewage. Raw sewage is a health hazard. The lagoon must be properly maintained in order to function as it should, and protect human health and fresh waters of the state. This chapter addresses all aspects of construction, operation, and maintenance of a lagoon. It should be diligently followed.

Proliferation of single-family wastewater lagoons within subdivisions of many homes should be avoided when other options are available. Multiple lots in close proximity with soil poorly suited to traditional in-ground systems may be suitable to other wastewater treatment options. A cluster system consisting of collection, pretreatment, and soil dispersal on a dedicated site should be considered as discussed in Assessing Wastewater Options for Small Communities in Kansas Manual (1999). This manual is available on the Kansas Department of Health and Environment (KDHE) website.

This chapter of the Environmental Health Handbook has been prepared to provide guidelines for the design, construction, operation, maintenance, and repair of small (less than 2,500 gallons per day) nondischarging wastewater lagoons. Guidelines in this chapter are intended primarily for private wastewater facilities for individual homes. However, guidance for wastewater treatment lagoons may be adapted to serve schools; institutions; and businesses such as motels, restaurants, camps, and mobile-home parks that have domestic type wastewater.

Any system receiving industrial wastewater, including shop floor drains, must be referred to the Kansas Department of Health and Environment.

HOW TREATMENT OCCURS IN A WASTEWATER LAGOON

Lagoons support physical, biological, and chemical processes that result in treatment of wastewater. Natural conditions in a properly operating lagoon result in three layers: aerobic on top, anaerobic on the bottom, and an intermediate or mixed layer. Treatment and conditions are different in each of the three layers. Wind on the surface of the lagoon is important to introduce oxygen into the water, supporting aerobic bacteria in the top layer. Sunlight supports algae growth in this layer. Algae produce oxygen through photosynthesis, supporting the aerobic bacteria. The bacteria release carbon dioxide used by the algae. To assure wind and sun exposure to the lagoon, trees and shrubs must be sufficiently distant so as not to shade the lagoon or inhibit wind contact.

When functioning stably, this symbiotic relationship results in a bright green color at certain times of the year. When wastes are broken down, some gases are released into the air and small amounts of solids settle to the bottom. In a properly constructed and managed lagoon, household wastewater can be treated for up to 30 years and solids will not likely build up to the point they need to be removed. It is essential to maintain the lagoon in a properly functioning state. The Protocol – Home Maintenance and Inspection Checklist at the end of this chapter summarizes ongoing, required maintenance.

KDHE AND LOCAL JURISDICTION RESPONSIBILITIES

The Kansas Department of Health and Environment has defined their responsibility for permitting wastewater lagoon systems as follows:

1) Discharge to the surface.

2) Receive any amount of industrial wastewater discharge.

3) Serve wastewater systems owned by local government or other public entity.

Authority to regulate wastewater lagoons is granted to local governments under K.S.A. 19- 3701 et seq., K.S.A. 19-101a, K.S.A. 12-3302 or 3303, and K.A.R. 28-5-6.

Local governments may regulate wastewater treatment lagoons if they have a KDHE-approved sanitary code, providing them authority. The lagoon must be nondischarging and receive less than 2,500 gallons per day of domestic sewage. For more detail, see Protocol – Permitting Authority at the back of this chapter.

CONSIDERATIONS FOR LAGOON SITING

Due to space requirements and access for maintenance and repair, many factors must be considered in deciding on a lagoon for sewage treatment. These factors include the following:

1) Adequate space – the footprint area required by a lagoon may be 10,000 square feet or more, for an individual home, and potentially larger for a business. In additional to the initial lagoon location, planning for a replacement must also be considered.

2) Separation and setback – distances from property lines, wells, surface water and drainage, easements, buildings, and flood plain are determined by local code and state minimum standards. See Table IV-7 in Chapter IV for minimum required and recommended setback. All buried gas, electrical, or other utility lines must be located prior to excavation.

3) Separation of tall vegetation – the site should have adequate separation distances from trees and other vegetation that could impair functioning, especially shading, air-flow restriction, and leaf drop.

4) Ease of maintenance – routine care of berms, fences, and vegetation is required on a regular schedule.

5) Site conditions – slope of land and restrictive soil conditions within 5 feet of the ground surface. A high-water table or a saturated zone near ground surface may prohibit a lagoon.

6) Adequate area – a minimum lot size of 3 to 5 acres is typically needed to accommodate a private well and lagoon with all required setback and/or appropriate separation distances.

7) For more specific information, see Protocol – Evaluating and Siting a Lagoon later in this chapter.

SITE EVALUATION

See Chapter IV of this handbook for additional discussion about site and soil evaluation. Conducting a proper site evaluation for a lagoon includes the following specific steps:

1) Determine the appropriate local agency responsible for facility permitting. In most cases this would be the sanitarian in the local health department, or planning and zoning office.

2) Conduct a preliminary site evaluation to select the most suitable location. See Protocol Site Evaluation for On-site Wastewater Systems in Chapter IV. Note all conditions that could adversely affect location and construction, such as private or public water wells or pipelines, sandy or rocky soil, utilities, easements, property lines, topography, and geology. Utilize all available site-specific information such as site history, soil profiles, and county soil survey book available from the local USDA NRCS office or the NRCS Web Soil Survey.

3) Evaluate potential effects of unexpected overflow or release, and resultant contamination to surrounding property and environment.

4) Based on a soil profile evaluation, obtain the estimated design loading rate (DLR) using Table IV-4 in Chapter IV. Soil textures and structures with no suitable DLR are frequently acceptable for a wastewater lagoon with adequate compaction. Fine-textured soils with a DLR of 0.2 gallons per day, especially in Eastern Kansas, may be suitable for lagoons.

5) Compare results with permeability of the soil on the site in the SCS/NRCS county soil survey to see if general agreement exists. Large discrepancies in results should be reconciled by further testing, done by someone experienced with soil texture, structure, and permeability.

A lagoon location downslope and downwind from the source is preferred so sewage will flow by gravity at the correct slope. The site should be downwind of the residence or facility to minimize possible nuisance conditions such as odor, in Kansas usually to the east or northeast. Only rarely do objectionable odors occur from a properly operated and maintained lagoon. However, odors may be noticed for a brief period in the spring or fall when a stratified lagoon turns over or when there are several consecutive overcast days.

Separation distances from surface water, wells, property lines, and public water lines must be in compliance with local codes and/or KDHE Bulletin 4-2; or Chapter IV, Table IV-7 in this handbook.

A detailed site plan showing all physical features, surface and buried, and contour elevations will be a great help to locate and design a wastewater lagoon. The bottom of the lagoon should be at least 4 feet above the highest groundwater level or other limiting conditions.

To assure adequate drainage and to avoid the risk of a backup in the residence or facility, the top of a lagoon berm should be below the lowest drain or cleanout in the house.

Sometimes the lagoon must be located upgrade from the house, which necessitates a pump tank and pump. Pumps are subject to failure, require an energy source and maintenance, and will increase costs. When pumping is required, it is advisable to add a septic tank and use an effluent pump. To assure good hydraulic operation, use a high-quality sewage or grinder pump and have the system designed by an experienced person. Adherence to hydraulic principals including pump selection and backflow prevention from the lagoon are essential.

The findings of site investigation and pertinent preliminary information should be reviewed with both parties. An original, and at least two additional sets of construction plans and specifications should be prepared. The contractor and homeowner should receive the copies and the original should be retained in the office permit files.

Applicants need to be informed that single-family wastewater lagoons are to be constructed, operated, and maintained according to county or city/county requirements. Failure to do so can result in a declaration of a public health nuisance by the local board of health (KSA 65-159) and prosecution by the county attorney (KSA 65-160).

Additionally, applicants should be informed that if a central collection system becomes available, within 400 feet of the property, connection to the central collection system may be required as defined by county code. If connection occurs, proper abandonment of the wastewater lagoon must occur.

When the site evaluation indicates a lagoon is the most appropriate and acceptable option, sizing, design, specifications, and construction plans are the next step.

SIZING THE LAGOON

The primary objective of sizing the lagoon is to provide adequate depth and wastewater treatment, and prevent overflow. Optimum lagoon water depth is 5 feet measured from the bottom of the lagoon to the water surface. Satisfactory operation occurs with water depths of 3 to 5 feet. Water level may drop as low as 2½ feet for short periods without adversely affecting the lagoon's operation. However, sunlight may penetrate a shallower depth and plant growth across the lagoon bottom with depths less than 2½ feet will impair a lagoon's operation.

Estimating wastewater retention in a lagoon is achieved by identifying the amount of wastewater flow minus net water loss. Water loss occurs through evaporation and seepage. Evaporation plus seepage can range up to 14 feet in annual loss in Southwestern Kansas, to 10 feet or less in Eastern Kansas. Seepage varies with the soil and compaction from very low to the maximum allowable of 0.25 inches per day (few inches to 7.6 feet per year). Preferably, seepage should be no more than 1/8-inch per day. Precipitation and evaporation data are collected only at certain sites across the state and have been extrapolated to include areas where data were not available.

Wastewater flow for sizing a lagoon is based on average flow rather than peak flow, which is used for sizing an in-ground wastewater system. Lagoons easily handle temporary high flows with a rise in water level, which results in an increase in losses. Conversely, in-ground systems must be able to handle these peak flows to avoid malfunction or failure.

Actual water records, when available, are a preferable source of determining expected average flow. Factors to consider when estimating wastewater flow to size of lagoon follow:

1) Wastewater design flows are based on average number of persons expected to reside in the house. This is certainly less than full occupancy of two persons per number of bedrooms. Use a wastewater flow rate of typically 40 to 50 gallons per person per day. Use two- to five-person average occupancy for a three-bedroom house with corresponding flows of 100 to 250 gpd.

2) Assess lifestyle factors for a deviation above or below the average wastewater flow. Low wastewater flow may result in lower average water depths, which allow rooted vegetation, rodent and disease-transmitting insect habitats, poor operation, and excessive odor. For example, a couple living in a four-bedroom home might better utilize a lagoon dug deeper to a smaller base, requiring less water to maintain adequate depth. The deep part of the lagoon would be sized for a home with two occupants. The overall size would be adequate for eight occupants. Alternately, a two-cell pond could be used to achieve maximum-capacity sizing. The first cell is sized for the minimum number of occupants; both cells together would accommodate the full size of the home. An overflow pipe between the two cells that maintained 3 feet of water in the first cell before overflowing into the second cell could be used. Ideally water in the first cell should rise to 5 feet deep and be drawn down to no less than 3 feet deep. Both cells must be fenced and maintained to keep weeds from growing or rodents from burrowing and damaging the liner. Once a second cell is used, it is important to maintain the 3-5-foot depth in both cells. A third option is to use a cell sized for the minimum number of occupants, with an overflow pipe at 5 feet. The overflow runs to a second, shallow (maximum three feet deep) wetland cell. Select plants that do not have seed easily transported by wind or birds. Fence both cells.

3) Additional water may need to be added, especially during dry periods. Ways to do this are from roof guttering and downspouts, sump pump that includes or diverts drainage, or the household water supply, especially from a private well. Construct all such diversions so they are easily disconnected during periods of excess rainfall because they may add too much water to the pond.

4) Avoid discharging large doses of chemicals to a lagoon to protect its chemical balance. Large doses of disinfectants from water well disinfection, swimming pools, or hot tubs, among other chemicals, can upset the lagoon's biological balance.

Table IX-1 lists guidelines for three household sizes and three locations in Kansas. Experience and advice from agencies and contractors will help determine the most suitable size. Table IX-1 shows the side length for square lagoons and diameter for round lagoons. Other shapes may be used but length should not exceed twice the width.

Table IX-1. Recommended sizes for square and round wastewater lagoons

	Square-side length ft[a]	Round diameter ft[a]	Surface area square ft[a]	Volume 100s gal[a]	Minimum flow per month[b]
Western					
Small	35	40	1225	18	4
Medium	40	45	1600	26	5.5
Large	45	51	2025	32	7
East Central					
Small	40	45	1600	26	4
Medium	45	51	2025	31	5
Large	50	56	2500	43	6
Eastern					
Small	45	51	2025	32	3
Medium	50	56	2500	43	4
Large	55	62	3025	56	5

These sizings are based on an assumed 1/4-in/day seepage loss
Small = 3 or less people; medium = 3-5 people; large = 6 or more;
[a] *contents at 5-ft depth;*
[b] *minimum flow (1,000 gallons/month) to maintain a 3-ft depth*

All city and county code requirements shall be met prior to construction. Construction of a wastewater lagoon may be considered if soil properties at the bottom of the lagoon are satisfactory as indicated by slow percolation rates, minimal porosity, and fine soil texture. Soil profiles can be used to determine texture giving percentages of sand, silt, and clay. A soil profile evaluation is recommended because permeability rates obtained from a perc test vary in accuracy depending on soil moisture content at the time of testing. In the absence of a soil profile evaluation, a permeability rate of less than an inch per hour indicated by a perc test may be a good indicator for a suitable lagoon site.

Separation distance requirements: *These measurements are from the inside of the berm at the 5-foot operational water level as measured vertically from the bottom of the lagoon.*

1) A minimum of 50 feet (200 ft recommended) from property boundaries. Sometimes adjacent property owners are willing to agree to a legal easement in which a wastewater lagoon may be constructed closer. An adjacent property owner needs to be made aware that construction of a private water well requires a 50-foot distance from a wastewater lagoon. If a legal easement is obtained, a wastewater lagoon may be constructed closer than 50 feet from adjacent property. Legal easements must be filed with the register of deeds to protect the interests of all present or future parties.

2) Public roadways (total right-of-way) may be considered part of the separation distance; however, no part of a wastewater lagoon may be placed on a public access or utility easement.

3) Any potable public water supply or suction line must be 100 feet from the lagoon's operational water level.

PRETREATMENT OPTIONS FOR LAGOONS

In most cases a lagoon will work fine with no pretreatment of normal household wastewater before it enters the lagoon. The ideal sewer grade is 1/8- to 1/4-inch of drop per foot of sewer pipe or 1 to 3 percent grade of the sewer line. Slopes substantially greater or flatter than this can lead to problems of solids separation from the wastewater.

A septic tank can be added ahead of the lagoon to remove solids and reduce problems resulting from a substantially flatter or greater grade on the line leading to the lagoon. A septic tank has the advantages of removing solids (this expands the range of suitable sewer grade slope), reducing organic load (aids lagoon function), minimizing the chance of odor as long as the discharge line is under the water surface, and reducing rate of solids accumulation.

Other advantages include allowing use of a smaller-diameter effluent line and effluent pump, increased distance between cleanouts, greater variability in sewer grade, and greater flexibility for placement. Disadvantages include increased construction cost overall, anaerobic wastewater discharge to a pond, and maintenance for the tank. When a tank is used, it must be pumped regularly to avoid solids carryover that could block the effluent line. Outflow from the septic tank is still sewage and because of bacteria and safety issues, the lagoon must still be fenced.

GUIDELINES FOR DESIGNING AND CONSTRUCTING LAGOONS

1) **Rock or porous strata**. Excavation that penetrates or terminates in rock or porous strata should be over-excavated a minimum depth of 2 feet on both side slopes and bottom. The entire excavation area must be filled with nonpermeable earthen material to limit seepage from the lagoon to a maximum value of 1/4-inch per day (0.01 inch per hour). Use high clay subsoil that is free of rocks, or fill soil that is mixed with bentonite clay and applied at the manufacturer's recommended rate and then compacted.

2) **Compact to avoid excessive water loss.** Compaction is essential to achieve consistent low water loss from lagoons. A sheepsfoot roller compacted lining built in three- to six-inch lifts to make a lining of at least 1½ feet thick is strongly recommended. See Protocol – Compacted Linings at the end of this chapter.

3) **Prevent surface water entry.** Divert surface runoff to prevent sediment entry and lagoon overfill/overflow. Construct the berm above the surrounding soil level or make an interception terrace (trench and ridge) to carry runoff away from the upslope side to accomplish this.

4) **Prevent berm erosion with vegetation.** Following final grading, establish a perennial or temporary annual groundcover on the berm as soon as feasible; mulching until vegetation is established helps prevent erosion.

5) **Assure adequate air flow and avoid shading.** Sunlight and air circulation over the lagoon are essential for good lagoon operation. Trees need to be located at least 30 feet outside the embankment and shrubs should be at least 15 feet outside the embankment. Because sunlight is essential for algae to produce oxygen, a lagoon's east, south, and west sides should not be shaded. It is recommended no plants grow taller than a 22-degree angle (approximately 2½ horizontal to 1 vertical ratio) from the top outer edge of the berm.

6) **Fence for human and animal safety.** These lagoons contain raw sewage that can easily spread disease. If unfenced, they can create both a hazard and liability, especially with drowning, which is the second leading cause of accidental death in children. State and county codes require all wastewater lagoons be fenced. Fencing should preferably be located 3 feet outside the berm toe. A 4-foot-wide, rigid-frame hinged gate can allow easy access to mowing equipment. Gating must provide the same degree of resistance to entry as fencing and requires a padlock. Fencing diagrams are located in Figures IX-1, IX-2, IX-3, IX-4, and IX-5.

Specifications for lagoon fence

a) Height: 4 feet minimum. If fence will also be accessible to livestock, a double strand of barbed wire placed above the fence top or an electrical fence placed outside the inner fence may also be installed.

b) Size: 12.5-gauge wire.

c) Open space: 8 square inches or smaller; example 2" x 4."

d) Warning signs: A sign stating "WASTEWATER TREATMENT LAGOON" or "RAW SEWAGE, KEEP OUT," shall be posted on the gate or fence adjacent to the gate.

CONSTRUCTION

1) **Soil condition**. Soil moist enough to compact into a firm ball is most suitable. Muddy soil is not only difficult to work but also forms clods that can be difficult to smooth out. Soil too dry for compaction into a firm ball can have moisture added.

   Topsoil needs to be removed and stockpiled for later use on the berm. Once the lagoon construction is completed, the topsoil may then be placed on the berm surface to support groundcover growth. Berm compaction needs to be done in layers, preferably by sheepsfoot roller, rather than by machine traffic or other provision. This practice is critical if the soil is borderline acceptable for a wastewater lagoon. Fill layers shall be no more than 6 inches thick.

2) **Lagoon depth**. Lagoons are normally excavated to a depth no greater than 8 feet below the surface of the surrounding ground. Greater depth may contribute to problems of inadequate sunlight and/or air transfer. Surfaces of the berm and lagoon bottom should have uniform slope. They need to be free of rocks, debris, ruts, and ridges. When rock is encountered in excavation, the hole must be over-excavated by at least one foot to

remove rock, then filled and compacted with at least one foot of clay material. The bottom of the lagoon must be at least four feet above the highest expected groundwater level or fractured bedrock.

3) **Berms.** Wastewater lagoons must be completely enclosed by berms 3 feet higher than the surface of the surrounding ground. Both the interior and exterior slope should be no less than 3 feet of lateral movement for each foot of vertical drop; 3.5 ft is better when space allows. The top width of the berm should be at least five feet to allow for easier mowing.

4) **Linings.** Where soil percolation rates exceed one-inch fall per hour, the bottom and interior sides of the wastewater lagoon need to be lined with a compacted clay of sufficient thickness to reduce the soil absorption rate to 1/4-inch per day or less, preferably 1/8-inch per day. See Protocol - Compacted Lining at the end of this chapter. Refer to manufacturer's recommended rate when using bentonite clay, asphalt cement, or membrane application.

5) **Sewage inflow.** The pipe carrying wastewater from the house to the lagoon must be at least 4 inches in diameter. Schedule 40 thermoplastic sewer pipe with solvent-welded joints is recommended. Slope can vary between 1/8- and 3/8-inch per foot. A 1/4-inch slope per foot, or 2-foot slope per 100 feet is recommended to avoid solids accumulation in the line. Pipe entry needs to be located below the water surface and extend nearly to the lagoon center, ideally located at 18 to 20 inches off the bottom. Beneath the pipe ending, at the lagoon center bottom, place a concrete pad of 2 feet x 2 feet x 4 inches thick. This pad can protect the lagoon lining from effluent damage. Supporting the end pipe can be done by anchoring it above concrete blocks with posts and/or steel support.

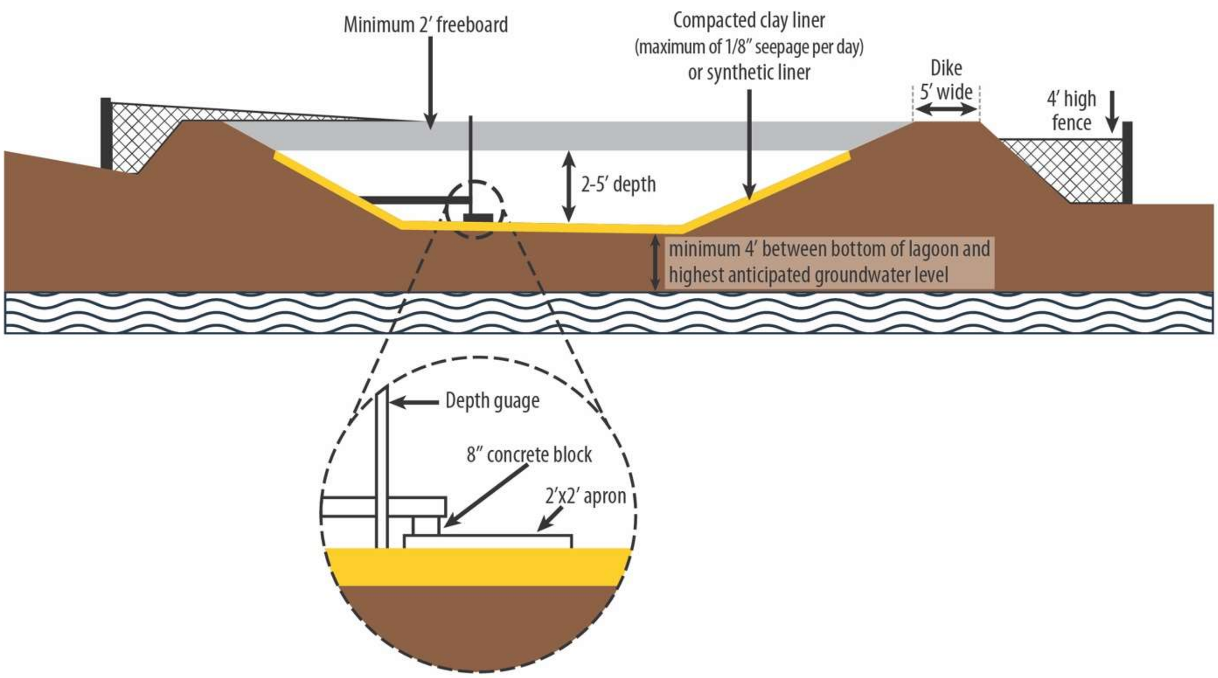
6) **Monitoring lagoon-water depth.** Installation of a post with clear markings in one-foot increments, located near the center, is recommended for ease in observation of water depth. Bentonite or clay soil can be packed around the base of the marker.

7) **Install at least two cleanouts.** One located near the outside of the house and the second one near the lagoon where the ground surface is approximately 6 inches higher than the berm, are favorable locations. Additional cleanouts are recommended with any change in pipe direction or distance of greater than 100 feet. A Tee or Y design may be used. However, a Y- shaped design allows easier access and double cleanouts allow for easier cleaning in both directions.

8) **Topsoil replacement to berm.** Application of topsoil is for the purpose of supporting groundcover growth. Reapplying topsoil by spreading in a loose manner is desirable, or if packed too firmly, it can be tilled prior to planting groundcover. Perennial groundcover, for preventing erosion, needs to be seeded as promptly as possible following construction. Natural Resources Conservation Service or Extension may provide recommendations for groundcover most suitable to one's specific location. Protective covering of straw or hay mulch may be beneficial in holding the soil and seeding during the process of establishing groundcover growth.

9) **Fencing installation.** Fencing must be completed as soon as possible for public safety. Posts need to be placed 2½ to 3 feet deep and backfilled with tightly compacted soil. Placing cemented posts at a 2½-foot depth is an alternative option. Wire needs to be stretched tightly using a come-along (wire stretcher), tractor, or other method. Figures IX-1 through IX-5 illustrate gate and fencing specifications.

Figure IX-1. Lagoon Design



TESTING FINAL SEEPAGE RATE

Use one of three ways to test the final seepage rate of the lagoon to assure it does not exceed ¼-inch per day. A rate of 1/8-inch per day is preferred. An independent soil lab can take a sample of the soil for testing prior to filling the lagoon. This may be expensive and leave a hole that would compromise the lagoon. The hole can be plugged with bentonite or soil used for the liner, and then compacted.

Alternately, the two-barrel method requires two 55-gallon drums. One is the “control” drum, which records water loss due to evaporation or gain due to precipitation. This drum is set on the bottom of the lagoon, closed end down. The second drum has had the top and bottom removed. This is the “seepage” drum. It is placed a few inches into the sealed soil layer on the bottom of the lagoon. A bead of bentonite should be packed around the inside edge of the drum. The seepage drum should be kept filled with water for two days prior to beginning the test. This assures the soil is saturated. Weights are suspended on the outside of the seepage drum to keep it from popping up during the test; however, the top must remain uncovered so there is no interference with precipitation entering the drum. To conduct the test, fill each drum with an equal amount of water. For at least seven days, measure and record the difference in water levels; refill the barrels to the original levels. The difference between the two levels in the barrels is due to seepage and must not exceed ¼-inch per day. A 1/8-inch seepage rate is preferable.

Another choice for testing seepage is the five-gallon bucket test. To conduct this test, fill the lagoon with fresh water to a depth of two feet. After water sits for two days to achieve soil saturation, mark this level on the permanent depth marker. Near the lagoon, partially bury a five-gallon bucket filled with water to a line marked near the top. Water-level changes in the bucket will be due to weather. The changes in the lagoon will be the result of weather and seepage. Record the water levels daily for at least seven days. The difference in the measurements is the seepage. It must not exceed ¼-inch per day and 1/8-inch is preferred.

If seepage exceeds ¼-inch per day, bentonite or soda ash must be added and compacted on the lagoon bottom and sides, or a synthetic liner must be installed.

INSPECTION

Sample inspection report forms are provided at the end of this chapter. These may serve as a guideline in addressing important points of an inspection.

OPERATION AND MAINTENANCE

1) **Establish and maintain groundcover.** All areas bounded by the toe of the berms and within the fence shall have an ample stand of low-growing perennial groundcover. Once the groundcover is established, it needs to be regularly maintained during the growing season at a height of 6 inches or less. Under no circumstances should trees or tall weeds be allowed to develop on the berm area. Near the lagoon edge, it is preferable to cut the vegetation shorter than 6 inches to prevent any drooping into the water. Ideally, grass clippings should be removed from the lagoon area. At a minimum, they must be directed away from the lagoon.

2) **Remove any trees and additional vegetation.** All trees, weeds, cattails, duckweed, floating algae, and other undesirable vegetation need to be removed promptly with the first signs of their development in the water or along the berm. This vegetation is a habitat for mosquito breeding, produces excess organic loading, and degrades oxygen transfer. The best way to keep these plants from growing in the lagoon is to keep three feet or more of water in it. Removing weeds by hand before they become embedded and contribute to the lagoon's organic load is advisable. Take precautions to minimize exposure to wastewater by wearing protective clothing and waterproof gloves. After working with wastewater, thoroughly wash hands, or shower and disinfect any breaks in skin. Excess vegetation can create additional problems including a reduction of air flow, decreased evaporation, lagoon filling, shading, and less sunlight activity over the lagoon. Mosquito production is often directly proportional to the amount of such vegetation. Destruction of the lagoon's seal by root penetration can also occur. To repair a leaking lagoon, see Protocol – Sealing a Leaking Lagoon at the end of this chapter.

3) **Avoid herbicide use. Improper use of herbicides can cause temporary system failure.** If use becomes necessary, consult with the local county Extension Office or environmental health officer for the most recent product advice. Follow the

manufacturer's label, and avoid spillage or drift that might cause chemical holes or kill groundcover on the berm.

4) **Keep undesirable materials out of the wastewater.** It is important to keep hazardous materials (drain cleaners, paint, varnishes, solvents, fuels, waste oil, photographic solutions, pesticides or other organic chemicals) out of domestic wastewater that enters the lagoon. Also, minimize fats and greases that may clog the pipes as well as feminine hygiene products, coffee grounds, bones, cigarette butts, disposable diapers, paper towels, facial tissues, and other materials that decompose very slowly.

5) **Maintain desirable water depth – as close as feasible to 5 feet.** A short-term water depth of 2.5 feet during drought conditions is acceptable. Adequate treatment can become a problem if the depth becomes less than 2.5 feet. Therefore, a design of directing roof drains and/or sump pump wastewater to the lagoon as a temporary condition is desirable and must include a plan for rerouting the same wastewater elsewhere during prolonged periods of wet weather. Two feet of freeboard (berm height above the water surface) for water storage needs to be maintained to provide for times of exceptional storms. For emergency situations in which wastewater is encroaching on the freeboard and may overflow the lagoon, follow procedures in Protocol - Emergency Dewatering at the end of this chapter.

6) **Repair berm damage.** A certain amount of erosion will occur on the berm after initial construction. Any damage incurred by reasons of weather, animal entry, or other means should be repaired by shaping the area to the original plan and reestablishing perennial groundcover. Among the most common causes of damage are settling, erosion, and rodent burrowing.

7) **Evaluate wastewater lagoon conditions.** Proper operation of a wastewater lagoon can be evaluated by color, odor, and water testing. Generally routine testing is beyond the ability of the owner or user. Thus, one must rely on appearance and odor for operation information. Table IX-2 gives a color-interpretation guide. Lagoon color is directly related to pH and dissolved oxygen (DO).

8) **Maintain essential lagoon features.** The fence, gate, vegetation height, and inlet pipe shall also be maintained in the condition called for in the original plans and specifications. Assure the fence and gate are in good condition at least twice per year. The gap between the gate and post or space at the bottom of the fence to the ground should not be bigger than 2 inches. Check for loose or damaged posts, loose anchors, sags in wire, and any damage. The fence must keep animals, especially pets, and children away from the lagoon. Any diversions provided to keep surface runoff away shall be maintained in satisfactory condition and at sufficient height to protect the lagoon.

9) **Pay attention to odors.** Properly operating lagoons rarely emit an odor. Odors may indicate the lagoon is not functioning properly. Odors may be due to the following: a) sludge may be filling the lagoon; b) lagoon may be improperly sized; or c) lagoon may be overloaded. Odor that persists longer than two days indicates an operational problem and the cause must be determined.

10) **Measure and record sludge.** Maintain at least 18 inches of water above the level of sludge. Measure the depth of sludge in the same area of the lagoon, preferably near the center, after 10 years, and then again every three to five years. It is not safe to walk into a lagoon with waders. Rather, use a small pump with an intake suspended from a float at an adjustable depth. Move the intake deeper until solids are first noticed. The depth of the intake below the surface is the depth to the sludge. Keep a record of depths of sludge and the years it was measured.

Table IX-2. Visual Indicators of a Lagoon's Condition

COLOR	CONDITION	SYMPTOM OR CAUSE
Dark sparkling green	good	high pH and DO
Dull green to yellow	not as good	pH and DO are dropping blue-green-type algae are becoming predominant
Gray to black	very bad	lagoon is septic with anaerobic conditions prevailing
Tan to brown	Ok if…	due to predominance of a type of brown algae (not found in Kansas)
	Not good if…	due to silt or bank erosion

Source: Stabilization Ponds - Operations Manual. Aug 1977, EPA Office of Water Program Operations, O-15

SLUDGE REMOVAL

Wastewater lagoons will begin to fill with silt, sludge, and organic debris after a period of extended use. Lack of maintenance will increase the rate of fill. Leaves, uncut grass, grass clippings, waterfowl, animal burrowing, and livestock damage will accelerate the rate of filling occurring in the lagoon. Original lagoon volume must be maintained so that overflow does not occur.

Evidence of filling includes 1) overflow; 2) presence of cattails or other aquatic vegetation toward the center of the lagoon; 3) over-loaded condition indicated by heavy algae growth, dark lagoon water, decreased wave action, slow-flowing toilets, and foul air odor; and 4) water level on the berm near overflow condition during periods of normal rainfall.

Any of the above conditions, by themselves, may be attributed to inadequate lagoon sizing, or unusually heavy or light wastewater flow. Dewatering may be necessary to determine the cause. Consulting the local environmental health officer for assistance in determining whether to clean and reconstruct, abandon, or initiate other corrective action may be beneficial.

Procedure to clean and reconstruct the lagoon:

1) Contact the regulating authority for permit requirements or improvement requirements.

2) Lagoon dewatering must be accomplished with the greatest degree of environmental safety possible. Refer to Protocol - Emergency Dewatering Procedure at the end of this chapter.

3) Sludge may then be removed, utilizing a backhoe, bulldozer, or front-end loader in accordance with guidelines established by the local regulatory agency. The sludge can then be taken to a publicly owned wastewater treatment facility such as a landfill permitted and willing to accept sludge, or it can be tilled into farmland. If the sludge material is applied to farmland, it needs to be tilled into the soil as soon as possible (within 24 hours). (Refer to EPA 40 CFR Part 503 Regulations.)

4) Clay or bentonite layers, or lining originally installed to control seepage losses need to be checked and restored. See Protocol - Sealing a Leaking Lagoon at the end of this chapter.

5) Inlet pipes and cleanouts need to be checked for proper functioning with repairs made if needed.

6) Berm must be reshaped, packed, and smoothed. Reseeding and restoring the fence to an approved condition needs to be done.

7) Water level should be restored to a 2 ½-foot depth before the lagoon is returned to service.

LAGOON ABANDONMENT

Reasons for abandonment of a wastewater lagoon may include the following:

1) Public sewer available to the property within a feasible distance.

2) Lagoon will not retain wastewater.

3) Sludge level is at a depth that impairs proper functioning of the lagoon.

4) Local environmental health officer determines the system cannot be made to function properly; cannot adequately protect health of property owner or health of the public, or the quality of state waters.

Abandoning a wastewater lagoon would normally entail dewatering, sludge removal by a licensed septage hauler, and returning the land area to the contour it held prior to lagoon construction. Kansas Department of Health and Environment issues addendums as new laws and procedures are developed. Wastewater lagoons are subject to these additions. Current guideline procedures for abandoning a wastewater lagoon are as follow:

1) Dewater according to the Protocol – Emergency Dewatering procedure at the end of this chapter.

2) If the dry sludge is more than 18 inches thick, it should be removed and disposed following the local code and EPA 40 CFR Part 503 regulations, then proceed with the steps below.

3) Push berms in to fill lagoon. A slight elevation above the center is desirable to eliminate the possibility of an area holding water once settling occurs.

4) Cover the area with topsoil and reseed with suitable groundcover.

REFERENCES AND OTHER READING MATERIALS

The following publications are available from K-State Research and Extension, https://bookstore.ksre.ksu.edu/ or local Extension office.

Aquatic Plants and Their Control, C-667, KSU Agricultural Experiment Station and Cooperative Extension Service, https://bookstore.ksre.ksu.edu/pubs/c667.pdf, August 2005.

Site and Soil Evaluation for Onsite Wastewater Systems, MF-2645, KSU Agricultural Experiment Station and Cooperative Extension Service, https://bookstore.ksre.ksu.edu/pubs/MF2645.pdf, March 2004.

Minimum Standards for Design and Construction of Onsite Wastewater Systems: Bulletin 4-2, MF-2214, Kansas Department of Health and Environment and KSU Agricultural Experiment Station and Cooperative Extension Service, https://bookstore.ksre.ksu.edu/Item.aspx?catId=386&pubId=769, March 1997.

Wastewater Pond Operation, Maintenance and Repair, MF-2290, KSU Agricultural Experiment Station and Cooperative Extension Service, https://bookstore.ksre.ksu.edu/Item.aspx?catId=371&pubId=837, April 2005.

The following publications are available from other state Cooperative Extensions as indicated.

Individual Home Sewage Treatment Systems: Lagoons, AE 892, North Dakota State University, https://www.ag.ndsu.edu/publications/home-farm/individual-home-sewage-treatment-systems#section-25 February 1997.

Residential On-site Wastewater Treatment: Lagoon Design and Construction, G01-1441-A, NebGuide, U of Nebraska, Cooperative Extension, http://extensionpublications.unl.edu/assets/pdf/g1441.pdf, March 2010.

Residential Sewage Lagoon Systems: A Homeowner's Guide to Installation and Maintenance, WQ 402, U of Missouri, Extension, Columbia, MO, https://extension2.missouri.edu/wq402, March 1997.

Reducing Pond Seepage, G1555, November 1997, MU Guide, available from Outreach and Extension, University of Missouri - Columbia, Agriculture Building, Columbia, MO, 65211, https://extension2.missouri.edu/g1555, January 1998.

The following publications are available from the respective state environment agency as shown.

Assessing Wastewater Options for Small Communities in Kansas, Kansas Department of Health & Environment, K-State Research & Extension, Midwest Assistance Program, and Crawford County Health Department, on KDHE web site at http://www.kdheks.gov/nps/ww_options_manual/index.html, November 1999.

Lagoon Sewage Disposal Systems: It's Your On-site System, Operation and Maintenance Guide for Homeowners, Oklahoma Department of Environmental Quality, July 2003. https://www.deq.ok.gov/wp-content/uploads/environmental-complaints/Lagoon-.pdf

Figure IX-2. Gate and Fencing

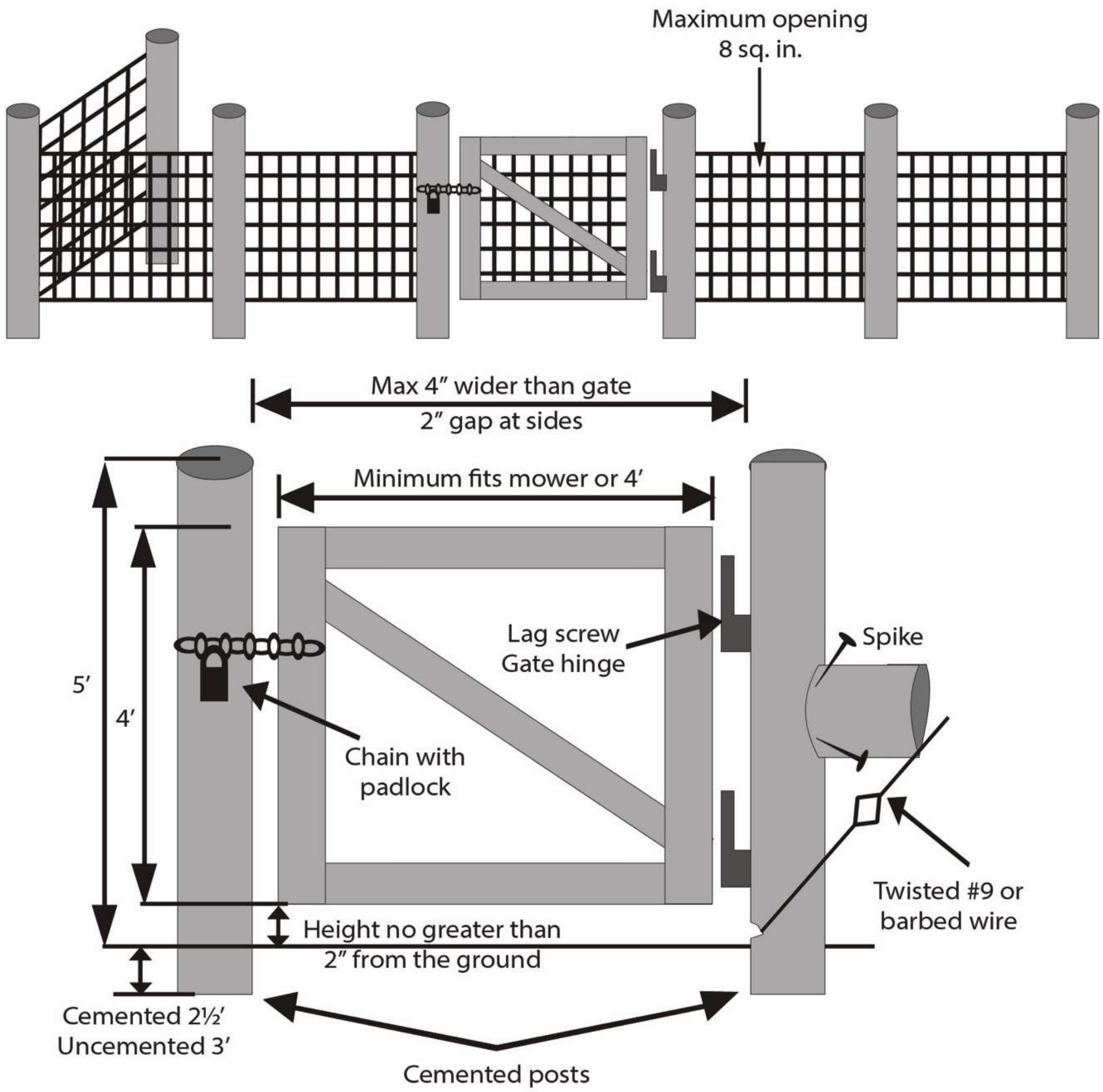


Figure IX-3. Fencing: The Standard Fence

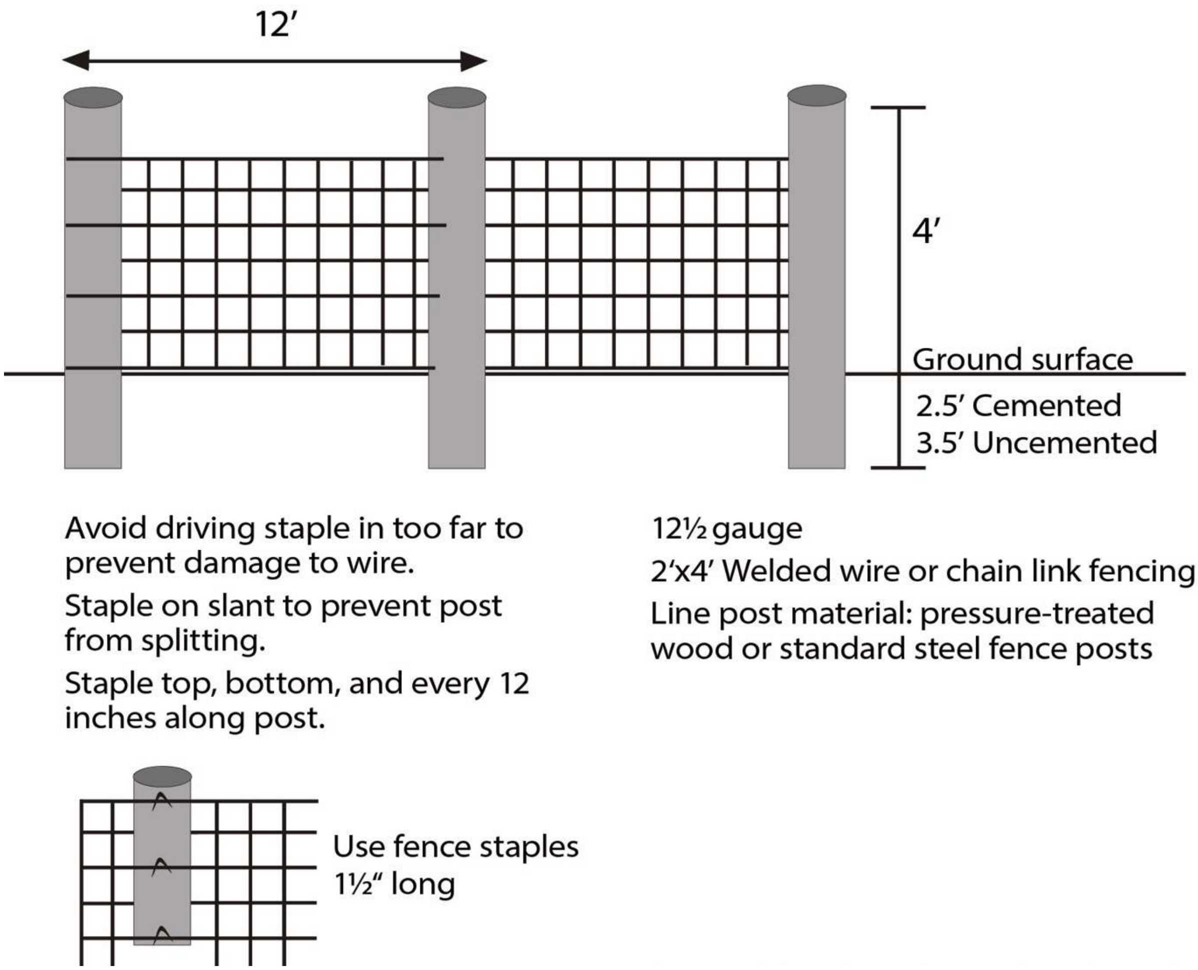


Figure IX-4. Fencing: “H” Style Corner Brace

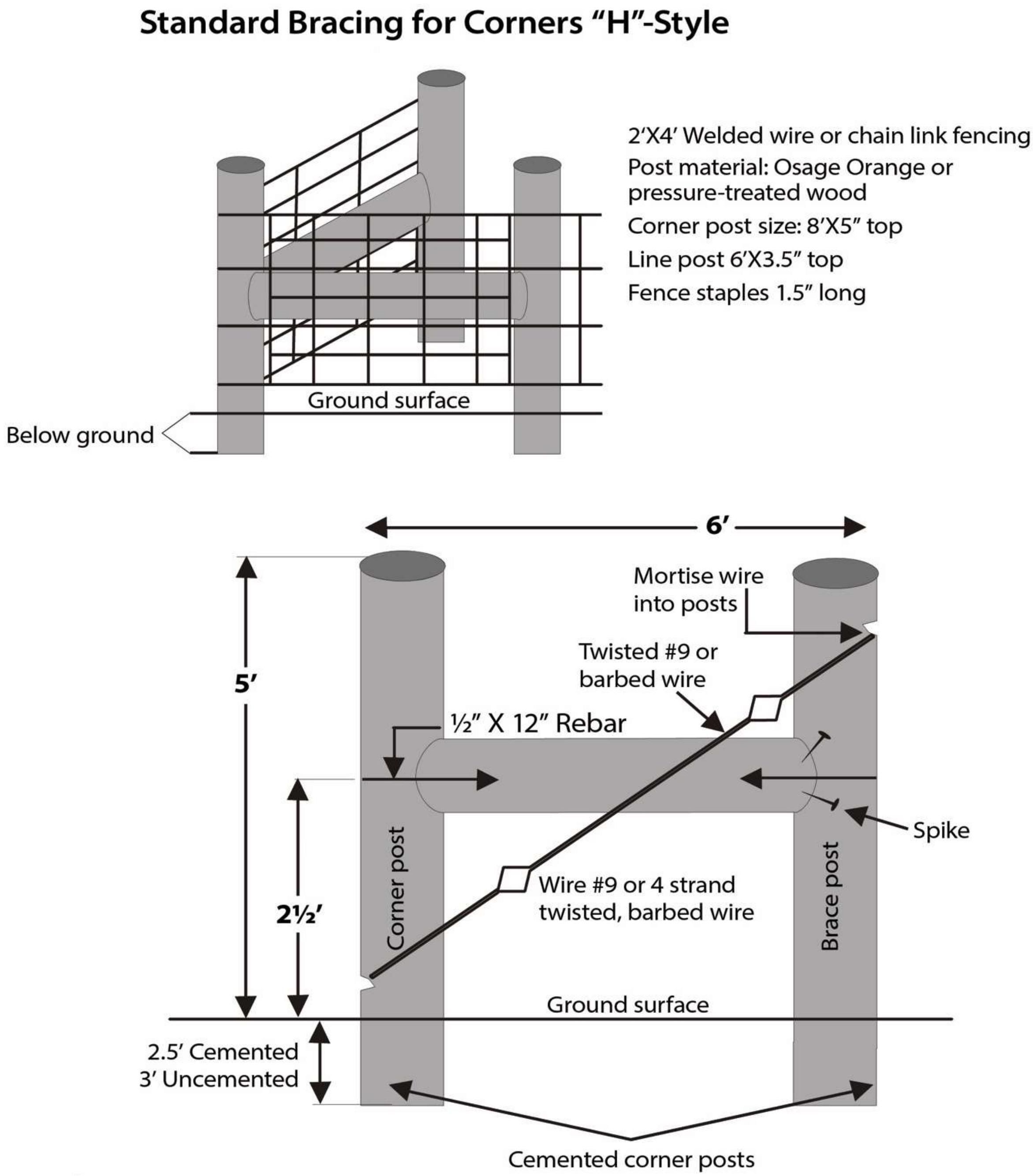


Figure IX-5. Fencing: “N” Style Corner Brace

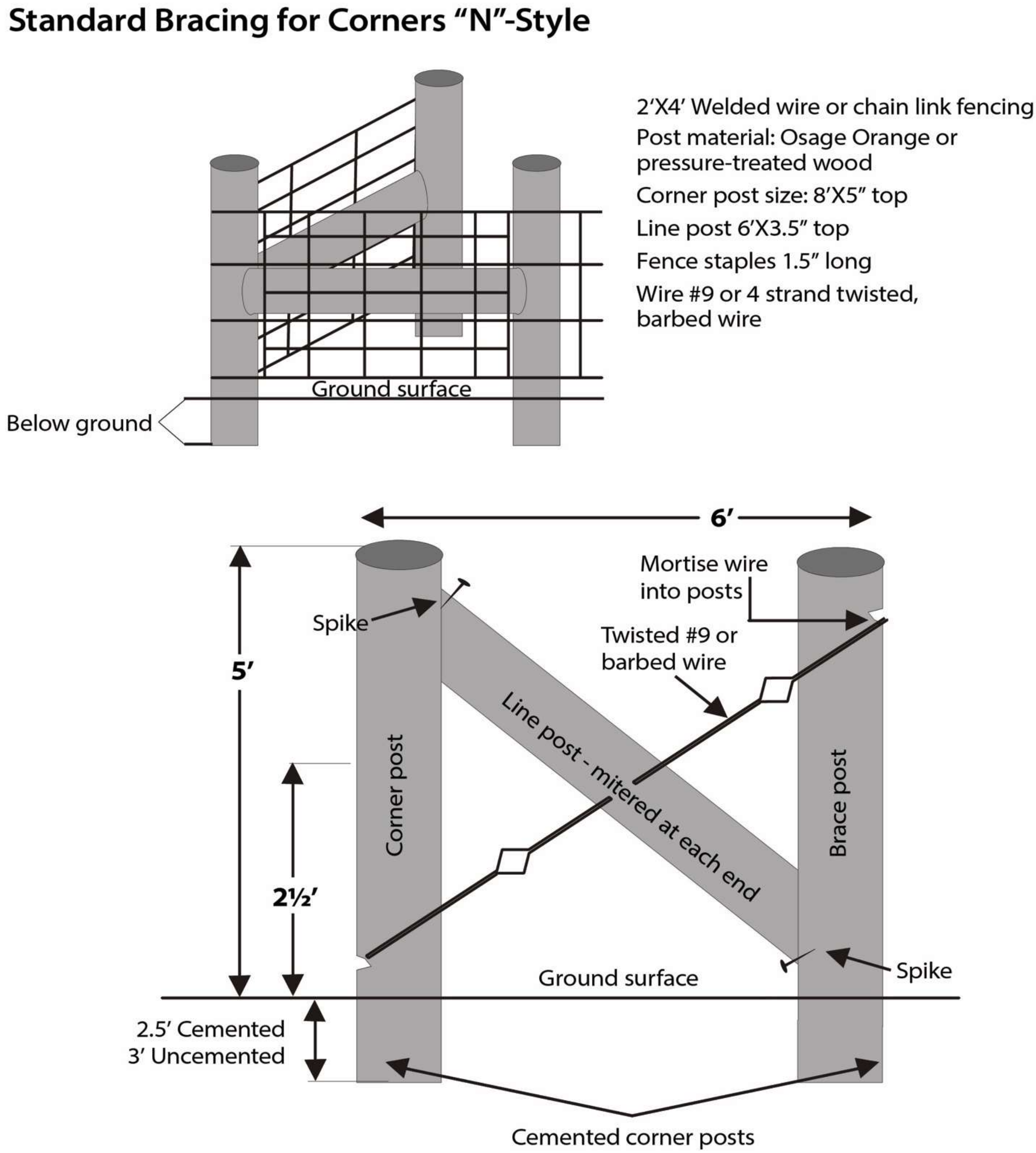


Figure IX-6. Fencing: Placement

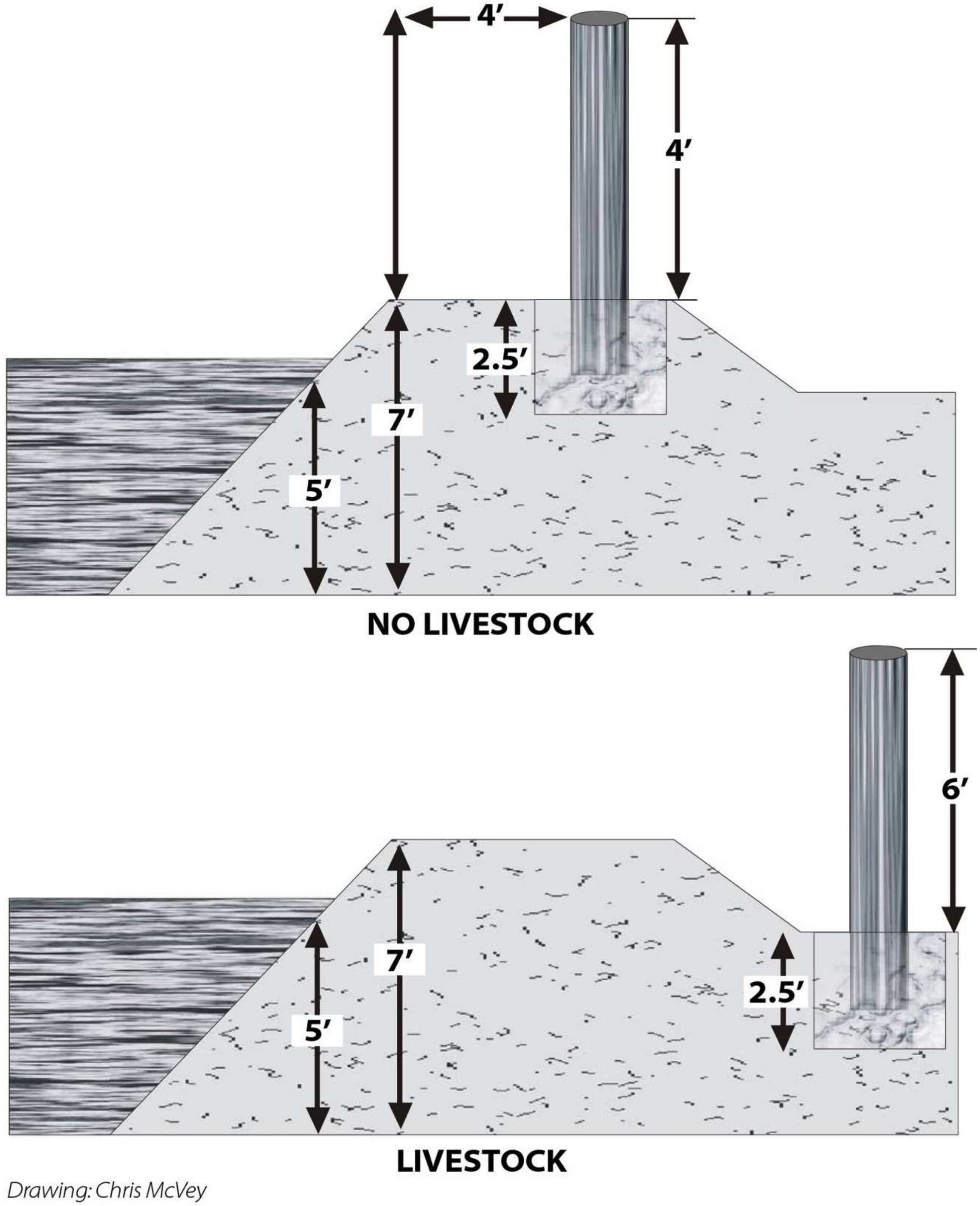
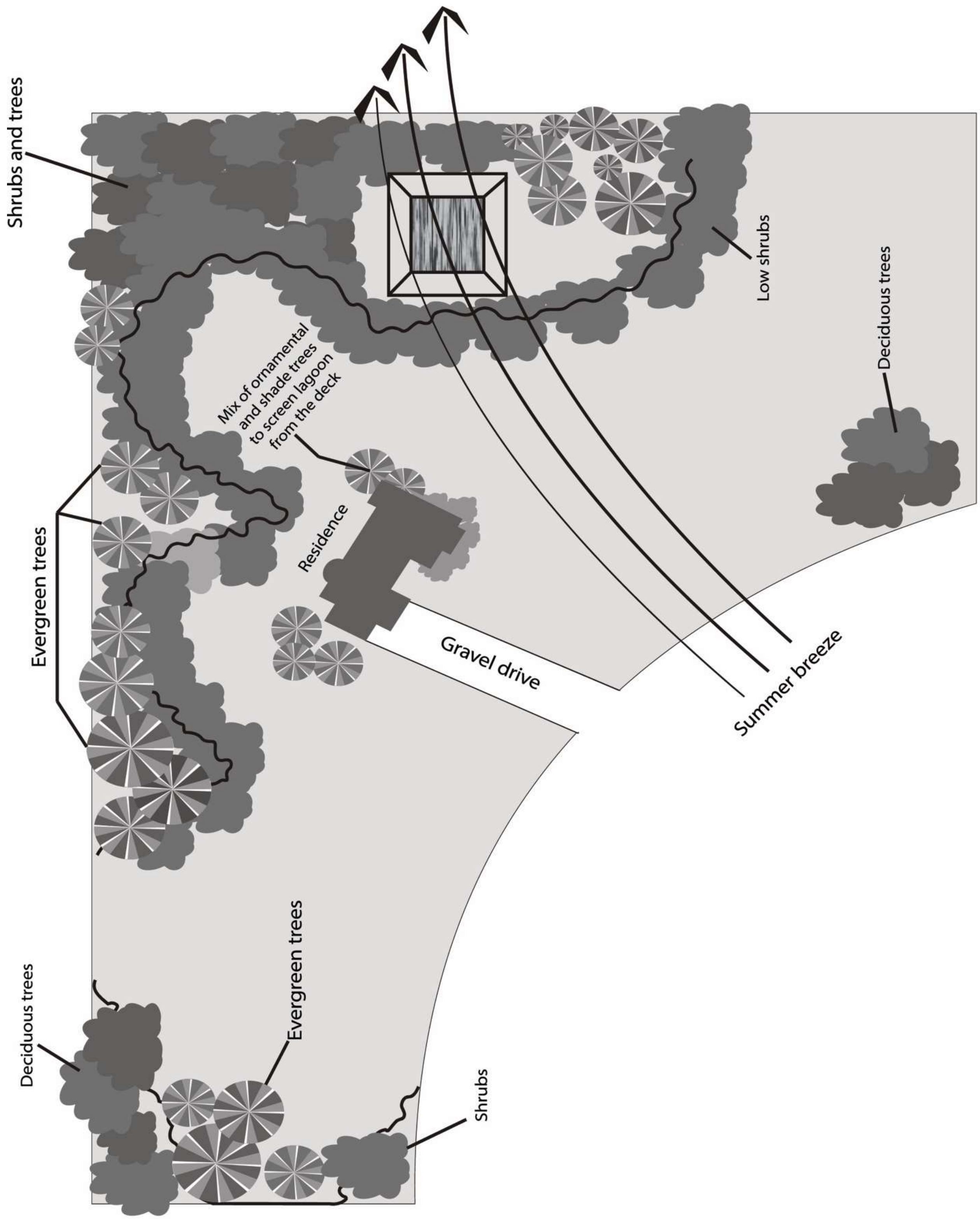


Figure IX-7. Lagoon Siting and Design



PROTOCOL
PERMITTING AUTHORITY

GOAL: Determine regulatory authority and associated procedures covering construction and operation of wastewater lagoons.

POLICY: Local governments with a KDHE-approved sanitary code have authority to regulate small, nondischarging wastewater treatment lagoons. If the local unit of government does not object to the proposed project but does not choose to exercise the option to permit and regulate the lagoon, they must refer the owner to the KDHE Wastewater Permitting Section and notify that office.

PROCEDURE

Determine Regulatory Authority

The Kansas Department of Health and Environment has defined its responsibility for permitting wastewater lagoon systems that discharge to the surface, receive any amount of industrial wastewater discharge, or serve wastewater systems owned by a local government or other public entity. Authority to regulate wastewater lagoons is granted to local government under K.S.A. 19-3701 et seq.; K.S.A. 19-101a; K.S.A. 12-3302 or 3303; and K.A.R. 28-5-6.

Local governments may regulate wastewater treatment lagoons if all conditions specified in paragraphs 1 through 3 shown below are satisfied.

1) Local governments, which have a KDHE-approved sanitary code, have authority and may regulate small wastewater lagoons that receive domestic wastewater. Domestic sewage consists of wastewater originating primarily from kitchen, bathroom, and laundry sources including waste from food preparation, dishwashing, garbage-grinding, toilets, baths, showers, laundry, and sinks.

2) Local governments generally regulate wastewater lagoons to which less than 2,500 gallons per day (gpd) of domestic type sewage is discharged. Wastewater lagoons receiving more than 2,500 gpd of sewage (daily average) generally obtain a permit from the Kansas Department of Health and Environment.

3) All discharging lagoons require a permit from KDHE. Local governments may regulate only nondischarging lagoons.

Responsibility of Local Authority

If the local authority chooses to exercise the option to permit and regulate the lagoon, the local authority will approve plans, conduct inspections during construction, conduct periodic inspections of the property, and take enforcement action when necessary to maintain compliance with local government requirements for wastewater lagoons regulated by that local authority.

The local authority should also inform the customer that if a city or regional wastewater collection system becomes available, within 400 to 1,500 feet of the location, the local authority and/or KDHE may require connection to the central collection system and proper abandonment of the local wastewater treatment system.

If the local authority desires assistance from the Kansas Department of Health and Environment, the local authority should initially contact the appropriate district office (district environmental administrator or district water program staff) or the Topeka LEPP program staff person. LEPP staff will provide technical materials and other information as available to help support local government. KDHE district offices will provide assistance and advice, including backup inspections as requested by the local entity.

If the local unit of government objects to the proposed project, it should state the objections in writing to both the owner and KDHE to assure intergovernmental coordination.

If the local unit of government does not object to the proposed project but does not choose to exercise the option to permit and regulate the lagoon, they must refer the owner to the appropriate KDHE district office and notify that office.

Responsibility of KDHE

KDHE will inform the owner that the local authority has chosen not to accept local regulatory authority for the wastewater system (or for this particular lagoon, whichever is the case), and therefore, the customer is subject to state regulation. The Wastewater Permitting Section staff will take appropriate action.

PROTOCOL
EVALUATING AND SITING A LAGOON

GOAL: Determine if a lagoon system is well suited to the site conditions and determine the best location on the property for a lagoon. It should protect public health, assure safe wastewater treatment, and prevent contamination to the state's water supplies.

POLICY: Site and soil evaluation for a new wastewater lagoon may be completed upon a request of the landowner, realtor, contractor, lending agency, or other interested party and payment of necessary fees. Listed below are evaluation points for discussion during the inspection. All individuals who have legal interest in the outcome of the evaluation need to be provided with a report summarizing the assessment. Whenever a site is unsuitable, a letter documenting the reasons and offering alternative solutions, if possible, is recommended. Letters and documents need to be maintained on file for future reference.

PROCEDURE

1) Follow the code, and local regulatory agency policies and procedures regarding the application and site evaluation.

2) Evaluation may include an initial inspection visit to the property to meet with the owner and any other interested parties.

3) Inspect property and proposed lagoon site for conditions affecting location. Such conditions include, but are not limited to, wells, soil conditions, property lines, easements, depth to groundwater, and slope. The NRCS Web Soil Survey can be utilized to determine probable soil type and general suitability for a wastewater lagoon. Note: Conducting a soil-profile evaluation is the best method of assuring suitable soil conditions.

4) Mark the proposed lagoon location with flags, and take photos of the proposed lagoon site from each side and looking away from the site in each direction.

5) If site conditions have been evaluated as favorable for a wastewater lagoon, an application requesting a wastewater lagoon installation permit must be completed by the landowner.

6) Lagoon sizing can be done according to round, square, or rectangular designs (Refer to Table IX-1).

7) Instructions and diagrams for construction need to be provided in writing for agency files and a copy given to the landowner.

8) A permit to construct a wastewater lagoon shall be provided to the landowner. It is recommended the landowner be given a time limit in which construction is to be completed. The landowner needs to be instructed that delays that prevent completion by the agreed upon time will require the landowner to contact the inspector for an extension.

If an extension is not requested, the property owner may be required to reapply. It is the landowner's responsibility to contact the inspector for construction inspections.

9) Once the inspector has been notified that construction is complete, a final inspection needs to be made to assure compliance with county codes. Lagoon construction is not complete until the fence has been built. If construction is acceptable, a permit to operate shall be issued at that time.

10) Permit to operate shall state the regulating agency has the right to inspect the lagoon at any time it deems necessary to determine county code compliance.

PROTOCOL
INSPECTION OF EXISTING WASTEWATER LAGOON

GOAL: Determine system integrity in order to provide for safe public water and to prevent contamination of any water supply within the state.

POLICY: Evaluation of an existing private wastewater lagoon may be completed on the request of a lending agency, real estate agency, landowner, or complainant. A written letter summarizing the evaluation should be sent to all parties who have interest in the outcome of the evaluation. Possible parties may include, but are not be limited to, buyers, sellers, realtors, lending institutions, zoning boards, and contractors. When a system does not comply with county requirements, it is the responsibility of the inspector to determine the needed corrections. Proof of system correction and adequate operation must be established prior to approval.

EVALUATION

1) Acquire any previous records such as files of a permit, inspections, and contractor bills, and name and address of current property owner.

2) Information that may be appropriate for evaluation purposes —

   a) Identification of any additional features used in conjunction with the wastewater lagoon and the location of these additional features such as septic tank, holding tank, or devices altering the gravity flow of wastewater.

   b) Proof of where water lines are located (public or private).

   c) Receipts for septage pumping and/or herbicide purchase.

   d) Name and address for anyone not living in the household and served by the same system (i.e., two homes sharing the same lagoon).

   e) Location of any wells or cisterns used for potable and non-potable purposes.

   f) Easements for right-of-way which include the lagoon area.

   g) Number of persons presently and potentially served by system and an average estimated wastewater flow.

   h) Map showing location of sewage pipes, wells, potable water pipes, and improvements.

   i) Name of buyer with address and phone number.

   j) Real estate and/or lending agency's address and phone number, if applicable.

   k) Contractor name, address, and phone number or contact information for person constructing the system.

l) System maintenance person's name, address, and phone number, if applicable.

3) Examine water and sewage pipes where they exit the house and from the basement, if possible. Determine if all household wastewater is discharged into the lagoon.

4) Check cleanouts for proper flow of wastewater and location. They need to be located at every change of direction and within 100 feet of each other along a straight line. They should also be covered to prevent entry of water such as rainfall. It is desirable to have a combination cap and vent to allow dissipation of gases that may back up with a clogged pipe.

5) Measure the slope of the wastewater pipe from the house to the lagoon (should be 12.5 inches to 36 inches per 100 feet.) Determine if there is a possibility of backflow from the lagoon or cleanout during times of high lagoon water. A contractor's or engineer's level may be needed to give an accurate evaluation of potential backflow occurrence.

6) Fencing — check adequacy of height, spacing, strength, and safety measures such as a lock and posted signs to prevent unauthorized entry of humans or animals.

7) Berm evaluation — observe area for rocks, clods, ruts, groundcover, erosion, trees, tall weeds, accessibility to mowing machinery, ability to divert surface runoff away from lagoon, and presence of animals. Note any shading by adjacent vegetation.

8) Lagoon evaluation — check that a post with measurement markings at every foot is located near the lagoon center. Check that water depth is maintained between 2.5 feet and 5 feet. An absence of aquatic vegetation is an indication that water depth stays above 2.5 feet. There should be no foul odor. The color should be sparkling dark green, which indicates the pH is correct and there is adequate dissolved oxygen.

9) Surface area — measure the width of the lagoon at the operational level (five foot water depth) and determine the current surface area. The surface area of the system should reasonably correspond to the surface area indicated on the recommended model size.

10) Evaluate the outlet pipe. The pipe should enter the lagoon beneath the water level and extend to a point located near the lagoon center. The pipe end should be set at a height of approximately 1.5 feet above the bottom of the lagoon. A concrete pad should be placed under the pipe end to prevent lining damage from the force of wastewater discharge. Check that the end of the pipe is stabilized, such as being supported by concrete blocks and secured by chain or other means, to prevent movement and possible breakage.

11) Evaluate corrections and replacement considerations. Know how many years the lagoon has been in operation. Know if the lagoon has ever risen higher than the 2 feet of freeboard. Know if the lagoon ever overflowed. Know if the water level ever dropped below 2.5 feet. If there are indications of sludge build up, or undersizing of lagoon for amount of household wastewater discharge, consider what options exist to build a second cell or provide other system replacement. This needs to be documented on a map of the site. If the household has a relatively low amount of wastewater discharge for the lagoon

size, consider if it is feasible to add water from roof drains, sump pumps, or other sources.

12) Complete change-of-ownership papers on permit records if appropriate. Provide owners with a copy of the permit.

13) Two sample inspection report forms may be useful and are included later in this chapter.

PROTOCOL
EMERGENCY DEWATERING PROCEDURE

GOAL: Prevent overflow of lagoon due to temporary conditions such as extra water use or prolonged wet weather conditions.

POLICY: *Dewatering is not a normal operating procedure*; it is an emergency procedure that should only be used on rare occasions when the lagoon water depth is less than 2 feet below the top of the berm.

PROCEDURE

Occasionally, short-term conditions such as prolonged wet weather conditions or use of extra water may result in the lagoon level being higher than 2 feet below the top of the berm. This condition requires dewatering. Irrigation may be used to dewater the lagoon in such a situation. Dewatering is not to be considered a normal operating procedure; it is an emergency procedure to be used on rare occasions. If the threat of overflow persists, other measures must be taken such as enlargement of the existing lagoon or construction of an additional cell.

1) Excess water, without solids, should be pumped to a vegetated area through a sprinkler so runoff does not occur. Care should be taken to minimize taking up fresh or untreated sewage, and sewage solids with the irrigation water. The water intake should be about 8 to 12 inches below the water's surface. Perforated hoses, sprinklers, and sprayers can be useful but may clog if solids are present.

2) This water must be distributed so that it is all absorbed into the ground without runoff. Irrigation is not an option when the ground is saturated or frozen.

3) The area to be irrigated should not be within 50 feet of a property line not under the control of the facility owner or within 100 feet of a water well. The preferred irrigation area is relatively level, tilled cropland or grassland. People and animals must be kept out of the application area for at least 30 days. The irrigation area should not be used for children's play area, garden area, or be accessible to lactating dairy animals. Wait at least 30 days to harvest hay or graze animals in the area.

4) When the ground is frozen or already saturated, the acceptable alternative is to have the excess sewage hauled by a licensed septage hauler. Stringent water conservation practices should be used during such times.

5) The lagoon owner must get permission from the appropriate regulatory authority before dewatering.

PROTOCOL
SEALING A LEAKING LAGOON

GOAL: Determine the cause of seepage and implement a solution to stop it.

POLICY: The maximum allowable seepage is ¼-inch per day. Ideally, water in the lagoon should be maintained between 3 and 5 feet.

PROCEDURE

Excess seepage can lower the water in the lagoon to unusable levels. Seepage can commonly be attributed to areas of permeable soils in the bottom or sides of the lagoon. Different methods can be used to reduce the seepage. Before any investment is made in sealing a lagoon, an evaluation of the problem area by a trained soil scientist, engineer, or technician is beneficial. Contact the local Natural Resources Conservation Service and/or the county sanitarian for assistance on sealing leaking lagoons. Once the cause of seepage is reasonably determined, the best and most practical method for sealing can be chosen.

Sealing with earth blankets

Sites with too little clay to prevent excessive seepage can be sealed by an earth blanket compacted over the leaky area.

1) The best blanket material should have a good mix of particle sizes from small gravel or coarse sand to fine sand, silt, and clay in the desired proportions. The clay particles should make up about 20 % of the weight.

2) The area to be sealed should be prepared by draining the lagoon and permitting the area to dry.

3) The area should then be worked with a disc, tiller, or similar equipment and the blanket material uniformly spread over the area in 6- to 8-inch layers. Each layer should be thoroughly compacted by a roller before the next layer is placed. Generally, two or three layers is adequate.

4) For this method to be practical, a suitable borrow area should be close enough to permit hauling the blanket material at a reasonable cost.

Sealing with flexible membrane lining

This method, though generally expensive, is perhaps the most effective because it eliminates virtually all seepage when properly installed. Flexible membranes made of plastic, rubber, or similar materials are placed as impermeable liners in the bottom of the lagoon.

1) All membranes should be constructed of high-quality materials and should be certified by the manufacturer to be suitable for use as liners.

2) The area to be lined should be drained and allowed to dry until the surface is firm, and can support the people and equipment that must travel over it during installation of the lining.

3) All rocks, stumps, hard clods, and other materials that could damage the liner should be removed from the surface before the liner is laid.

4) The liner should be installed according to the manufacturer's recommendations and specifications.

Sealing with bentonite
Bentonite is a high-swell clay material suitable for use on soils having a high proportion of coarse-grained materials and insufficient clay. Bentonite absorbs several times its own weight of water and when completely saturated can swell 8-20 times its original volume. Bentonite can be purchased in bag or bulk as a powder or in pellet form. Farm supply stores, co-ops, or well drillers often supply bentonite.

1) The area to be treated must be drained and dried prior to applying the bentonite. (Dumping bentonite in the water in an undrained lagoon does not work and can have detrimental effects on the water quality.)

2) Bentonite is mixed with the existing coarse material soil. Rates of application vary from 1-3 pounds per square foot, depending on the site material.

3) The mixed soil must be thoroughly compacted. The saturated bentonite will swell to fill the voids and pores, sealing the lagoon.

4) Upon drying, bentonite returns to its original volume, so it is not usually suitable for lagoons with a wide fluctuation in water level.

Sealing with soil dispersant
Excessive seepage can occur in a lagoon even in clay soils because the clay particles are arranged to form an open, porous, or honeycomb structure. Applying small amounts of certain chemicals to these porous materials can disperse them and reduce soil permeability. These chemicals are referred to as dispersing agents.

1) Prior to application, the area should be drained and dried.

2) Sodium chloride (common salt), sodium tripolyphosphate (STPP), and tetrasodium pyrophosphate (TSPP) are all effective dispersing agents. Commercial phosphatic fertilizer should *not* be used. Farm and feed supply stores and co-ops often supply the proper type of salt or dispersing agent. The dispersing agent should be applied at a uniform rate and thoroughly mixed into each 6-inch layer treated with a disc or tiller.

3) Rates of application range from 0.05-0.33 pounds per square foot depending on the type of soil and type of dispersant used.

4) Each treated layer should then be thoroughly compacted.

PROTOCOL
COMPACTED LINING FOR SMALL WASTEWATER LAGOON

Purpose: Guidelines for lagoon construction where soils do not have extremely slow drainage and where it is shallow to bedrock (bottom of lagoon is less than a foot above or into rock).

Suitable Soil: Determine subsoil is at least 30 percent clay, either by determining soil texture or testing the soil to determine percent clay.

Construction Procedure:

1) Remove topsoil and stockpile it near the site for later use. Vegetation should be permanently removed and not used to construct the berm because it will eventually decay and cause soil settling.

2) Test to determine if soil is at or slightly above the plastic limit by rolling out a small clump of soil into a wire shape, 1/8-inch diameter or smaller, without breaking apart. If it breaks, it is either not wet enough or does not contain enough clay. Add water and test again. If repeated attempts are not successful, there may not be enough clay and the choice of a lagoon for this site should be reconsidered.

3) Remove the subsoil 12 to 18 inches below the bottom and sides of the lagoon and stockpile for reuse. When the bottom is shaped, measure the bottom area and, using a level, determine elevations near the inner corners and center. Measure horizontal distances from permanent reference points to the corners to verify thickness of the constructed lining.

4) Compact the bottom and side layer using at least four passes.

    a) A sheepsfoot or other full-coverage roller is preferred.

    b) If a sheepsfoot roller is not available, use a heavily weighted wheel tractor, making passes so there is complete coverage of the surface to equal one pass with a full-coverage roller. Given the small percent of tire to machine width, to get full coverage of the surface may require a total of 16 to 20 passes for each width of the tractor.

5) Add a layer of loose subsoil (clay) material and compact. If the amount of material removed is not adequate, a similar subsoil material must be imported to the site.

    a) If a sheepsfoot roller is used, add 9 inches of loose material and compact to a 5- to 6-inch thickness, or add 6 inches of loose material and compact to 3.5 to 4 inches.

    b) If a tractor is used for compaction, add 6 inches of loose material and compact to 3.5 to 4 inches.

6) Repeat step (5) until a 1.5-foot-thick compacted layer is constructed.

7) After the compacted liner is complete, finish final grade of the compacted bottom and sides of the lagoon to maintain the proper side slope. The interior slopes should be no steeper than 3:1; 3.5:1 is better.

8) Place the topsoil over the outside, top, and top-third of the inside of the berm.

9) Using field tests, verify that compaction has been achieved.

   a) Compaction makes the soil firm and it should be very difficult to insert a hand probe more than a few inches. This gives a good indication of compaction. KDHE recommends an electronic soil compaction meter (Field Scout or equivalent) to test compaction.

   b) To evaluate compaction of the entire liner thickness, use a 4-pound hammer to drive an 18- to 24-inch-long number 3 rebar 1½ to 2 feet into the lagoon lining. Count the number of blows to drive it for each 6-inch interval. The number of blows should increase with depth. The bar will be quite difficult to remove, so if removal is important, plan how to do this before you go to the field. If a shorter bar is used and left flush or slightly below the surface, removal is not essential.

PROTOCOL
HOME MAINTENANCE AND MONTHLY INSPECTION CHECKLIST

Conduct Inspections Monthly • Date of Inspection ________________

Name and address of home occupant ____

Person conducting inspection ____________________________ Date_____________

Number of Occupants Served _____________ Number of Bedrooms _____________

Approx. Vertical Distance- water level to top of embankment ______________________

Water depth _____________________________

Color

___ Dark sparkling green (best condition, indicates dissolved oxygen (DO) and pH high)

___ Dull green to yellow (not as good, indicates DO and pH less than optimum; blue-green algae may be becoming predominant.

___ Gray to black (very bad, anaerobic, or septic conditions prevail; odors likely. Too much sludge is possible.

___ Tan to brown (bad in Kansas where brown algae is not found, usually means erosion or inflow of surface water; okay if algae is brown).

Review: Mark lagoon deficiencies, provide any necessary details on back.

1) Lagoon area fence is strong and intact all around perimeter, keeping out children and livestock.
2) No evidence of lagoon discharging.
3) No surface drainage into lagoon.
4) No eroded or damaged berm in need of modification or repair. Slope should be no steeper than 3 to 1.
5) No vegetation height more than 6 inches.
6) Stand of groundcover on berms is adequate for erosion control.
7) No cattails or other vegetation growth in lagoon; no plants floating on water.
8) No tree or woody plant growth within 50 feet of lagoon, which produces leaf debris in lagoon, and/or blocks sunlight and airflow action on lagoon.

Name: __________________________ Date: ____________ Title: _________________

INSPECTION REPORT FORM: DATA FOR A SMALL LAGOON

Name of Owner ______________________________ Phone_____________________

Address of Owner ____

Person(s) Contacted at Site ____

Legal Description S_________, T ___________, R __________, County__________

Number of Occupants Served _______ X 50 gpd = _______ total gpd = Estimated Flow

Approx. Vertical Distance - water level to top of embankment ____________________

Horizontal Distance to nearest property line ___________________________________

Distance to property owner's nearest well _____________________________________

Review: Mark lagoon deficiencies, provide any necessary details on back.

CONSTRUCTION:

_____ Lagoon construction incomplete or substandard.

SIZING:

_____ Lagoon used by more than one household

_____ Lagoon not sized according to plans and specifications.

_____ Lagoon does not meet size requirement for number of people or estimated wastewater flow

LOCATION:

_____ There is not a potential site for a second system

_____ Lagoon is located on easement (type) ___________________________

Easement Holder ____

_____ Lagoon located too near well(s) or weeds and trees

PLUMBING:

_____ Household is served by two or more disposal systems

_____ Greywater is not discharged into lagoon

_____ Sewer pipe slope is not within acceptable limits

_____ Berm is above the point where sewage exits house

_____ Outlet pipe does not terminate in approximate lagoon center

_____ Water from roof/patio/foundation drains enters lagoon

_____ Overflow pipe present

_____ Clean outs not properly installed/maintained

FENCING:

_____ Fencing/gate requirements have not been met

VEGETATION:

_____ Berm vegetation is over 6 inches high

_____ Floating vegetation present

_____ Cattails present

BERM:

_____ Berm does not have stand of short-rooted perennial groundcover

_____ Lagoon berm eroded/damaged/berm slopes not within acceptable limits

_____ Animals/farm machinery has access to lagoon berm

_____ Surface drainage can enter lagoon

OPERATION:

_____ Water depth not between 2 ½ feet and 5 feet

_____ Seepage present

_____ Lagoon overflowing

_____ Lagoon too shallow to prevent overflow

_____ Lagoon water used routinely for irrigation

_____ Lagoon overloaded

_____ Wave action sluggish or absent, indicating anaerobic conditions or an oily surface

_____ Evidence of siphoning or pumping

REGISTRATION:

_____ Application form incomplete

_____ Provide map of sewage/potable water pipes

_____ Lagoon is not registered with health department

_____ Change of ownership forms have not been received

_____ Required fees have not been paid

OTHER:

Name: ___________________________ Date: _____________ Title: _______________

Chapter X

PUMPS AND HYDRAULICS

TABLES

FIGURES

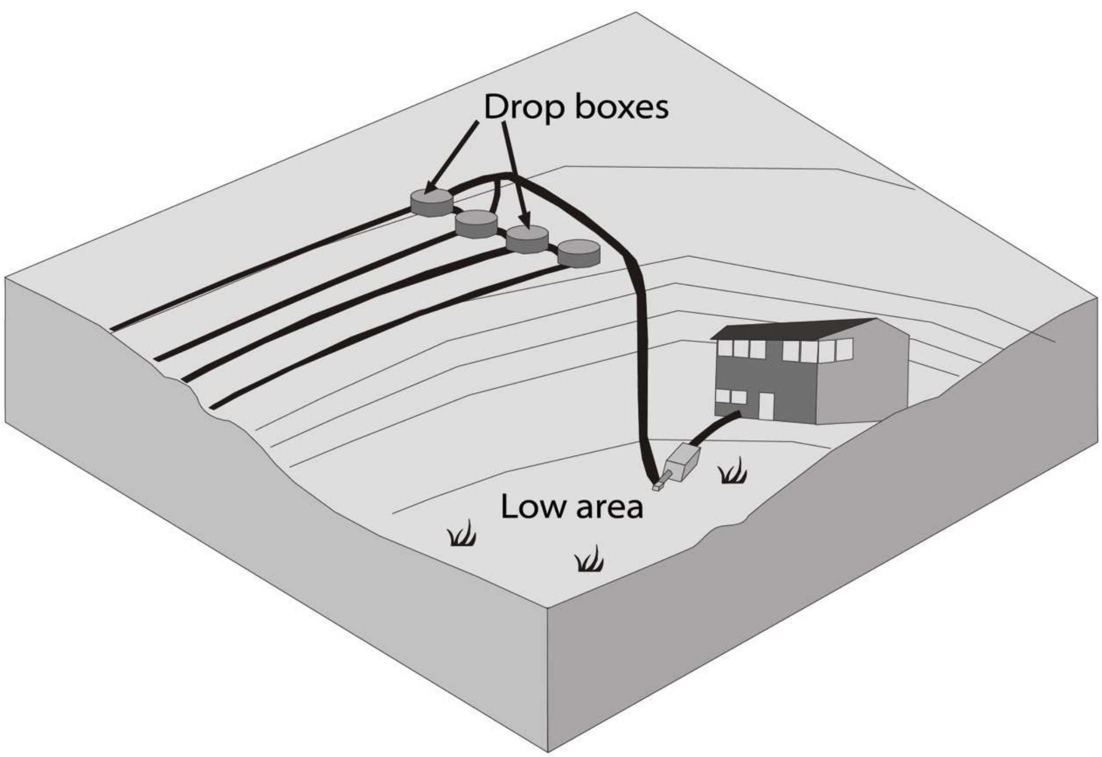
INTRODUCTION

Pumps are often utilized in on-site wastewater systems to —

- lift wastewater for improved system location options on a site
- distribute effluent uniformly
- time-dose an enhanced treatment or soil absorption system component
- inject air into an aerobic treatment unit (ATU)
- lift drainage water to lower a water table

Figure X-1 shows use of a pump to lift effluent to a soil-absorption area at higher elevation than the wastewater source. This use allows much greater flexibility in selection of the wastewater system and its location. Whenever a pump is required, maintenance and accessibility of the system are critical factors in its continued operation. Pump stations require careful design, installation, and maintenance by qualified technicians. Pump equipment and controls should be located in an accessible area protected from weather and vandalism. All components of the pumping station should be watertight and resistant to corrosion.

Figure X-1. Pump Used to Lift Wastewater to a Higher Elevation than the Source



PUMP APPLICATIONS

Pumping raw sewage requires a pump design to handle the solids found in raw wastewater. This type of pump has a non-clog impeller and many also have a grinder designed to handle tough and stringy solids such as rags or flushable wipes to avoid clogging the pump. Two common applications for pumping raw sewage are when a lagoon is at a higher elevation or plumbing fixtures in a basement must be lifted to the septic tank placed at the preferred shallow depth. A grinder pump might typically be chosen to handle all of the household sewage to pressurize or lift to a higher level. A non-clog sewage pump might be selected to serve fixtures in the basement such as a bath and laundry. These types of pumps are expensive and require frequent maintenance to meet service requirements. In addition, these pumps are typically low-head, and thus are designed for a limited lift or head of the wastewater.

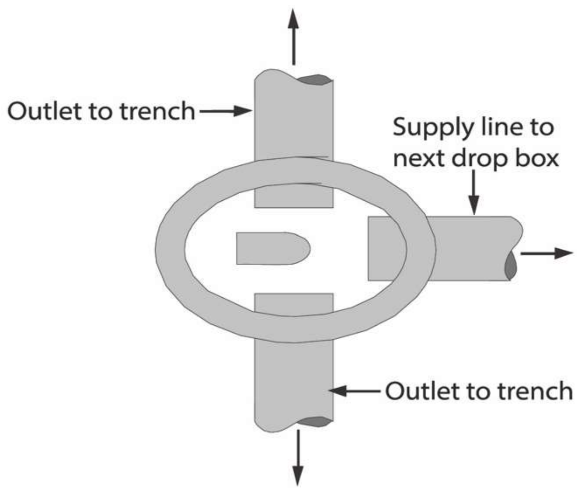
The vertical distance from the lowest water level at the pump to the highest point of the discharge is called lift or head (usually measured in feet). The cost to pump wastewater against high heads can become quite expensive. However, lifts of 10 to 20 feet with an efficient pump will be a modest price. Most on-site wastewater systems are designed to minimize the head required for the pump in order to keep the cost for the pump and its operation reasonable.

The most common type of pumping situation for on-site wastewater systems involves pumping the septic tank effluent after the solids have been removed and the effluent screened. For this application, the capacity to handle solids is not nearly as important as when pumping raw sewage. These pumps are classified as effluent pumps and usually use a turbine-type impeller. They are less expensive than non-clog or grinder pumps, not subject to clogging because of low solids, and some models are available to pump against a higher head.

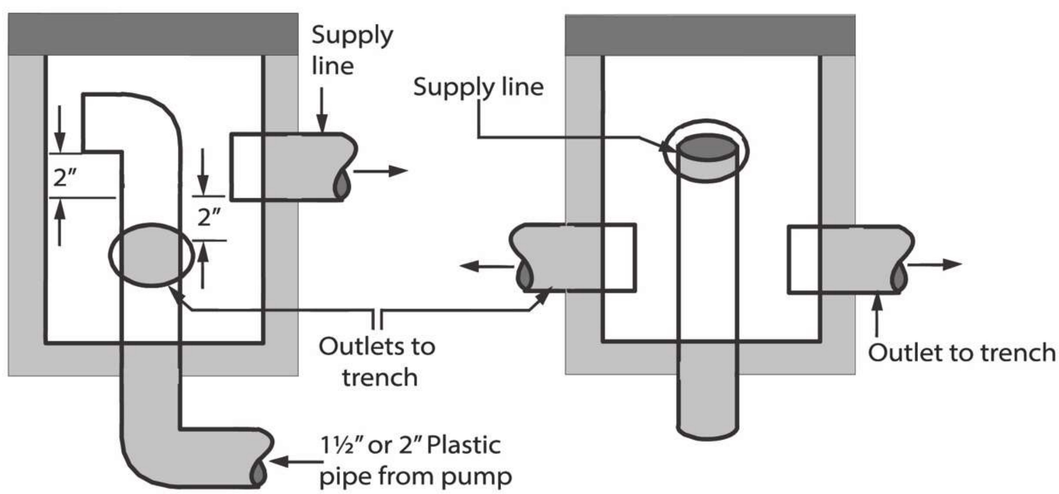
An effluent pump may be used for a low-pressure pipe system, to reach an absorption area at a higher elevation for a drip-distribution system, sand or media filter, or simply to provide even distribution and/or dosing of the effluent. Effluent pumps usually have a screen that covers the pump intake and are preceded by a septic tank effluent filter. These filters must be kept clean to allow the effluent to enter the pump intake. Most of these pumps are designed to use water as a lubricant and coolant so the pump must not be operated under dry conditions. If screens are plugged and water cannot enter the intake, the pump may be damaged.

When an effluent pump is used to deliver wastewater to a conventional absorption field, flow may discharge to a drop box as shown in Figure X-2. On a slope, as shown in Figure X-1, water that upper laterals cannot absorb overflows via drop boxes, shown in Figure X-3, to lower laterals. In designing the drop-box system, the invert (bottom) of the discharge pipe from the pump must be at least 2 inches higher than the elevation of the supply line to the next drop box. **This arrangement will allow water in the discharge pipe to drain back to the pump tank but will not allow water from the rest of the absorption field to drain back into the pump.** The distribution box should be arranged so that effluent from the discharge pipe coming from the pump is directed to the wall of the drop box, opposite the supply line pipe. The outlet lines to the absorption field are then located on the sides of the box at a 90-degree angle from the inlet pipe. If this arrangement is not carefully designed, flow from the distribution box will not be evenly distributed. If additional trenches need to be supplied in a pumped system, drop boxes (see drop box design detail in Figure X-3) may be used in series, as shown in Figure X-1, to direct the flow through the absorption field.

Figure X-2. Pump Discharge Delivery to a Gravity-Distribution, Lateral Drop Box

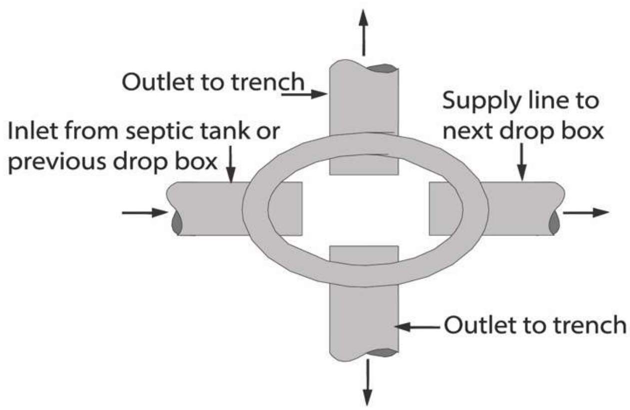


1. All pipes other than the pressure pipe should be at least 4” diameter
2. Elevation of inlet and suppy line to next drop box may be adjusted up or down for desired effluent level in trench.
3. Suggested trench liquid level is at top of trench rock if permeable synthetic fabric covers rock.
4. Invert of pipe from pump must be at least two inches higher than invert of supply pipe to next drop box.
5. Trenches may outlet one side or both sides of drop box.

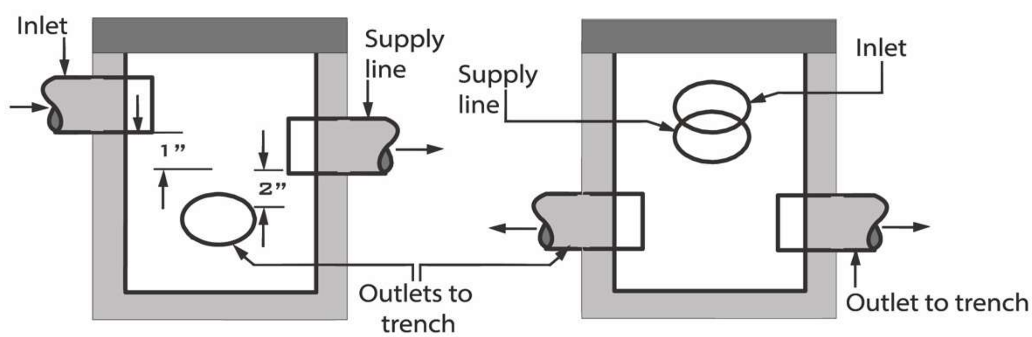


Drop Box for Pump Effluent

Figure X-3. Gravity Distribution Lateral Drop Box



1. All pipes should be at least 4” diameter
2. Elevation of inlet and suppy line to next drop box may be adjusted up or down for desired effluent level in trench.
3. Suggested trench liquid level is at top of trench rock if permeable synthetic fabric covers rock.
4. Invert of pipe from pump must be at least two inches higher than invert of supply pipe to next drop box.
5. Trenches may outlet one side or both sides of drop box.



Drop Box

PUMP TANKS

The pump tank must be watertight and corrosion resistant. Most pump tanks available today are concrete, fiberglass, or polyethylene. All openings to the tank must be sealed and watertight to prevent the flow of groundwater or surface water into the tank and also to prevent the flow of wastewater out of the tank, except through the pump discharge. The pump tank must contain a minimum volume of water at all times in order to prevent the tank from “floating” when the ground is saturated. The pump inside the tank should be elevated above the bottom of the tank to allow for unobstructed flow into the pump intake and to prevent solids from clogging the intake or plugging orifices. Note: Orifice is synonymous with perforation. The pump manufacturer will provide information on how high the pump intake should be from the bottom of the tank. Examples of pump tank configuration are shown in Figures X-4, X-5, and X-6.

Figure X-4. Gravity Serves Ground Floor and a Pump Lifts Sewage from Basement

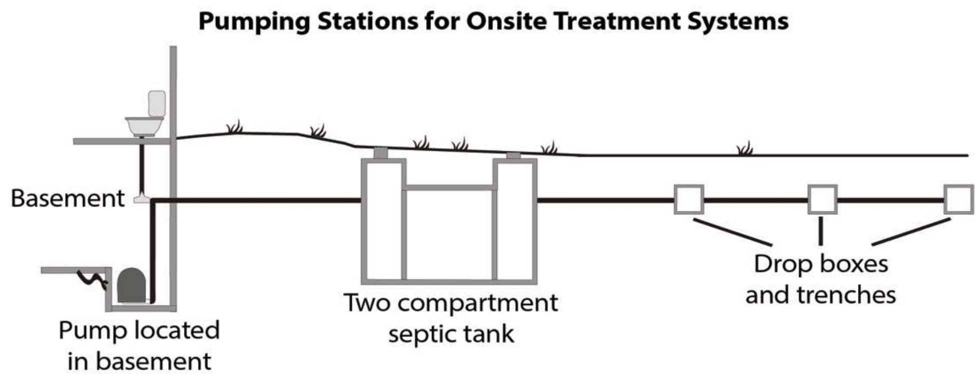
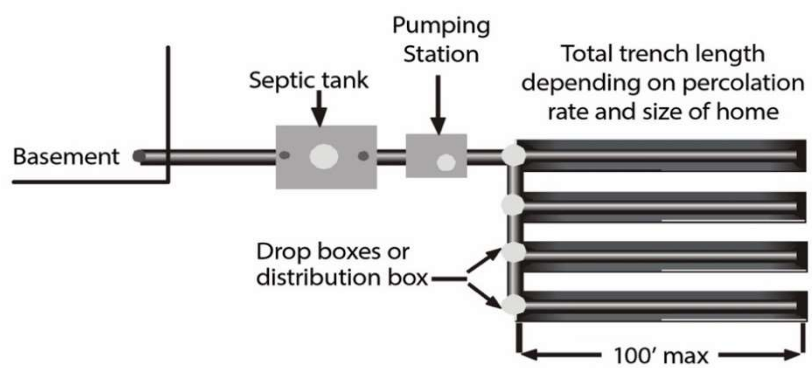


Figure X-5. Pump Lifts Tank Effluent to a Shallow Absorption Field



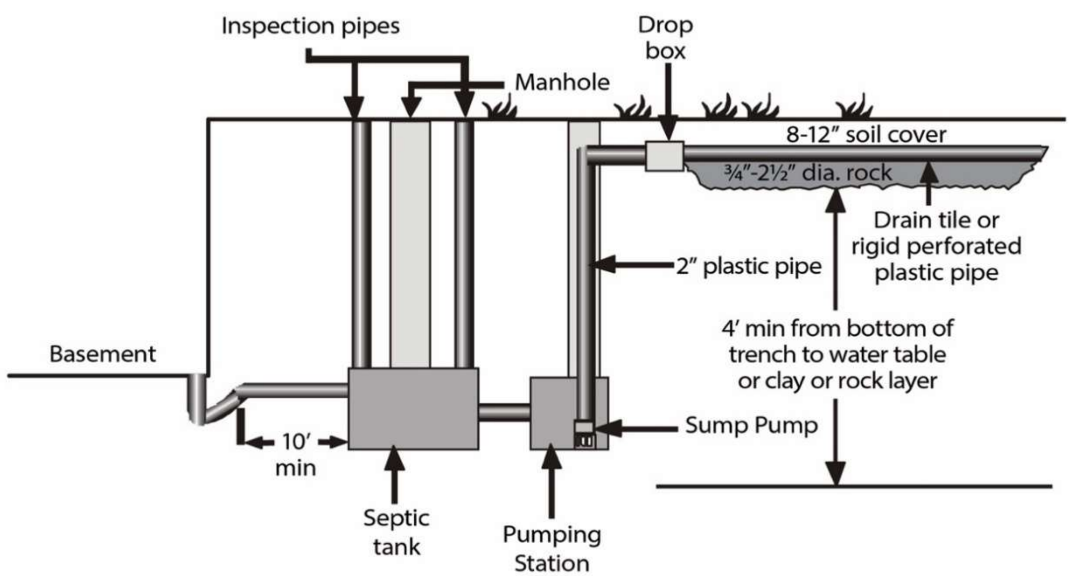
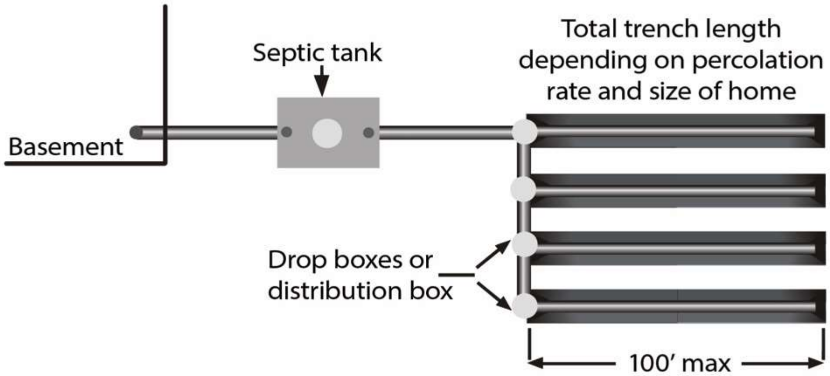
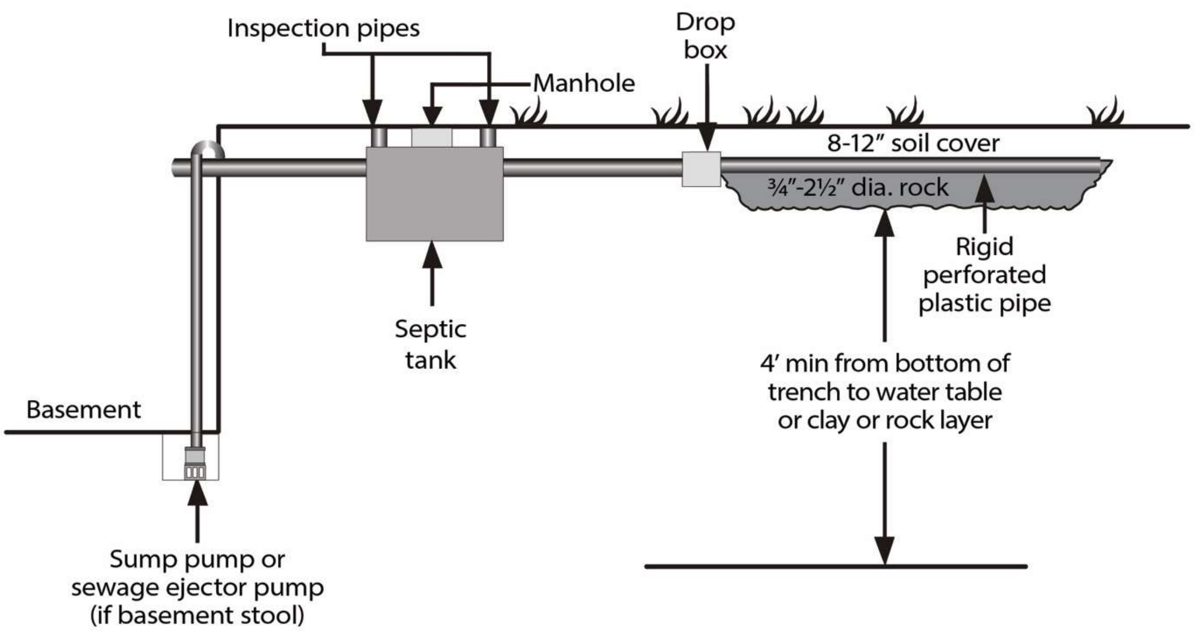


Figure X-6. Pump Lifts Sewage to Shallow Septic Tank Placement for Easier and Much Less Costly Maintenance





Pumping station for homes (pump in basement)

The pump tank must be accessible for maintenance. A manhole with a minimum diameter of 24 inches must be provided into the pump tank. The access opening into the tank itself must be a minimum of 20 inches. A larger manhole is preferred and may be required depending on the type of pump used. The manhole cover must have a lock mechanism to prevent unauthorized persons from opening the tank. An unsecured manhole cover is a serious safety hazard and may become a target for vandalism. The pumping station is a confined space and may contain dangerous gases. The manhole must provide access for maintenance and servicing the pump but in no case should the pump tank be entered unless all OSHA safety regulations regarding a confined space entry are observed. The pump should be installed with a quick-release discharge that is accessible at the top of the manhole. This will allow the pump to be serviced or replaced as needed. All electrical connections should be made outside the pump tank in approved waterproof connection boxes. The pump station must have an electrical disconnect that is located outside the house and is accessible for a service technician to cut the power to the system before any maintenance work is begun.

The pump tank should have a volume adequate to provide the minimum volume needed to keep the pump intake submerged, the pump-down volume of one pump cycle, and a reserve capacity of 75% of the daily flow in case the pump fails. Most pump stations are equipped with an alarm to indicate when the water level is rising above the normal volume. Once the alarm is activated, the pump tank should have enough reserve to handle 75% of the daily flow. However, in many situations even this reserve volume may not allow enough time to get the pump operational. Some pump stations are now equipped with an additional power outlet to allow the pump tank to operate using a portable pump. This will provide additional capacity until the pump can be repaired.

Most pump stations are designed so that the discharge line from the pump will drain back into the pump tank by gravity when the pump shuts off. The pump used in this application must be designed to allow this drain-back feature, which will make the impeller turn backwards. This feature will help prevent freezing of the lines in the absorption field. In addition, the pump discharge line should be fitted with a quick disconnect or union so the pump can be easily removed for repair. Easy access to the pump tank for maintenance and repair is a critical factor in the design of a pump station. The pump station may need to have some type of built-in rail or guide to allow the pump to be easily installed or removed.

If the pump tank is not concrete, then the tank may need to be bedded in concrete or anchored to prevent floatation when the tank is nearly empty. Fiberglass and polyethylene tanks will need to have some type of anti-floatation design incorporated into the installation of the tank. Usually the manufacturer will include installation specifications designed to prevent floatation. If the tank has two or more compartments, at least one of the compartments should be full enough to prevent the possibility of floatation.

Depending upon the application, the pump station may require a filter. If the pumped effluent is being discharged into a soil absorption field, then the pump station will usually have some type of effluent filter to keep solids out of the absorption field. Effluent filters should also be used in pump stations that dose a media filter, such as sand or textile filters. If the pump station is using any type of high-head effluent pump, then a filter and pump screen are mandatory. A variety of different sizes and configurations are available for these effluent filters. The type of filter used will depend upon the application, the tank, and the type of pump being used. The filter will need to be accessible for cleaning and should be designed for easy removal.

PUMP TYPES

Recently, the grinder pump has become more common for use in individual homes. It is equipped with blades mounted on the impeller that literally grind and shred solids before they enter the impeller. The grinder pump must grind solids to a size that will not clog the impeller. Two types are currently available: a centrifugal grinder pump and a positive displacement grinder pump. The centrifugal grinder pump is more common, but is usually not capable of pumping against a high head. However, the positive displacement grinder pump can handle a high-head application. Regardless of the type of grinder pump used, the blades will need to be replaced and the pump will require maintenance. Some grinder pumps require a great deal of maintenance and repairs can be very expensive. The grinder pump is most commonly used to convey wastewater into a small diameter sewer that serves some type of central wastewater treatment facility.

A pump that handles solids, or an ejector pump, is commonly used to deliver wastewater from a basement into a septic tank. This type of pump system must be designed to deliver the required volume during each pump cycle, without any drain-back from the line into the septic tank.

Ejector pumps are usually equipped with a check valve to prevent this from happening. When sewage is pumped into a septic tank, turbulence is created in the septic tank. For this reason, the septic tank should have at least two compartments, or have two tanks installed in series, in order to minimize the turbulence and allow the septic tank to function properly in removing solids and scum. The volume of wastewater delivered in one pump cycle should be no greater than 1% of the volume of the first compartment. If two septic tanks are used in series, the volume of the pump cycle may be increased to 5% of the volume of the first tank

PUMP CONTROLS

The pump is usually controlled by floats suspended in the pump tank. These may be mechanical floats and may be rated as “normally on” or “normally off.” In either case, the float is designed to hang vertically so that as the water level in the tank rises, the float gradually becomes suspended until the water completely covers it and it is inverted in the water. When the float is inverted, it will throw an electrical circuit either open or shut, depending upon the wiring configuration. Many pump stations have three floats: a low-water alarm, the on/off float, and a high-water alarm. In the three-float system, the low-water alarm float is always submerged unless the water level falls below the low-water alarm level.

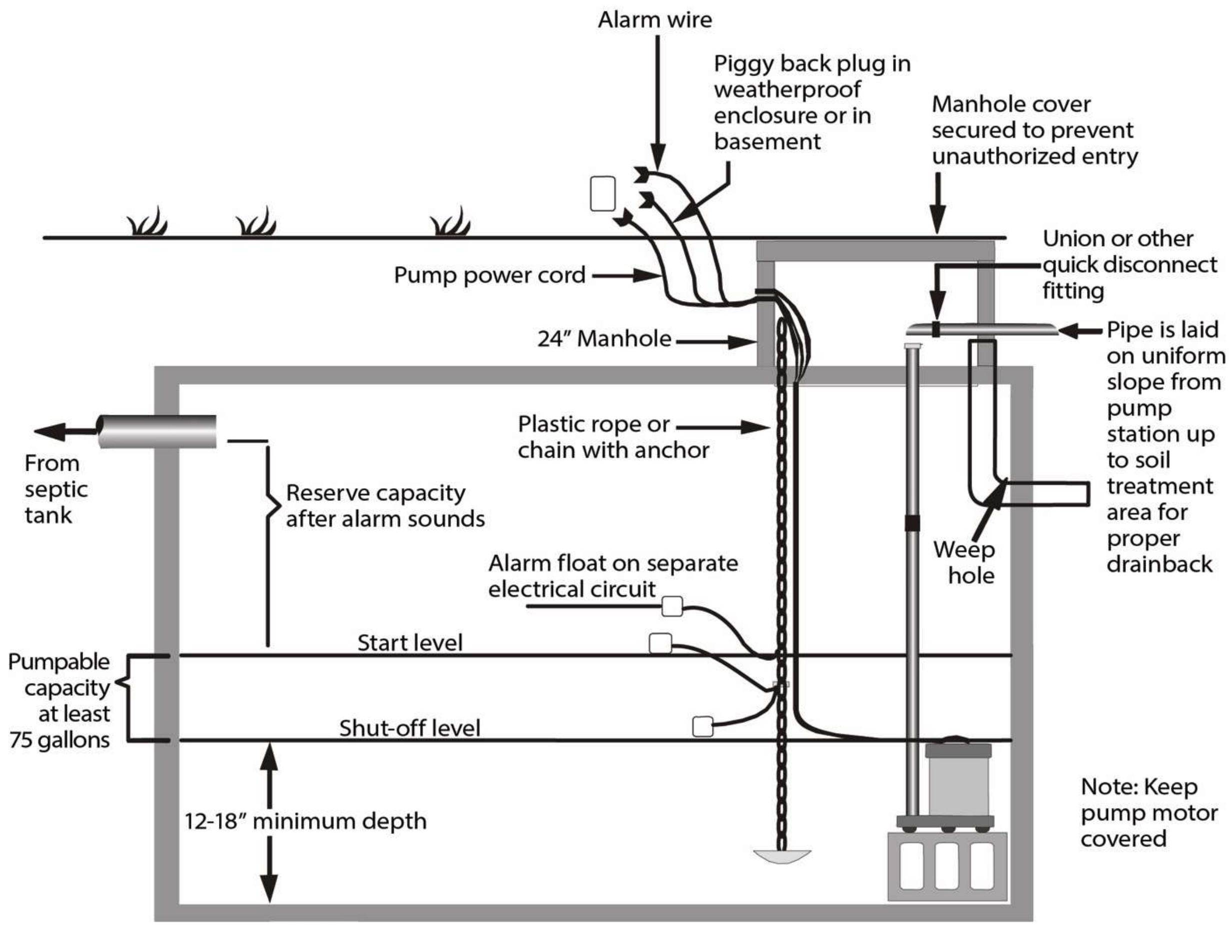
Remember the pump intake and body of the pump must be kept submerged to provide lubrication and cooling of the pump. The low-water alarm will indicate abnormal conditions and alert the homeowner to a problem in the pump tank. The on/off float is designed to turn the pump on when the water level gets high and to turn the pump off when the water level returns to the normal operating level. The high-water alarm is activated when the water level gets high. It should be set so that additional reserve capacity, in the event of pump failure, is still available in the tank.

Examples of the float configuration for a pump station are shown in Figure X-7 where the control box is attached to the house exterior, and Figure X-8 where the control box is remote.

Please note the floats should be tethered to a rigid float tree that is mounted in the tank. They should be on a short tether and must be carefully set so as not to become tangled up with each other or come to rest on the top of any surface (especially the pump casing) inside the tank. The most common problem encountered with these systems is that the floats are entangled and not able to work properly. Also, the vertical location of the pumps must be carefully set to provide the proper dose volume per cycle to protect the pump with the low-water alarm, and to notify the homeowner when high-water conditions exist. A qualified installer should be employed to set the floats at the proper height and configuration.

Some pumping stations may be equipped with a timer to operate the on/off cycle of the pump. These stations are designed to provide a specific dose at a given time interval. This type of configuration is commonly used for dosing media in a fixed-film treatment system or for a media filter such as a sand or textile filter. These systems also have low- and high-water alarms but the on/off cycle is controlled by the timer in the control box that may have to be adjusted to provide the proper dose. Adjusting the timer on these systems must be done by a qualified technician who understands how the timer is set. The control box for the pump station must be waterproof and corrosion-resistant. The control box should be mounted in a protected area near the pump tank. The control panel should be within sight of the pump tank to facilitate service on the unit. All electrical connections must be watertight and in accordance with local electrical codes. The control box should contain a wiring diagram mounted permanently in the box. The control box should contain an electrical shut-off to allow the service provider to cut the power to the system and should also be equipped with an audible and visual alarm to notify the homeowner when alarm conditions exist. The alarm circuit should be separate from the pump circuit so that if the pump trips the circuit breaker, the alarm circuit will continue to operate. Most control boxes have a silencer to shutoff the audible alarm after the homeowner is aware of the conditions. The wiring from the control box to the pump tank is usually buried and must be protected from traffic.

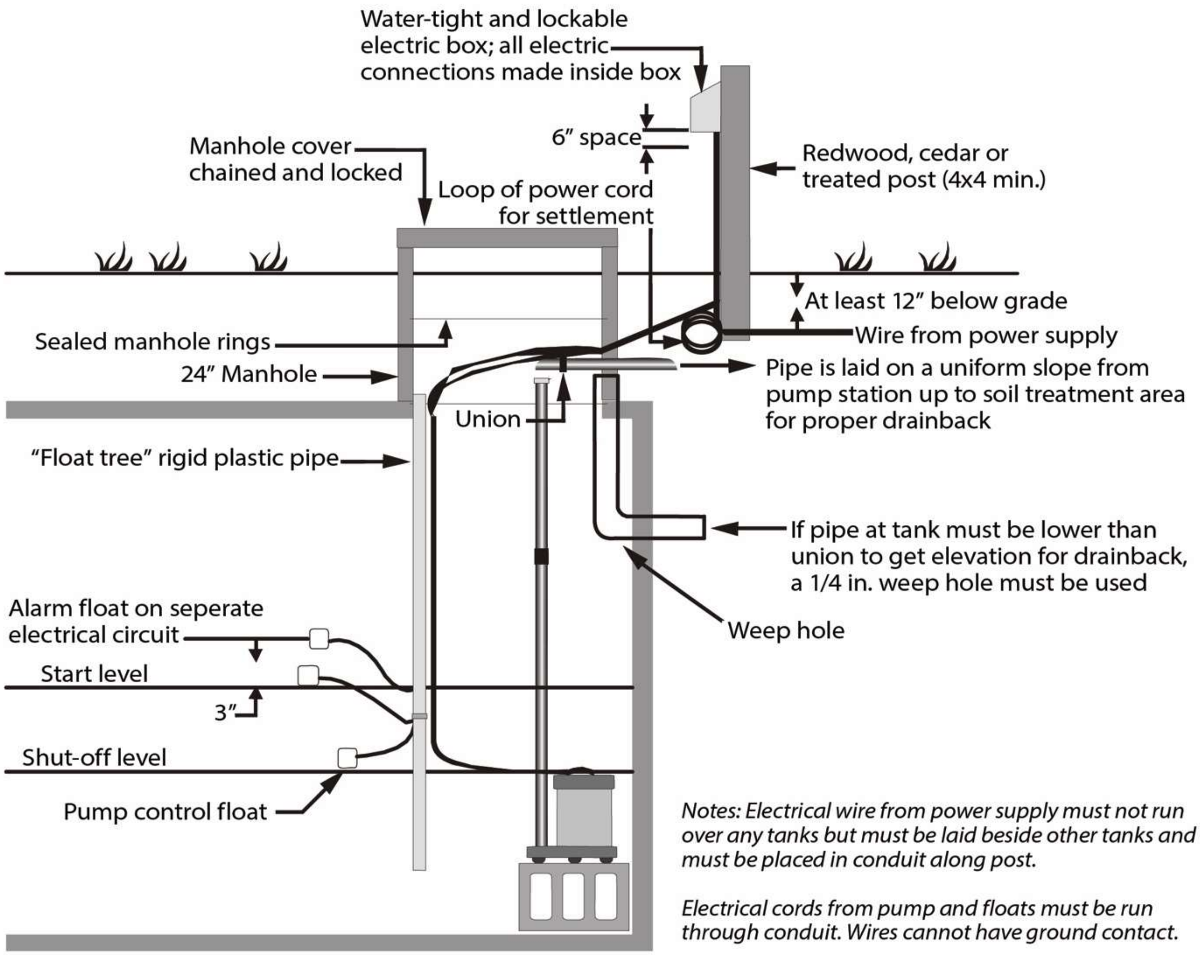
Figure X-7. Section of Pump Tank Showing Pump, Wiring, and Float Locations



Whenever two or more residences have a common soil treatment system, or if an establishment deals with the public (such as a restaurant, motel, or school), dual pumps should be installed as shown in Figure X-9. The dual pumps provide a back-up to keep the system in operation during mechanical problems with one pump. The dual pump, or duplex system, is similar to the single, or simplex pump, except that the control box must contain an alternator that alternates the pump being used.

The duplex system is set up so that if one pumps fails, the alarm will be activated, while the other pump will be operated to keep the system working. In addition, if the flow increases and one pump cannot keep the water level down, then the other pump will also operate. This configuration is called the lead pump and the lag pump. All duplex control panels should be wired to operate in this way.

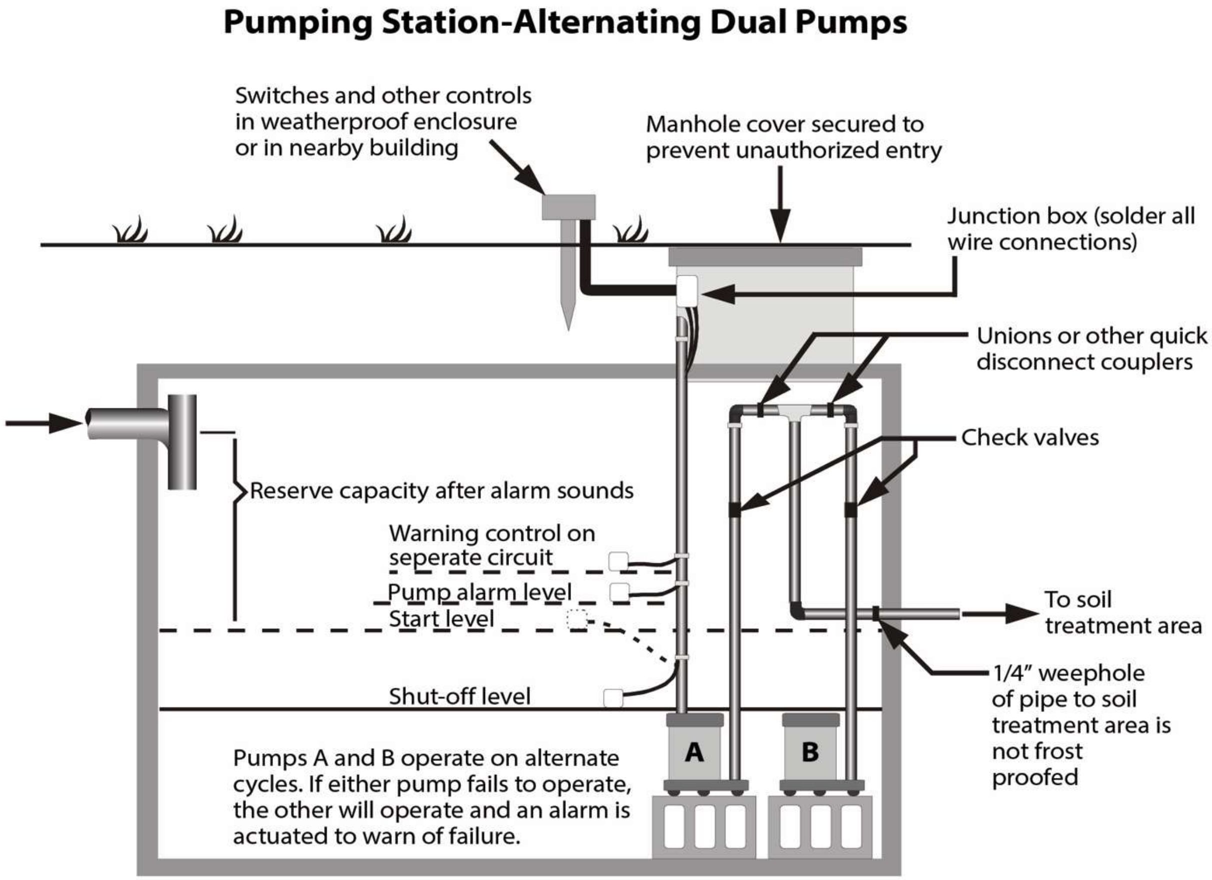
Figure X-8. Section of Pump Tank Showing Wiring and Electricity Away from House



PUMP PRESSURE AND FLOW

For dosing the absorption field, the pump station should be designed to provide a pump-out volume of 25% of the daily design flow per dose. The daily sewage flow from a four-bedroom home is 600 gpd. Thus, the start and stop levels should be set to pump 0.25 x 600 gpd = 150 gallons. Note that in the case of a large home with fewer occupants than designed for, the dose rate may need to be recalculated.

Figure X-9. Duplex Pump Station with Two Alternating Pumps



Setting the pump's start and stop controls depends on the configuration of the tank. For example, if the pump tank is rectangular with inside dimensions of 4 by 5 feet, the surface area is 20 square feet. Since each cubic foot of water contains 7.5 gallons, a l-foot depth of liquid (20 cu. ft.) in this tank would contain 7.5 gal./sq. ft. x 20 sq. ft. = 150 gallons. Thus, to pump 150 gallons, the pump start level should be 1 foot above the pump stop level.

In most domestic applications, the pipe from the pumping station is buried only deep enough to prevent physical damage and on enough of a slope to drain back to the tank after each pump operation. If exactly 150 gallons is pumped, then with the drain-back, less than 150 gallons will be pumped to the absorption field. The volume of drain-back must be calculated based on the capacity and length of the pipe to the distribution box. This volume must be added to the volume to be pumped to provide a net pump dose of 150 gallons.

For a circular tank, which is four feet in diameter, the surface area is calculated as pi or π (3.14) times the radius squared. In this case the surface area would be 3.14 x 2^{2} = 12.57 square feet. For a foot depth in the tank, there are 12.5 cubic feet. 12.5 ft^3 x 7.5 gal/ft^3 = 94 gallons. If 150 gallons are to be pumped and the tank contains 94 gallons per foot of depth, then 150 gal/ 94 gal/ft = 1.6 feet or 19 inches. The start control must be 19 inches higher than the stop control in order to pump out the 150 gallons per cycle. Again, the drain-back liquid must also be added into the flow to provide the proper net dose. The amount of liquid (gallons/100 linear feet) for various pipe sizes is included in Table X-1.

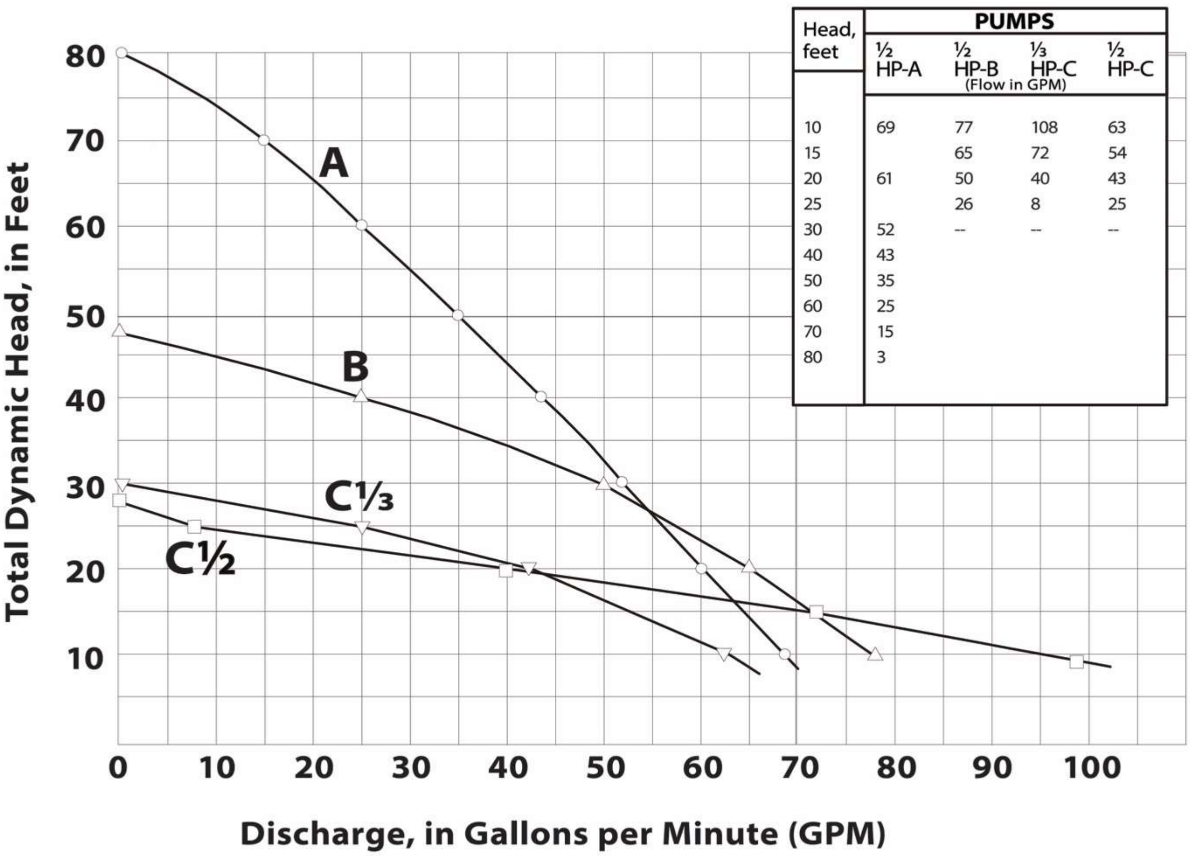
PUMP DISCHARGE CURVE

The common submersible sump pump operates under conditions described by the characteristic pump curve. The pump curve is unique for each pump at a specific operating speed and describes the head-discharge relationship for the pump. Four pump curves are shown in Figure X-10 as examples. The total dynamic head is given on the vertical axis and the pump discharge in gallons per minute is shown on the horizontal axis.

As the discharge rate increases, the total dynamic head a centrifugal pump can deliver will decline. The point at which the characteristic curve intersects the vertical axis is the maximum head the pump develops and is often called the shut-off head. The maximum head for pump C with a ⅓ horsepower as shown in Figure X-10 (labeled C ⅓) is 30 feet. This can be visualized by thinking of a standpipe just over 30 feet tall. The pump can raise the liquid level to a height of 30 feet but the flow at or above that head is zero. At any head less than 30 feet, some flow will occur. For example, at 25 feet of total head, the discharge will be approximately 25 gallons per minute. Referring to Figure X-10, the shutoff head of the ½-horsepower pump "A" is 80 feet (intersection of the pump curve with the vertical axis). At 40 feet of head, the pump can discharge 43 gallons per minute. The pump supplier can provide a pump curve to be used to select the right pump for each application. Note that even though pumps A, B, and C ½ all are half horsepower, each has a very different pump curve.

If requirements for a system are that a pump delivers 20 gallons per minute at 20 feet of total dynamic head, none of the pumps presented in Figure X-10 will deliver precisely this specification. A gate valve will need to be installed to dissipate a small amount of head so that the actual head delivered by the pump will be approximately 21 feet. If the ½-horsepower high-head pump A is used, and exactly 20 gallons per minute are desired, then the pump will actually deliver about 65 feet of total head, 45 feet of which will be dissipated in the gate valve. If the pump application is to deliver flow to a pressure distribution system in a mound, for example, this is a self-balancing system. As the flow tends to increase, the pressure at the perforations also increases and the pump simply operates at a particular point on its own particular characteristic curve. A gate valve is not needed with a pressure distribution system.

Figure X-10. Example Pump Curves for Four Pumps: Two Low-Head with Different Size Motors, a Medium-Head, and a Higher-Head Pump



Head, feet	PUMPS			
	½ HP-A	½ HP-B	⅓ HP-C	½ HP-C
	(Flow in GPM)			
10	69	77	108	63
15		65	72	54
20	61	50	40	43
25		26	8	25
30	52	--	--	--
40	43			
50	35			
60	25			
70	15			
80	3			

Table X-1. Plastic Pipe Friction Loss, Diameter, and Volume

Pipe Diameter	1"	1.25"	1.5"	2"	2.5"	3"	4"
Inside dia. Gals/100ft	1.05" 4.4	1.38" 7.8	1.61" 10.6	2.067" 17.4	2.47" 24.9	3.07" 38.4	4.03" 66.1
Flow,gal/min							
1	0.08						
2	0.28						
3	0.59	0.16					
4	1.01	0.27					
5	1.53	0.40	0.19				
6	2.14	0.56	0.27				
7	2.85	0.75	0.35	0.11			
8	3.65	0.96	0.45	0.13			
9	4.53	1.19	0.56	0.17			
10	5.51	1.45	0.69	0.20	0.09		
12	7.72	2.03	0.96	0.28	0.12		
14	10.27	2.70	1.28	0.38	0.16		
16	13.14	3.46	1.63	0.48	0.20		
18		4.30	2.03	0.60	0.25		
20		5.23	2.47	0.73	0.31	0.11	
25		7.90	3.73	1.11	0.47	0.16	
30		11.07	5.23	1.55	0.65	0.23	
35		14.73	6.96	2.06	0.87	0.30	
40			8.91	2.64	1.11	0.39	0.10
45			11.07	3.28	1.38	0.48	0.13
50			13.46	3.99	1.68	0.58	0.13
55				4.76	2.00	0.70	0.19
60				5.60	2.35	0.82	0.22
65				6.48	2.73	0.95	0.25
70				7.44	3.13	1.09	0.29
80				9.52	4.01	1.39	0.37
90				11.84	4.98	1.73	0.46
100				14.38	6.06	2.11	0.56
125					9.15	3.18	0.85
150					12.83	4.46	1.19
175					17.06	5.93	1.58
200						7.59	2.02

SELECT THE PUMP FOR THE APPLICATION

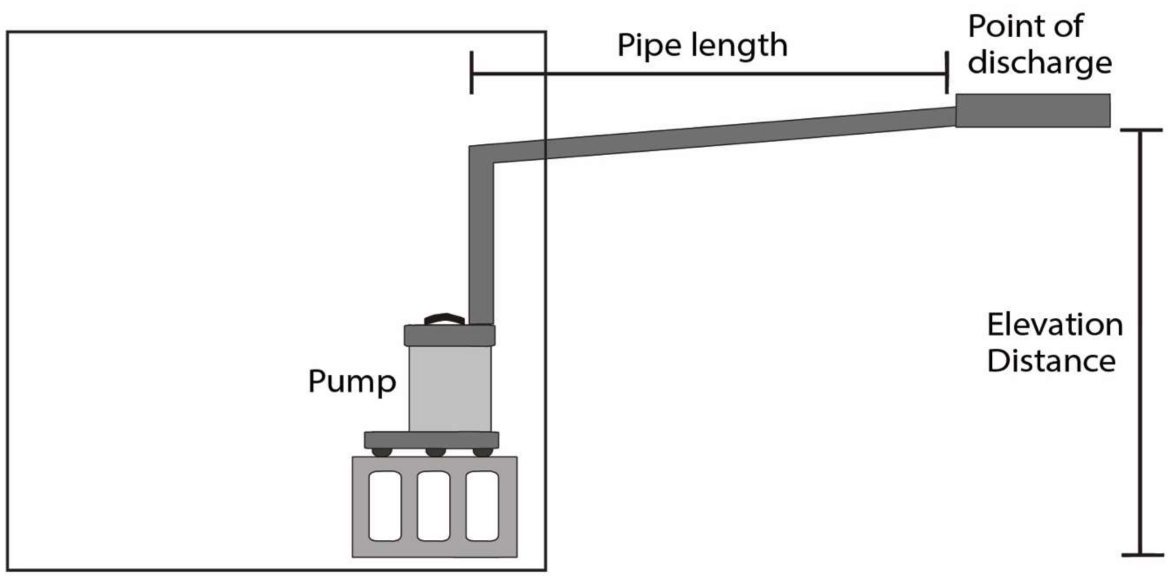
The pumps must be selected for the specific flow and head (or pressure) requirements; not just on the basis of horsepower, voltage, or other factors. Just because a pump worked well in one application does not mean it will work well in a different one. With wastewater, the presence of solids must be considered. Three factors determine the total dynamic head of a pump:

- elevation difference between the pump and point of discharge,
- pressure requirements of the operating system, and
- friction loss in the piping.

Example: Size a system to deliver 40 gallons/min to a manifold in a mound-style wastewater treatment system that is 140 feet from the pump.

This example is illustrated in Figure X-11, where an elevation difference of 17 feet exists between the top of the pump and the manifold, which is the point of discharge in the pressure-distribution system. When pumping to a pressure distribution system, as in this example, add five feet for pressure required at the manifold. If pumping to a drop-box gravity system, no additional friction loss needs to be added. Table X-1 shows the friction loss for Schedule-40 PVC plastic pipe. Friction loss calculations are based on the Hazen-Williams equation. The table also includes the amount of water contained in 100 feet of the various pipe diameters.

Figure X-11 Example Problem



Friction loss depends on the flow rate, type of pipe, pipe diameter and length, and fittings. Friction loss for 40 gallons per minute (gpm) in 2-inch Schedule-40 plastic pipe is 2.64 feet per 100 feet. (Note from Table X-1 that friction loss increases very rapidly as the pipe diameter decreases. For example, friction loss for a 40 gpm in 1 ½ -inch diameter pipe is 8.91 feet per 100 feet.)

Total friction loss from the pump to the manifold due to the pipe, fittings, and manifold itself must be calculated and added to the pump head requirements. Friction losses within pressure-distribution laterals are already included in their design.

In addition to straight pipe, the piping system has valves, elbows, tees, and other fittings. Each of these fittings can be expressed in equivalent lengths of straight pipe. A simplified way to account for these fittings is to multiply the length of the straight pipe by a factor of 1.25.

Multiply the delivery-line length (140 ft.) by 1.25, the factor to allow for fitting losses, resulting in a total equivalent length of 175 feet. Total friction loss for the fittings is 175 x 2.64 ft/100 ft = 4.6 feet. Total head requirement for this system is the sum of the friction losses due to the straight pipe, plus manifold, plus fittings: 17 + 5 + 4.6 = 26.6 feet of head.

The pump must be selected to deliver at least 40 gallons per minute at a total dynamic head of 26.6 feet. This point located on the curves in Figure X-10 falls above the characteristic curves of the ⅓ -horsepower and the ½-horsepower low-head pumps. Thus, these pumps are not suitable for these requirements. If these pumps were the only ones available, the flow would need to be reduced by using fewer or smaller perforations in the mound, or in some cases the friction loss could be reduced by using a larger diameter pipe.

Since a requirement is to have slightly excess capacity to deliver flow at the specified head, select the pump curve just above the plotted head-flow point (26.6-40) on Figure X-10. This point is above the low-head curves, but below the ½-horsepower medium head (B). Because discharge into a pressure-distribution system is self-balancing, no valve is needed to reduce pressure.

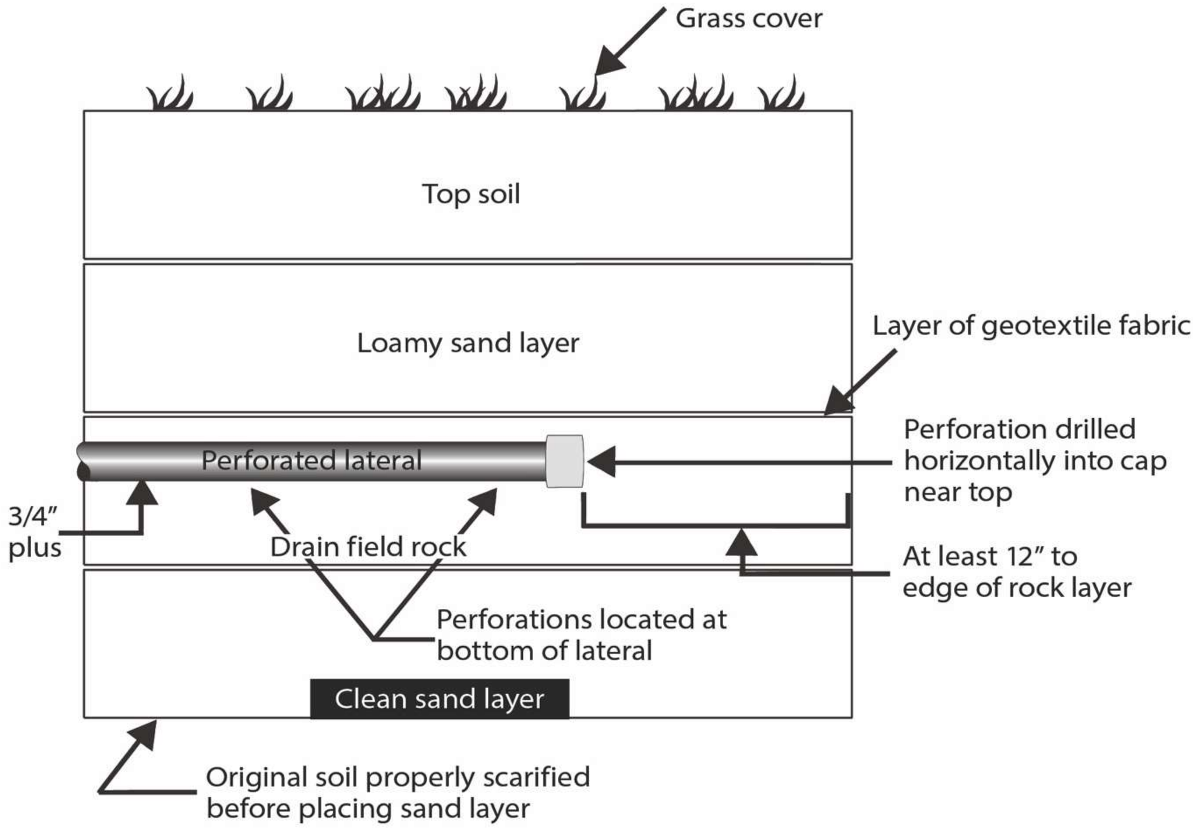
While it can be exactly calculated by a trial-and-error solution, the pump will likely deliver somewhat in excess of 45 gallons per minute at a total dynamic head of slightly more than 30 feet. Again, it is necessary to point out that the B ½-horsepower pump operates exactly on its own characteristic curve.

ENERGY REQUIREMENTS

The amount of energy required for pumping sewage is relatively small. If the pump delivers 40 gallons per minute and 174 gallons are to be pumped per dose, then pump operating time is 4.35 minutes per cycle with 4 cycles per day for a total time of 17.4 minutes per day. The ½-horsepower pump will likely use about 600 watts of power. (Wattage may be estimated. The nameplate amperage on a motor is typically the maximum current draw during startup, which occurs very rapidly. Continuous running current is often ½ to ⅓ of the startup amperage. An estimate of the pump energy use can be calculated by multiplying the current (amps) by the voltage (V) to obtain the wattage, if the running amperage is not known use ½ of the startup amperage.) In this example, the pump will use 600 watts x 0.29 hours = 174 watt-hours or 0.18 kilowatt hours per day. Given the kilowatt hours, energy costs may be calculated using the current price per kilowatt hour.

Although freezing of lines has not been identified as a problem for continuous use-systems, Figure X-12 shows how to frost-proof the lateral line in the soil absorption system. The discharge piping should be sloped to drain back into the pump station as described earlier.

Figure X-12. Section of Low-Pressure Pipe Lateral Indicating Holes for Drainage to Minimize Chances of Freezing



PRESSURE DISTRIBUTION NETWORK

Designing a pressure distribution network is a detailed procedure involving flow rates, pipe diameters, number and size of orifices, lateral pressure, and pressure or head delivered by the pump. Interrelationships are involved such as pipe size versus friction head loss. The process may require trying various combinations to come up with a design that produces an efficient system. However, tables and charts have been developed to help determine appropriate combinations for common designs. If the first design combination isn't satisfactory for some reason, such as requiring an unusually expensive pump, other combinations can be tried to see if improvements can be made.

A pressure distribution network must be designed to ensure uniform distribution of the wastewater. The pressure distribution system consists of the following:

1) lateral pipes with equally spaced holes drilled into the invert of the pipe;

2) manifold and main connected to the laterals;

3) dosing or pump tank to collect septic tank effluent to be pumped to the mound;

4) pump to pressurize the system; and

5) controls, alarm and power supply to operate the pump.

To avoid requiring a very large pump, small-diameter pipes, usually 1- to 1½-inch but occasionally larger, are used to distribute the wastewater. The 4-inch lateral pipe used for gravity-fed soil absorption systems is not suitable because it is too large, and the holes are not appropriately sized or spaced to provide even effluent distribution.

Schedule-40 PVC pipe and fittings are typically used in low-pressure on-site distribution systems. Orifices (holes) are drilled perpendicular to the pipe and are placed on the pipe invert (underside) or top. Any burrs or rough edges must be removed from the holes so they do not collect debris and clog. Holes should be drilled carefully. If the holes are not very close to the size specified in the design, the discharge will be different and will alter the performance of the system.

PRESSURE DISTRIBUTION NETWORK DESIGN

The following design is for the mound system described in Chapter VI pages VI-11 to VI-29. A very similar design procedure is used for any pressure distribution network including sand filter, media filter, low-pressure laterals, or drip dispersal.

Pipe Network Design Steps

1) Refer to the mound design to determine the absorption bed area (A x B). Mound design is covered in Chapter VI. The network configuration and length of the laterals will be based on the absorption bed area. The absorption area width will determine how many parallel lines will be used for the distribution network. The lateral length is measured from the distribution manifold to the end of the lateral. A center manifold is preferred because it minimizes pipe sizes. Remember: all lateral lines are to be on the same elevation or the operating head must be adjusted so they are equal.

2) The spacing between lateral lines should always be less than 5 feet. Spacing can also be based on 6 sq ft per orifice, as is used in sand-filter systems.

3) Determine the perforation spacing and size. The size of the perforations or orifices, spacing of the orifices, and number of orifices must be matched with the flow rate to the network. Typical orifice sizes are ¼” and $^{3}/_{16}$” with spacing of 30-36 inches. See Table X-2 for orifice discharge rates (gpm) for a typical range of pressure heads (ft).

4) Determine the lateral pipe diameter. Select a diameter large enough to keep pressure losses low (less than 15 percent of the operating pressure), but small enough to keep costs low. The lateral diameter selection is based on hole size, hole spacing, and lateral length. Charts have been developed to help in selecting suitable minimum lateral diameters. See Table X-1 for friction loss of Schedule-40 PVC pipe.

5) Determine the number of perforations per lateral.

6) Determine the lateral discharge rate, discharge per orifice times number of orifices. Select the pressure head to be maintained at the end of each lateral. Typical distal pressure is 2.5 ft for ¼” orifices, 3.5 ft for $^{3}/_{16}$” orifices and if smaller holes, such as ⅛” are used, consider using 5 ft of head. The lower the operating head, the more critical the friction head loss becomes to keep discharge uniform along laterals.

7) Determine the number of laterals and the spacing between laterals. If the 6 sq ft per orifice guideline is used, the orifice spacing and lateral spacing are interrelated. For absorption area widths of 3 feet, one distribution pipe along the length requires an orifice spacing of 2 feet. For a 6-ft-wide absorption area with the same configuration, it would require orifice spacing of 1 foot along the pipe.

8) Calculate the manifold size and length. Determine the main connection to the manifold, center, or end. The point of the main/manifold connection determines the length of the manifold. The manifold length is measured from the main/manifold connection to the end of the manifold. The minimum manifold diameter can be determined from a chart and is based on the lateral flow rate, lateral spacing, and manifold length.

   Determine the network discharge rate. This value is used to size the pump or siphon. Take the lateral discharge rate and multiply it by the number of laterals, or take the perforation discharge rate and multiply it by the number of perforations.

9) Develop a system performance curve as a way to predict how the distribution system performs under various flow rates and heads. The flow rate is a function of the total head that the pump works against. As the head becomes larger, the flow rate decreases, but the flow rate determines the network pressure and thus the relative uniformity of discharge throughout the distribution network. The easiest way to select the correctly sized pump is to evaluate the system performance curve and the pump performance curve. Where the two curves cross is where the system operates relative to flow rate and head. The total dynamic head the pump must operate at is the sum of —

   a) System network head (1.3 x distal pressure with minimum 2.5 feet),

   b) Elevation difference, and

   c) Friction loss in the pipe network.

Table X-2. Orifice Discharge Rates in Gallons Per Minute (gpm)

Pressure head (Feet)	**Orifice Diameter (in)**				
	1/8	**3/16**	**1/4**	**5/16**	**3/8**
2.5	0.29	0.66	1.17	1.82	2.62
3.0	0.32	0.72	1.28	1.99	2.87
3.5	0.34	0.78	1.38	2.15	3.10
4.0	0.37	0.83	1.47	2.30	3.32
4.5	0.39	0.88	1.56	2.44	3.52
5.0	0.41	0.93	1.65	2.57	3.71
5.5	0.43	0.97	1.73	2.70	3.89
6.0	0.45	1.02	1.80	2.82	4.06
6.5	0.47	1.06	1.88	2.94	4.23
7.0	0.49	1.10	1.95	3.05	4.39
7.5	0.50	1.14	2.02	3.15	4.54
8.0	0.52	1.17	2.08	3.26	4.83
8.5	0.54	1.21	2.15	3.36	4.97
9.0	0.55	1.24	2.21	3.45	4.97
9.5	0.57	1.28	2.27	3.55	5.11
10.0	0.58	1.31	2.33	3.64	5.24

Sizing the Pump or Siphon

The effluent pumps used for pressurizing the distribution networks are either centrifugal effluent pumps or turbine effluent pumps. The turbine effluent pump, which is a slightly modified well pump, is relatively new to the on-site domestic wastewater industry. In comparison, the centrifugal pump is a higher capacity/lower head pump with a relatively flat performance curve. The turbine pump is a lower-capacity/higher-head pump with a relatively steep performance curve. Turbine pumps probably have a longer life and may be the preferred choice for timed dosing because of their longevity relative to stop/starts.

Using pump performance curves, select the pump that best matches the required flow rate at the operating head. Plot the pump performance curve on the system curve. Then determine if the pump will produce the flow rate at the required head. Do not undersize the pump.

Care must be taken in sizing siphons. The head the network operates against has to be developed in the force main by backing up effluent in the pipe. If the discharge rate out of the perforations is greater than the siphon flow rate, the distal pressure in the network will not be sufficient. Some manufacturers recommend the force main be one size larger than the siphon diameter to allow the air in the force main to escape. However, this will reduce the distal pressure in the network, and it may drop below the design distal pressure.

1) Determine the dose volume required. The lateral pipe volume determines the minimum dose volume. The recommended dose volume has been 5-10 times the lateral volume. It has also been recommended the system be dosed four times daily, based on the design flow. Residents do not always use the design flow and so some mounds are only dosed once a day. When timed dosing is used, effluent is applied a number of times per day, with smaller doses. However, sufficient volume needs to be applied to distribute the effluent uniformly across the network. Thus, net dose volume is five times the lateral pipe volume.

2) Size the dose chamber. The dose chamber must be large enough to provide the following:

    - Dead space resulting from positioning the pump above the tank bottom
    - Dose volume
    - A few inches of head space for the alarm-warning float
    - Reserve capacity based on 100 gallons per bedroom (recommended)

    If timed dosing is selected, the pump chamber or septic tank/pump chamber must have sufficient surge capacity. If a turbine pump is used and must be submerged, there may not be enough surge capacity provided by the reserve capacity because turbine pumps are relatively tall.

3) Select quality controls and alarms. Follow electrical code for electrical connections. Some may have to be made outside the dose tank. There are excellent user-friendly control panels for timed-dose systems.

DESIGN EXAMPLE

Design a pressure distribution network for a mound whose absorption area is 150 ft long by 4 feet wide. The force main is 125 feet long and the elevation difference is 9 ft from the lowest wastewater level in the dosing tank to the highest point in the main or manifold.

Distribution Network Design Steps

1) Configuration of the network. This is a narrow absorption unit on a sloping site, so use 1 or 2 lines with a center feed creating two laterals.

2) Determine the lateral length using a center feed, the lateral length is

   lateral length = (B / 2) - 1 ft where: B = absorption length

   = (150 / 2) – 1 ft (The 1 ft = the distance from the end of the lateral pipe to the end of the gravel bed.)

   = 74 ft

3) Determine the perforation spacing and size. Two examples, A and B, are included. Each perforation covers a maximum area of 6 ft^2. The absorption area is 4 ft wide.

   a) With one lateral down the center on each side of the center feed, orifice spacing = area per orifice / width of absorption area

      = 6 ft^2/ 4 ft = 1.5 ft.

   b) With two laterals down the center on each side of the center feed, spacing = (area/orifice x no. of laterals) / (absorption area width)

      = (6 ft^2 X 2) / (4 ft) = 3 ft.

      The designer may stagger orifice spacings with laterals 1.5 ft apart. Perforation size —Select from ⅛, $^3/_{16}$ or ¼ inch. Use $^3/_{16}$ inch as per earlier discussion.

4) Determine the lateral diameter.

   Use Figure X-13 ($^3/_{16}$ inch) with a perforation spacing of 2 ft. Using one lateral on each side of the center feed with lateral length of 74 ft and 2-ft orifice spacing requires a lateral pipe diameter of 2 in (see Figure X-13).

   For 2 laterals on each side of the center feed and lateral length of 74 ft, with a

   3.5 ft orifice spacing allows the lateral pipe diameters to be reduced to 1.5 in. (Figure X-13: length = 74/2=37; orifice spacing = 3.5/2=1.75)

5) Determine number of perforations per lateral.

Using 2 ft spacing in 74 ft yields —

Number of perforations = (pipe length/orifice spacing) + 1 = (74 / 2) + 1 = 38 perforations/lateral. For two laterals (one on each side), the total number of perforations = 76 Check - maximum of 6 ft^2 / perforation = 150 ft x 3 ft / 6 sq ft = 75, so ok.

6) Determine lateral discharge rate (LDR).

Using network pressure (distal) pressure of 3.5 ft typical of the $^3/_{16}$" diameter perforations, table X-2 gives a discharge rate of 0.78 gpm.

LDR = 0.78 gpm/ perforation x 38 perforations = 29.6 gpm

7) Determine the number of laterals.

This was determined in Steps 3 and 4. Use one lateral on each side of center feed so two laterals are required. (If two laterals were used on each side of the center feed, they would be spaced 1.5 ft apart.)

8) Calculate the manifold size.

Since there is only one lateral per each side of center feed, there is no manifold. (Had two laterals been used, the manifold could be the same size as the force main as it is an extension of the force main.)

9) Determine the network discharge rate (NDR).

NDR = Number of laterals x lateral discharge rate (LDR)

= 2 laterals x 29.6 gpm

= 59.2 or 60 gpm

Pump has to discharge a minimum of 60 gpm against a total dynamic head yet to be determined.

10) Total dynamic head is the sum of the following:

System head = 1.3 x distal head (ft)

= 1.3 x 3.5 ft

= 4.5 ft

Elevation head = 9.0 ft

Friction Loss = Table X-1 for 60 gpm and 125 linear feet

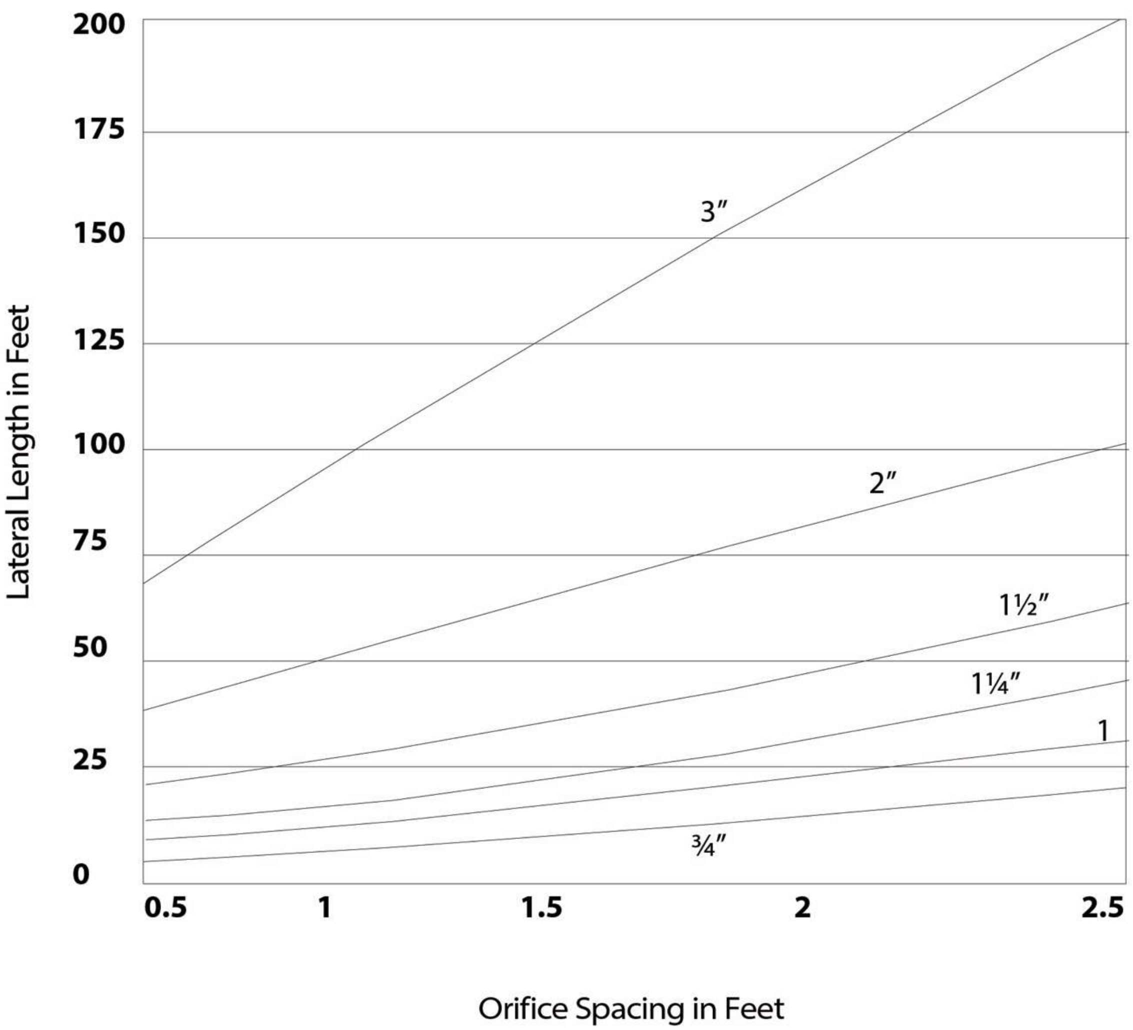
= 5.6 x 1.25 = 7 ft for 2" diameter. (Use 3" diameter (0.80 x 1.25 = 1) unless pump can't handle)

Total Dynamic Head = System network head + Elevation difference + Friction loss

4.5 + 9 + 1.21 = 14.7 ft (3” force main) or 4.5 + 9 + 8.75 = 22.3 ft (2” force main)

Pump must discharge 60 gpm against a head of 14.7 ft with 3” force main. These are the calculated flow and head values. The actual flow and head will be determined by the pump selected. A system performance curve plotted against the pump-performance curve will give a better estimate of the flow rate and total dynamic head the system will operate under. The next section gives an example.

Figure X-13. Graph of Lateral Length, Orifice Spacing, and Pipe Size for 3/16-inch Orifices.



Force Main, Pressurization Unit, Dose Tank, and Controls Design Steps

1) Calculate the system performance curve. Use Table X-4 to develop a system performance curve. Follow the procedures:

   a) Select five flow rates with 2 points above and below the network discharge rate of 60 gpm.

   b) Calculate the orifice (perforation) flow rate for each of the flows. This is done by dividing the flow rate by the number of orifices in the network. For the 30 gpm and 76 orifices, the orifice flow rate is 0.395 gpm.

   c) The elevation head is the height the effluent is lifted.

Table X-3. Heads and Calculations for Various Operating Flows and Pressures

Total Flow, gpm	Orifice Flow, gpm	Operating Head, ft	Elevation Difference, ft	Force Main Loss, ft	Total Head, ft
30	0.395	1.18	9	0.33	10.51
40	0.526	2.09	9	0.46	11.55
50	0.658	3.27	9	0.86	13.13
60	0.789	4.71	9	1.21	14.92
70	0.921	6.42	9	1.61	17.03
80	1.053	8.39	9	2.07	19.46

   d) The force main head is the head loss in the force main for the given flow rate. Select a force main diameter. For this example, use a 3-inch force main. The first three flow rates are not on the chart (Table X-1) and heads were calculated. Normally, the system is not operated in this range because velocities are less than 2 ft/sec. For the 60 gpm, the friction loss is (0.8 ft) x 1.25 (125 linear feet) = 1 ft. of head.

   e) The network head is calculated by $H = 1.3 \times (Q/(11.79 \times d^2))^2$. H is head in ft, Q is orifice flow rate in gpm, and d is orifice diameter in inches. The 1.3 is an adjustment factor for friction loss in laterals. For a $^3/_{16}$-inch diameter orifice, the equation is $H = 1.3 \times (Q/0.4145)^2$.

   f) The total head is the sum of the elevation, force main, and network heads.

2) Determine the force main diameter.

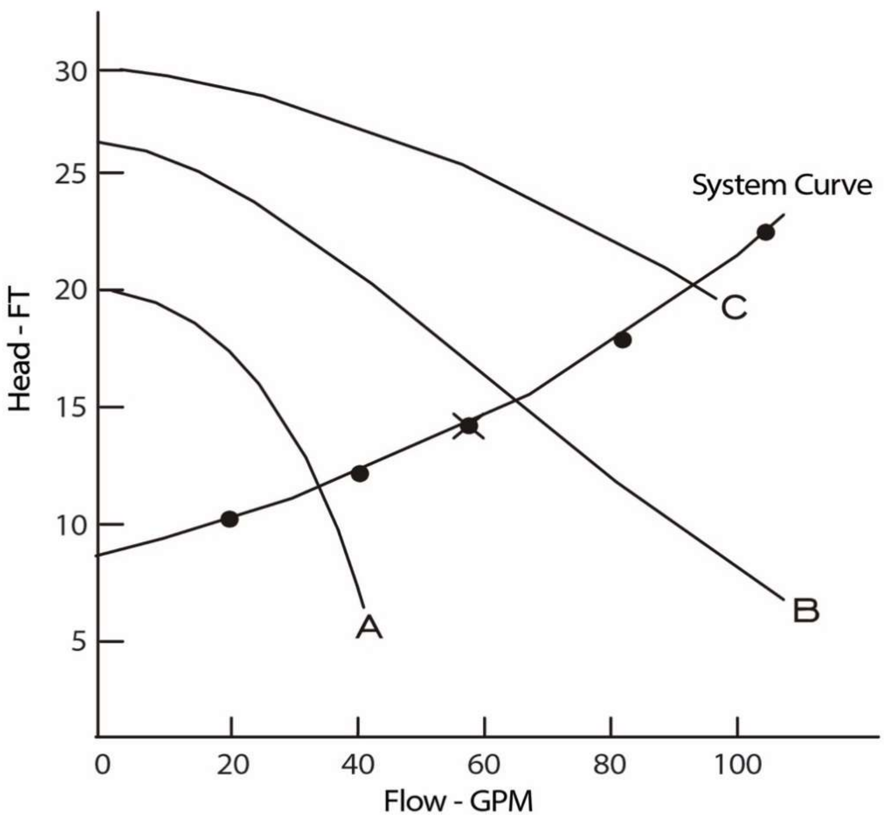
   Force main diameter = 3” (determined in Step 10 of Distribution Network Design).

3) Select the pressurization unit.

Plot the performance curves of several effluent pumps and the system performance curve. For the system curve, plot the flow rates versus the total head. On the system curve, Figure X-14, place an X on the curve at the desired flow rate (in this case 60 gpm).

Select the pump, represented by the pump performance curve, located next along the system performance curve just after 60 gpm (Pump B), as that is where the pump will operate. Pump C could be used but it is over sized for the conditions.

Figure X-14. Plotted System Operating Curve and Pump Curves to Select Pump



4) Determine the dose volume.

More recent thinking is that the dose volume should be reduced from the larger doses recommended in the past. Use five times the total pipe void volume. Calculate void volume from the length of pipe and the volume per foot from Table X-5 for the pipe sizes.

Lateral diameter = 2” | Force main diameter = 3”

Lateral length = 74 ft | Force main length = 125 ft

Void volume = 0.163 gal/ft | Void volume = 0.367 gal/ft

Net dose volume = 5 x 74 ft x 0.163 gal/ft = 60 gallons per dose

Flow back from the force main = 125 ft x 0.367 gal/ft = 46 gallons.

Set the floats so that a total of 106 gallons will be dosed, with 46 gallons flowing back into the pump chamber to drain the pipe when the pump stops.

5) Size the dose chamber.

   Based on the dose volume, storage volume, and room for a block beneath the pump and control space, a 500- to 750-gallon chamber will suffice. If timed dosing is implemented, then a larger tank will be required to provide surge storage. Use $^3/_{16}$ daily design flow for reserve capacity.

6) Select controls and alarm from products available from suppliers

Table X-4. Void Volume for Various Diameters of Schedule-40 Pipe

Normal Pipe Size (inches)	Void Volume (gal/ft)
3/4	0.023
1	0.041
1-1/4	0.064
1-1/2	0.092
2	0.163
3	0.367
4	0.650
6	1.469

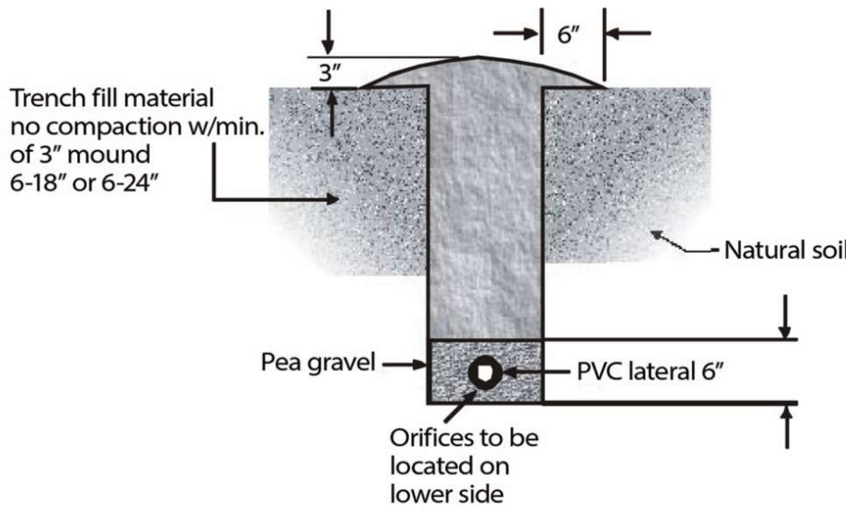
LOW-PRESSURE PIPE SYSTEM

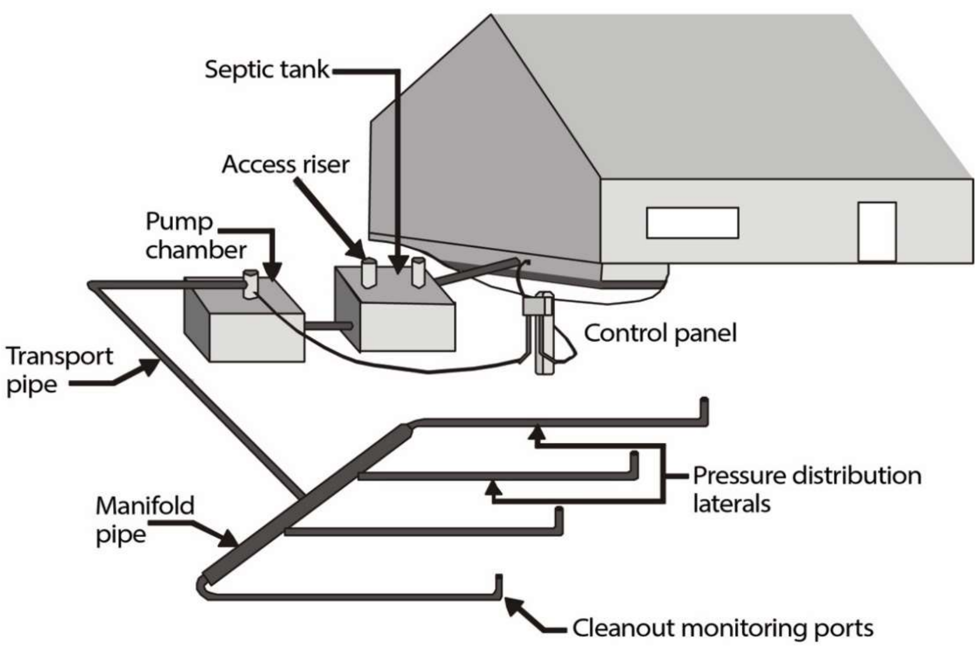
Wastewater distribution in lateral fields by gravity depends on careful elevation control. Some sites may have severe limiting factors that must be addressed by using a system such as the low-pressure pipe system. Common applications for low-pressure pipe systems include small lot sizes, shallow soils, soils with a slow permeability rate, or steep slopes. The low-pressure pipe system can overcome these limitations by providing uniform flow distribution, alternating dosing and resting cycles, and shallow trenches. The effluent is distributed into the absorption field with a low-pressure pump system which can distribute the flow more evenly over the soil infiltrative surface. The low-pressure pipe system functions to dose the soil with wastewater, then allow a resting period, and then dose the soil again, repeating this process throughout the day on a timed basis. Dosing helps maintain aerobic conditions in the soil, which improves treatment of the wastewater and maintains soil permeability. The shallow placement of the trenches increases the vertical distance between the trench and any restrictive layer. In addition, the shallow depth keeps the wastewater effluent in the active soil layers where microbiological and plant activity is maximized. A typical application for a low-pressure pipe system is shown in Figure X-15 with a detail of the trench cross-section.

Components

The low-pressure pipe system includes pretreatment with a septic tank or alternative system, septic tank effluent filter, pump tank (including controls and pump), transport line to connect the pump to the absorption field manifold, and small-diameter lateral pipes. The pretreatment system must include an effluent filter to prevent clogging of the small-diameter pipe and small holes used to distribute the flow in the absorption field. The effluent filter must be cleaned every three months to assure the system remains operational. A low-pressure pipe system is dependent upon the operation of several mechanical devices, including the pump, and must be supplied with a reliable power source. The system configuration is shown in Figure X-15. The system should have a visual and audible alarm to notify the homeowner if the system is malfunctioning.

Figure X-15. Typical Pump Tank, Controls, and Pipe Network Components





The laterals are usually 1- to 2-inch diameter, Schedule-40 PVC with $^{3}/_{16}$-inch holes drilled at specified intervals. The wastewater effluent travels in the transport line to the manifold, which is used to feed into the laterals. The best configuration for the system is shown in Figure X-15, which shows the pump tank located at the lowest elevation in the system. This configuration will allow the transport pipe and the manifold to drain back into the pump tank during the rest cycle. Using this configuration, the discharge line from the pump should have a small weep hole that empties into the pump tank to allow the lines to drain back into the pump tank. With this configuration, a check valve is not needed on the transport line; however, the supply manifold should have a ball valve between the manifold and the lateral located 6 inches above the lateral line, as illustrated in Figure X-16. The 6-inch elevation and holes drilled below the 12 o'clock position will help the laterals drain out into the drainfield and will prevent them from draining back into the pump tank. This configuration is commonly used on steep slopes when freezing conditions may develop if the lines are not self-draining. The ball valve is used to adjust the flow so that all lines operate at the same head pressure, which is needed to keep an even flow distribution. Other configurations that use a check-valve with a header manifold pipe or a tee-to-tee connection will trap the wastewater in the lateral lines, which may create a problem during freezing conditions.

The ends of the laterals opposite the supply end should be turned up and equipped with a cleanout as shown in Figure X-17. The cleanouts should have a threaded or removable cap to allow for flushing the lateral lines and to monitor the head pressure in the laterals. The yard box covering the cleanout should be at least 6 inches in diameter and must be readily accessible for maintenance. If the orifices are placed in the 12 o'clock position, then orifice shields must be used to distribute the flow and keep small particles out of the orifice.

The design and construction of a low-pressure pipe system includes determining the orifice size and spacing, dosing volume and lateral pipe size, and sizing the pump. All of these factors must be incorporated into the design and included in the calculations of the friction loss in the pipe, drain-back volume, dosing cycles, and operating pressure for the system. A sample calculation for a low-pressure pipe system is included to demonstrate how the tables shown are used to determine the various system components.

Performance Testing

Since the low-pressure pipe system is dependent upon equal-flow distribution, the system should be tested prior to covering the trenches to be sure it is properly functioning. The most common way to test the system is the squirt test. The difference in orifice discharge rate must not exceed 10% within in one lateral and may not exceed 15% over the whole system. Once the pressure is adjusted so that the minimum residual pressure is equal in all the lines, then the system should be tested to insure the actual volume of discharge does not vary more than 15%. This is especially important in systems on a steep slope designed to drain back between dosing cycles. In this type of system, the lower elevation lateral will pressurize first and receive effluent for a longer period of time. In addition, the lower lateral may receive additional flow from the manifold or from the upper laterals.

The system should also be tested to determine pump drawdown, pump run time, timer function, and squirt height or residual head. The pump drawdown is calculated by determining the number of inches the liquid level drops in the pump tank during one cycle. From this information and the dimensions of the tank, total volume pumped during each cycle can be determined and recorded. The pump run time should be determined with a stopwatch, also be used to measure the time interval between pump cycles.

This data should be recorded at the time the system is placed into service and should be kept available at the site to aid in long-term monitoring and maintenance. The last test of the system is to determine the squirt height or residual head. The minimum residual head should be between 2-5 feet. The easiest method for measuring the residual head is to attach a clear pipe onto the end of the lateral and measure the static head, which is the vertical distance between the lateral and the top of the liquid standing in the clear pipe.

Figure X-16. Supply Manifold and Connection to Low-Pressure Lateral

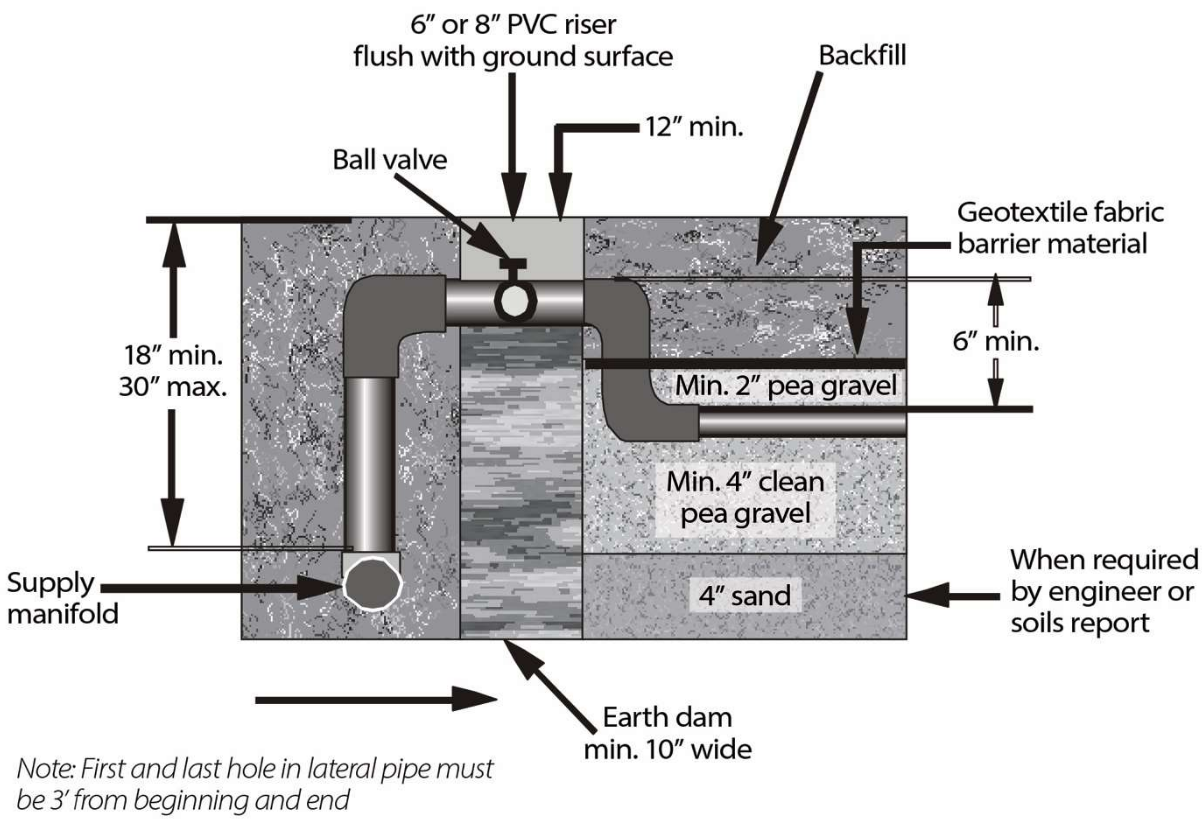
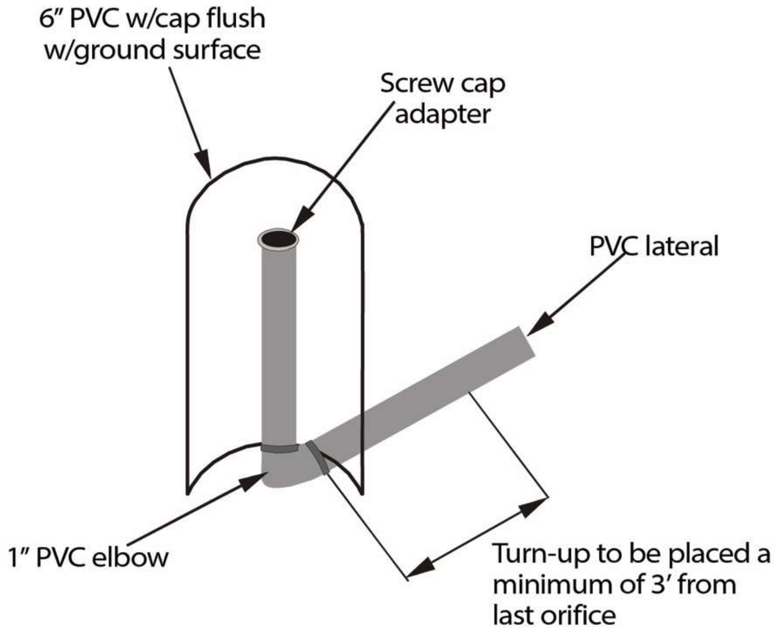


Figure X-17. Detail of Turn-Up and Cleanout for Low-Pressure Distribution for Sand Filter, Mound, or Low-Pressure Pipe Lateral



Maintenance

As discussed earlier, these systems will require maintenance. The equipment must be checked on a regular schedule to be sure screens in the tank or around the pump intake and the effluent filter are not clogged. In addition, the lateral lines should be flushed to dislodge any solids and remove the biological slime that develops in the pipes. The laterals should be tested for residual pressure and for equal flow. The pump run time and number of cycles should be checked against the original design of the system. The pump drawdown volume should also be checked periodically and may need to be adjusted with the timer in the control box. Additional items to be checked in the septic tank or pump tank include checking for sludge accumulation, checking the operation of floats, checking for signs of leaking in tank or the risers, and checking the operation of alarms present in the system.

Low-Pressure Pipe Design Example

Single-Family Residence: Design Flow = 360 gallons per day, (gpd); tables used in this section are from the EPA Design Manual for Onsite Wastewater Treatment and Disposal.

***Septic Tank*:**

a) Two-compartment septic tank with a minimum liquid volume of 1,000 gallons and equipped with an effluent filter having a maximum particle size of ⅛ inch.

b) Dosing tank with minimum of 500-gallon volume above pump intake.

***Absorption Field*:**

a) Elevation head = 15 ft from tank to highest line

b) Application rate = 0.2 gpd/ft^2

c) Minimum area = 360 gpd / 0.2 gpd/ft^2 = 1800 ft^2

d) Pipe 1-inch lines, 5 ft on center with $^3/_{16}$-inch holes drilled 6 ft on center

***Dosing Rate*:**

a) Based on $^3/_{16}$-inch holes at 4 ft of head

b) Number of holes per line = 60ft (length) - 2 holes (3 ft from each end)

Spacing - 6 ft on center

= 10 holes per line

c) For 6 lines = 60 holes total

d) Lateral lines are 1-inch, Schedule-40 PVC

e) Flow rate per hole (according to Table X-6) = 0.83 gpm/hole

4 ft head = 1.73 psi

2.31 psi/ft head

f) Total dose rate = (0.83 gpm/hole x 60 holes) + 0.83 gpm for air-vent hole

= 50.6 gpm

g) Elevation head = 5 ft (out of tank) + 15 ft (to top of absorption field)

= 20 ft

***Fitting Adjustment*:**

a) Supply line (from pump to last lateral) = 35 ft length, for a 2-inch diameter manifold at 50 gpm. See Table X-1 to find the friction loss per 100 ft of the supply line.

b) Friction head = 35 ft (supply line length) x 3.98 ft head x 1.25 fitting adj.

100 ft

= 1.68 ft head

c) Total head = 20 ft (elevation head) + 1.68 ft (friction head) + 4 ft (pressure head)

= 25.68 ft

***Dosing Volume*:**

a) 2-4 doses per day based upon use

b) Volume in lateral lines = 4.1 gal/100 ft of 1-inch pipe (Table X-5) x 360 ft of lateral pipe

   = 14.76 gallons

c) Volume in supply line = 16.2 gal/100 ft of 2-inch pipe x 35-ft supply line

   = 5.67 gallons

d) Total volume in system = (volume of laterals) 14.76 gal + (volume of supply line) 5.67 gal

   = 20.43 gallons

e) Volume of void space in trench = (cross sectional area) (0.5 ft x 0.5 ft) x 360 ft (length) x 7.5 gal/ft^3 (conversion factor)

   = 90 ft^3 x 7.5 gal/ft^3

   = 675 gal

   Trench should have approximately 30% void space

   = 675 gal x 30% = 203 gal

As long as the void space in the trench is smaller than the gallons per dose, the system will function.

Based upon these calculations, the pump must be sized to supply 50.6 gpm at 26 ft TDH (Total Dynamic Head).

Table X-5. Orifice Flow Rate in Gallons Per Minute (gpm) for Different Sizes and Operating Pressure Head

Pressure, psi	Head, ft	5/32 inch	3/16 inch	7/32 inch	1/4 inch
0.43	1.0	0.29	0.42	0.56	0.74
	1.5	0.35			
0.87	2.0	0.41	0.59	0.80	1.04
	2.5	0.45			
1.30	3.0	0.50	0.72	0.98	1.28
	3.5	0.54			
1.73	4.0	0.58	0.83	1.13	1.48
	4.5	0.61			
2.16	5.0	0.64	0.94	1.26	1.65
	5.5	0.66			
2.58	6.0	0.69	1.04	1.37	1.81

SUMMARY

Pumping stations may be required to overcome site obstacles. When pumping stations are needed, they must be carefully selected and designed to create a good working system. The pumping stations must be watertight and not subject to corrosion. Selection of the right pump based on pump type and pump characteristics can be time consuming but is critical to proper operation of the system. Pumping stations must be accessible to allow for service and maintenance on the pumps.

REFERENCES AND READING MATERIAL

Iowa DNR. *Onsite Sewage Design and Reference Manual, Section E: Pressure Distribution and Pumping Systems*, Iowa Department of Natural Resources, 2003. http://home.eng.iastate.edu/~tge/CCEE/Iowa%20On-Site%20WW%20manual.pdf

Jones, D.D., J.E. Yahner, and E.R. Miller. *Steps in Constructing a Mound (Bed-Type) Septic System*, ID-163, Purdue University, Cooperative Extension Service, April 1990. https://www.extension.purdue.edu/extmedia/ID/ID-163.html

Kang, Y.W. K. Mancl and R. Gustafson. *Pressure Distribution of Wastewater Design and Construction in Ohio*, Bulletin 829, The Ohio State University, Cooperative Extension https://extensionpubs.osu.edu/mound-system-pressure-distribution-of-wastewater/

Miller, E.R. D.D.Jones, and J.E. Yahner, *Steps in Constructing a Pressure Distribution Septic System*, ID-164, Purdue University, Cooperative Extension Service, January 1985. https://www.extension.purdue.edu/extmedia/ID/ID-164/ID-164-W.html

Missouri Extension. *Reducing the Risk of Groundwater Contamination by Improving Household Wastewater Treatment*, WQ680, University of Missouri, Farmstead Assessment System Fact Sheet #6, June 2017. https://extensiondata.missouri.edu/pub/pdf/envqual/eq0680.pdf

Mote, C.R. *Pressurized Distribution for On-Site Domestic Wastewater-Renovation Systems*, Bulletin 870, University of Arkansas, Agricultural Experiment Station, April 1984.

Sievers, D.M. *Design and Construction of On-Site Systems*, Special Report 477, University of Missouri, Department of Agricultural Engineering, Spring 1995.

Solomon, Clement, Peter Casey, Colleen Mackne, and Andrew Lake. *Low-Pressure Pipe Systems*, WWFSOM29, National Small Flows Clearinghouse. http://www.nesc.wvu.edu/pdf/WW/publications/eti/LPP_tech.pdf

US EPA. *Decentralized Systems Technology Fact Sheet: Low Pressure Pipe Systems*, EPA 832-F-99-076, EPA, Office of Water, September 1999. https://www.epa.gov/sites/production/files/2016-10/documents/decentralized_systems_technology_fact_sheet_low_pressure_pipe_systems.pdf

Washington. *Recommended Standards and Guidance for Performance, Application, Design, and Operation & Maintenance: Pressure Distribution Systems*, WA DOH Publication #337-022, Department of Health, Division of Environmental Health, Office of Shellfish and Water Protection, July 2012. **Error! Hyperlink reference not valid.**https://www.doh.wa.gov/Portals/1/Documents/Pubs/337-009.pdf

Wisconsin, DOC. *Pressure Distribution Component Manual for Private Onsite Wastewater Treatment Systems*, SBD-10706-P (N 01/01), Department of Commerce, Division of Safety and Buildings, January 2001.

WSU. *Properly Managing Your Pressure Distribution System*, EB1673, Washington State University, Cooperative Extension, June 1992. https://research.wsulibs.wsu.edu/xmlui/bitstream/handle/2376/6774/eb1673.pdf

Chapter XI
SEPTAGE MANAGEMENT

TABLES

INTRODUCTION

The information in this domestic septage guidance is provided to help the handlers, recyclers, and disposers of septage understand and follow a Federal rule called "Standards for the Use or Disposal of Sewage Sludge", which are commonly called 503 rules. In addition, portions of this chapter are important to owners of land where septage is applied.

Outlined in this chapter are the requirements for persons who apply domestic septage to non-public contact sites (sites not frequently visited by the public).

To meet federal requirements for application of domestic septage to non-public contact sites, the land applier must first assure he/she has only domestic septage according to the 503 rules. Domestic septage is described in the Federal Part 503 Regulation as the liquid or solid material removed from a septic tank, cesspool, portable toilet, type II marine sanitation device, or a similar system that receives only household, non-commercial, non-industrial sewage. Domestic septage may be applied only to sites not frequently visited by the public, called non-public contact sites in the Federal rule. Non-public contact sites include agricultural land, forests, and reclamation sites. The land applier must manage the domestic septage so that pathogens (disease-causing organisms) are reduced. The land applier must manage the domestic septage so that its attractiveness to vectors is reduced. Vectors are insects and rodents that can carry pathogens in or on their bodies and therefore transmit disease. The owner of the land where domestic septage has been applied must adhere to crop-harvesting, animal-grazing, and site-access restrictions. The land applier must certify that pathogen- and vector-attraction reduction requirements have been met, including crop-harvesting, animal-grazing, and site-access restrictions. The number of gallons of domestic septage applied per acre of land may not be more than needed to supply the nitrogen required by the crop being grown.

The person who applies domestic septage has choices about how to meet the pathogen- and vector-attraction-reduction requirements.

SEPTAGE MANAGEMENT

Goal: Septage must be treated and disposed of in a manner that reduces the potential for contamination and human disease caused by contaminants in the septage.

What Is Domestic Sewage?

Domestic Sewage is the liquid and solid material pumped from septic tanks or other devices during cleaning. It does not include commercial or industrial septage or grease-trap wastes.

Characteristics

1) About 40 to 50 percent of the solids found in domestic wastewater are retained in the septic tank.

2) There is approximately nine times more nitrogen and phosphorus in septage than in domestic wastewater.

3) Large numbers of disease-causing microorganisms including bacteria, viruses, and pathogenic human parasites are present in septage.

Septage Disposal Options

1) **Disposal at a municipal wastewater plant** is preferred and highly recommended for the following reasons:

   a) EPA 503 defined requirements for the septage hauler for a specific load ends once the septage is properly discharged and accepted by the municipal plant. The municipal plant then assumes responsibility for the septage.

   b) Best option to insure pathogens are destroyed as well as providing significantly better protection of surface and groundwater from excessive loading of nutrients and other contaminants.

   c) Significantly reduces paperwork requirements for the septage hauler.

   Recommendations: Septage hauler should contact municipal wastewater plant(s) in his or her service area to determine if they accept domestic septage and to acquire knowledge of the various dumping requirements and fees set forth by that plant.

   Kansas Department of Health and Environment recommends that septage not be disposed of at a public or private wastewater treatment lagoon or sludge lagoon.

2) Land application is the spraying or spreading of domestic septage onto the land surface or the incorporation or injection of domestic septage into the soil so that the sewage sludge can condition the soil and fertilize the vegetation grown in that soil.

   To legally land apply septage the following requirements must be met and documented:

   a) Determine the annual application rate for nitrogen for the planned crop. This amount shall be calculated and the nitrogen amount provided by septage shall not exceed that crop requirement.

   b) Provisions implemented for pathogen reduction.

   c) Provisions implemented for vector-attraction reduction.

   d) Records for all EPA 503 land application requirements shall be retained by the applier for at least five years.

LAND APPLICATION: STEP-BY-STEP INSTRUCTIONS ON HOW TO COMPLY

Determine the Allowed Annual Rate for Land Application

1) The maximum volume of domestic septage that may be applied to any site depends on the pounds of nitrogen required per acre by the planned crop for a specific projected yield.

   a) This information is listed for all Kansas-grown crops in KSU Bulletin MF-2586, *SOIL TEST INTERPRETATIONS AND FERTILIZER RECOMMENDATIONS*.

b) Secure this bulletin from your county extension office. The agent will gladly assist you in using it. Some information from page 4 of the bulletin is presented Table XI-1

Table XI-1. Nitrogen Recommendations

Crop	Area of State	Medium and Fine Textured Soils (Fallowed)	Medium and Fine Textured Soils (Continuous Cropped)	Coarse Textured (Sandy) Soils	Irrigated
		----------Nitrogen Application Per Acre, Pounds----------			
Corn, Wheat	Entire		100-200	100-200	160-220
	Eastern		40-70	40-70	50-80
	Central	20-40	30-60	40-60	50-80
	Western	0-40		25-50	50-80

The maximum volume of septage is calculated by the following formula:

Annual Application Rate (gallons/acre/year) = Annual Pounds of Nitrogen Required for the Crop and Yield ÷ (divided by) 0.0026 (conversion factor)

Example: If 74 pounds of nitrogen per acre is required to grow a 60 bushel per acre crop of wheat, then the annual application rate of domestic septage would be 28,461 gallons per acre.

Annual Application Rate = 74 ÷ 0.0026 = 28,461 gallons/acre/year

The primary reason for this annual-rate calculation is to prevent the application of nitrogen in excess of crop needs and its potential movement through soil to groundwater, resulting in nitrate contamination of groundwater.

Pathogen-Reduction/Crop- and Site-Restriction Requirements

Domestic septage must be managed so that pathogens are appropriately reduced. The Part 503 Regulation offers two alternatives that will meet this requirement. The first alternative, (no treatment) and its restrictions are presented in Table XI-2; requirements of the second option (pH 12 for a minimum of 30 minutes, i.e., mixing 50 pounds of hydrated lime/1,000 gallons of septage) are listed in Table XI-3.

Please note that both of the pathogen-reduction alternatives impose crop harvesting restrictions. However, site-access controls are only required when the soil incorporation alternative for pathogen reduction has been used. Remember that the owner/operator of the land where the domestic septage has been applied is required to be informed about the crop-harvesting and site access restriction requirements. This notification is required because the applier of the domestic septage must certify that these conditions are met.

NOTE: Part 503 Regulations ***do not*** restrict access to the site by the persons working the land. These regulations assume these persons, as well as the applier, are aware of appropriate practices to limit exposure and to minimize risk of infectious disease, and will follow 503 Regulations to minimize any problems with domestic septage.

Table XI-2. Pathogen-Reduction Alternative One for Domestic Septage Applies to Non-Public Contact Sites

Domestic septage is pumped from the septic tank or holding tank and land applied without treatment, i.e., septage is injected **OR** spread on soil and incorporated within six hours.	
Crop Restrictions:	A. Food crops with harvested parts that touch the septage/soil mixture and are totally above ground shall not be harvested for 14 months after application of domestic septage. Examples — melons and strawberries. B. Food crops with harvested parts below the surface of the land shall not be harvested for 38 months after application of domestic septage. Examples — potatoes, onions, and radishes. C. Animal feed, fiber, and those food crops that do not touch the soil surface shall not be harvested for 30 days after application of the domestic septage. Examples — wheat, corn, peaches, cotton, and hay. D. Turf grown on land where domestic septage is applied shall not be harvested for one year after application of the domestic septage when the harvested turf is placed on either a lawn or land with a high potential for public exposure, unless otherwise specified by the permitting authority.
Grazing Restriction:	A. Animals shall not be allowed to graze on the land for 30 days after application of domestic septage.
Site Access Restrictions:	A. Public access to land with a low potential for public exposure shall be restricted for 30 days after application of domestic septage. Examples of restricted access include remoteness, posting with no trespassing signs, and/or simple (3½- to 4-foot-tall agricultural type) fencing

Table XI-3. Pathogen Reduction Alternative Two, for Domestic Septage with pH Treatment Applied to Non-Public Contact Sites

The domestic septage pumped from the septic tank or holding tank has had its pH raised to 12 or higher by the addition of alkali such as hydrated lime and, without adding more alkali, it will remain at a pH of 12 or higher for at least 30 minutes prior to being land applied. To accomplish this goal, 50 lbs of hydrated lime shall be mixed and thoroughly agitated in each 1,000 gallons of septage.	
Crop Restrictions:	A. Food crops with harvested parts that touch the septage/soil mixture and are totally above ground shall not be harvested for 14 months after application of domestic septage. Examples — melons and strawberries. B. Food crops with harvested parts below the surface of the land shall not be harvested for 20 months after application of domestic septage when the domestic septage remains on the land surface for four months or longer prior to incorporation into the soil. Examples — potatoes, onions, and radishes. C. Food crops with harvested parts below the surface of the land shall not be harvested for 38 months after application of domestic septage when the domestic septage remains on the land surface for four months or longer prior to incorporation into the soil. Examples — potatoes, onions, and radishes. D. Animal feed, fiber, and those food crops whose harvested parts do not touch the soil surface shall not be harvested for 30 days after application of the domestic septage. Examples — wheat, corn, peaches, cotton, and hay. E. Turf grown on land where domestic septage is applied shall not be harvested for one year after application of the domestic septage when the harvested turf is placed on either a lawn or land with high potential for public exposure, unless otherwise specified by the permitting authority.
Grazing Restriction:	None
Site Access Restrictions:	None

Vector Reduction Alternatives

Choose one of the following methods for reducing vector attraction:

1. Inject septage immediately below the soil surface.

   OR

2. Apply septage to the land surface, and incorporate it into the soil surface plow layer within six hours.

   OR

3. Raise the pH of the septage to 12 or above, and hold at or above 12 for 30 minutes. The suggested procedure is to use a 50-pound bag of hydrated lime per 1,000 gallons of septage (see procedure below).

Procedure for Raising pH with Hydrated Lime

1) Agitate septic tank contents with truck vacuum hose.

2) Withdraw 200-400 gallons of septage from septic tank.

3) Add 50 pounds of hydrated lime to the septage through the vacuum hose. The dry lime (available at hardware stores and lumber yards) can be emptied into five-gallon buckets or can be vacuumed directly from the original paper bag.

4) The balance of the 1,000 gallons of septage should then be vacuumed into the truck.

5) Agitate septage/lime mixture for 15 minutes by frequent opening and closing of the main hose vacuum valve. The air bubbling through the mixture as well as the sloshing of the material inside the truck tank during transport to the field disposal site will accomplish adequate mixing.

6) Thirty minutes after the lime was mixed with the contents, the mixture can be surface-spread onto the soil.

7) This example illustrates a 1,000-gallon mix. If you have a 500-gallon truck, use 25 pounds of lime. Similarly a 1,500-gallon tank will require 75 pounds of hydrated lime to do the job.

8) Follow all label safety instructions printed on the lime package, i.e., wear rubber boots, gloves, and eye protection.

Certification of Application Site

1) The applicator must complete and sign for each application-site certification listed in Table XI-5 about meeting pathogen- and vector-attraction-reduction requirements.

EPA 503 RECORD KEEPING REQUIREMENTS

You must retain records for at least five years after any application of domestic septage to a site, but you *are not* required to report this information under the 503 Regulations. However, local authorities may require reporting certain information to them. These required records may be requested for review at any time by the permitting or enforcement authority. The retained records must include the information shown in Table XI-4 and a written certification (see Table XI-5). Forms 1 and 2 contains samples of forms which can be used to organize your record keeping. You are not required to use these forms, but they may be helpful.

Table XI-4. Record Keeping Requirements

1) The location of the site where domestic septage is applied: Provide the legal description, the street address if applicable, and the longitude and latitude coordinates of the site (available from U.S. Geological Survey maps, a GPS unit, or online services such as Google maps).
2) The number of acres to which domestic septage is applied at each site.
3) The date and time of each domestic septage application.
4) The nitrogen requirement for the crop or vegetation grown during the year on each site. Indicate the expected crop yield used to help establish the nitrogen requirement on the form.
5) The gallons of septage that were applied to the site during the specified annual (365-day) period.
6) The certification shown in Table XI-5.
7) A description of how the pathogen requirements are met for each load of domestic septage that is land applied
8) A description of how the vector-attraction-reduction requirement is met for each load of domestic septage that is land applied.

Table XI-5. Certification Statement To Be Incorporated into Record Forms

I certify, under penalty of law, that the pathogen-reduction requirement shown on this form for each site (*specify restrictions on harvesting and public access or pH treatment*) and the vector attraction reduction requirements shown on this form for each site (*specify injection, incorporation, or pH treatment*) have been met. This determination has been made under my direction and supervision in accordance with the system designed to assure that qualified personnel properly gather and evaluate the information used to determine that the pathogen requirements and vector-attraction-reduction requirements have been met. I am aware there are significant penalties for false certification including the possibility of fine and imprisonment. SIGNATURE____ PRINTED NAME _____________________________________ TITLE*____ *e.g., owner or employee of company or individual name

ADDITIONAL REQUIREMENTS FOR SEPTAGE LAND APPLICATION

1) Consult with county environmental health officials about local land application requirements and follow those requirements.

2) If county does not have more restrictive limits, the requirements noted below apply.

   a) Septage shall not be applied within 100 feet of a public or private water supply well.

   b) Septage shall not be applied within 50 feet of any surface water.

Definition of Terms

pH
a numerical measure of the acidity or alkalinity of a liquid (example - septage) or a solid substance such as soil.

2 ← 7 → 14

(very acid) neutral (very alkaline)

Pathogen Reduction
the number of disease-causing organisms commonly found in septage when that septage is land applied.

Vector Attraction Reduction
EPA 503 requires that the land applier manage domestic septage so that its attractiveness to vectors is reduced. Vectors are insects and rodents that carry pathogens in or on their bodies and, therefore, transmit disease.

Annual Application Rate
The maximum volume of domestic septage that may be applied to any site during a 365-day period. This is determined by the amount of nitrogen required by the planned crop and the targeted yield.

Forms 1 and 2

At the end of this chapter are two forms that may be helpful to septage pumpers and haulers for record keeping. The first of these forms (Form 1) has information about the business, the land to be used for application, and a sheet to record the annual plan by field. Here the user would describe the field name and location, crop to be grown, expected yield, and calculations of the amount of septage that can be applied per acre annually for each field. The second form (Form 2) is an example of a daily log that might be kept in the truck as domestic septage is pumped and land applied.

Following the blank forms are samples of both of these forms which have been filled in as an example of the type of information you might actually record.

REFERENCES AND READING MATERIALS

Chisam, Don. *Land Application of Septage: Domestic Septage*, Kansas Department of Health and Environment, Not dated but likely about 1995-1996.

Eberle, W.M., D.A. Whitney, and G.M. Powell. *Sewage Sludge Use on Agricultural Land*, MF- 1168, Kansas State University, Cooperative Extension Service, September 1994.

Mancl, Karen, Jay Johnson, and Michael Veenhuizen. *Septage Management in Ohio*, Bulletin 854, The Ohio State University, September 1995.

Morse, Ken. *Urban Septic Legends*, Environmental Health, December 1999.

Petrik, Bruce and Lyle Christensen. *Program Promotes Waste Minimization*, Water Environment & Technology, December 1994.

Solomon, Clement, Peter Casey, Colleen Mackne, and Andrew Lake. *Septate Management: A General Overview*, Fact Sheet WWFSGN109, National Small Flows Clearinghouse, 1998.

Solomon, Clement, Peter Casey, Colleen Mackne, and Andrew Lake. *Septate Management: A Technical Overview*, Fact Sheet WWFSOM31, National Small Flows Clearinghouse, 1998.

Starkis, Ken. Evaluating Land Application Effects: Results of Philadelphia sludge application program on corn and soybean fields, BioCycle, January 1987.

Ungvarsky, John and Karen Mancl. *Septage Use and Disposal*, Special Circular 317, The Pennsylvania State University, Extension Service, U.Ed. 85-1100 IVBIIC 3M885.

Ungvarsky, John and Karen Mancl. Septage Management in Pennsylvania, Special Circular 316, The Pennsylvania State University, Extension Service, U.Ed. IVBIIC 85-1101.

US EPA. *Domestic Septage Regulatory Guidance: A Guide to the EPA 503 Rule*, Office of Water, EPA 832-B-92-005, September 1993.

US EPA. *Guide to Septage Treatment and Disposal*, Office of Research and Development, EPA/625/R-94/002, September 1994.

Wooding, N.H. and R.F. Shipp. *Agricultural Use and Disposal of Septic Tank Sludge in Pennsylvania*, Special Circular 257, The Pennsylvania State University, Cooperative Extension Service, IVBIIc R5M579 U.Ed. 9-350.

EPA NPS SECTION 503 RECORD KEEPING FORM 1
LAND APPLICATION OF DOMESTIC SEPTAGE AT NON-PUBLIC CONTACT SITES

PART 1: BUSINESS AND LAND APPLICATION SITE INFORMATION

REPORT YEAR_______________ DATE_______________________________

SEPTAGE HAULER

NAME____

ADDRESS____

COUNTY LICENSE OR PERMIT NUMBER_____________________________________

LAND APPLICATION SITE

OWNER____

LOCATION____

(legal location, street address, and/or GPS coordinates)

SITE NUMBER OR NAME____

TOTAL ACRES AT SITE____

SITE OWNER'S SIGNATURE____

Note: All records must be maintained by the septage hauler for five (5) years

PART 2: ANNUAL APPLICATION RATE AND PUBLIC CONTACT INFORMATION

PUBLIC ACCESS CONTROL (check all that apply)

(1) Site remotely located _____

(2) Signs are posted _____

(3) Property is fenced _____

ANNUAL APPLICATION RATE (AAR)

$$AAR = \frac{\text{Nitrogen requirement of crop}}{0.0026}$$

	CROP	EXPECTED YIELD (bushels/acre)	NITROGEN REQUIREMENT (pounds N/year)	AAR (gal/acre/year)
CROP 1				
CROP 2				
CROP 3				

PLANTING/HARVESTING SCHEDULE

	PLANTING DATE	HARVEST DATE
CROP 1		
CROP 2		
CROP 3		

Note: All records must be maintained by the septage hauler for five (5) years.

EPA NPS SECTION 503 RECORD KEEPING FORM 1
LAND APPLICATION OF DOMESTIC SEPTAGE AT NON-PUBLIC CONTACT SITES

PART 1: BUSINESS AND LAND APPLICATION SITE INFORMATION

REPORT YEAR___2020___ DATE__________03/25/20__________

SEPTAGE HAULER

NAME_________________Joe's Septic Pumping Service_____________________

ADDRESS___________1591 E. Highway 21, Hays, KS 67601_____________________

COUNTY LICENSE OR PERMIT NUMBER_______#981_____

LAND APPLICATION SITE

OWNER____________Jones Farms____

LOCATION________SE/4 - 6 - Township 7 N - Range 3 West _____________________

(legal location, street address, and/or GPS coordinates)

SITE NUMBER OR NAME__Jones Farms____________________________________

TOTAL ACRES AT SITE____60____

SITE OWNER'S SIGNATURE____

Note: All records must be maintained by the septage hauler for five (5) years

PART 2: ANNUAL APPLICATION RATE AND PUBLIC CONTACT INFORMATION

PUBLIC ACCESS CONTROL (check all that apply)

(1) Site remotely located _x____

(2) Signs are posted ______

(3) Property is fenced ______

ANNUAL APPLICATION RATE (AAR) **AAR = $\frac{\text{Nitrogen requirement of crop}}{0.0026}$**

	CROP	EXPECTED YIELD (bushels/acre)	NITROGEN REQUIREMENT (pounds N/year)	AAR (gal/acre/year)
CROP 1	Fallow Wheat	60	60	23,077
CROP 2				
CROP 3				

PLANTING/HARVESTING SCHEDULE

	PLANTING DATE	HARVEST DATE
CROP 1	Estimated Oct 1, 2020	Estimated July 1, 2021
CROP 2		
CROP 3		

Note: All records must be maintained by the septage hauler for five (5)

EPA NPS SECTION 503 RECORD FORM 2 LAND APPLICATION OF DOMESTIC SEPTAGE AT NON-PUBLIC CONTACT SITES

LAND APPLICATION SITE:______________________ RECORD YEAR: ____________

NAME & ADDRESS WHERE SEPTAGE WAS PUMPED	DATE OF APPLIC. TO SITE	GALLONS APPLIED TO SITE	TOTAL GALS APPLIED Y.T.D.	WAS SEPTAGE INCORPORATED?#	WAS SEPTAGE INJECTED?	IF SEPTAGE WAS pH TREATED, INDICATE* *			
						Type	Amount	How mixed	pH 12 held for 30 min
				Yes No hours*	Yes No				Yes No
				Yes No hours*	Yes No				Yes No
				Yes No hours*	Yes No				Yes No
				Yes No hours*	Yes No				Yes No

* If septage was incorporated, how many hours after it was applied to the site?

** Type means what kind of alkaline material was used, e.g., lime.

Amount means how many pounds were added.

How mixed means how did you mix the alkaline material into the septage.

EPA NPS SECTION 503 RECORD FORM 2 LAND APPLICATION OF DOMESTIC SEPTAGE AT NON-PUBLIC CONTACT SITES COMPLETION EXAMPLE

LAND APPLICATION SITE:______________________________ RECORD YEAR:

NAME & ADDRESS WHERE SEPTAGE WAS PUMPED	DATE OF APPLIC. TO SITE	GALLONS APPLIED TO SITE	TOTAL GALS APPLIED Y.T.D.	WAS SEPTAGE INCORPORATED?#	WAS SEPTAGE INJECTED?	IF SEPTAGE WAS pH TREATED, INDICATE* *			
						Type	Amount	How mixed	pH 12 held for 30 min
Willis Brown 231 Wilson Hays, KS	3/25/20	1000	5000	Yes <u>No</u> hours*	Yes <u>No</u>	Hydrated lime	50 lbs	Agitated with vacuum valve	<u>Yes</u> No
				Yes No hours*	Yes No				Yes No
				Yes No hours*	Yes No				Yes No
				Yes No hours*	Yes No				Yes No