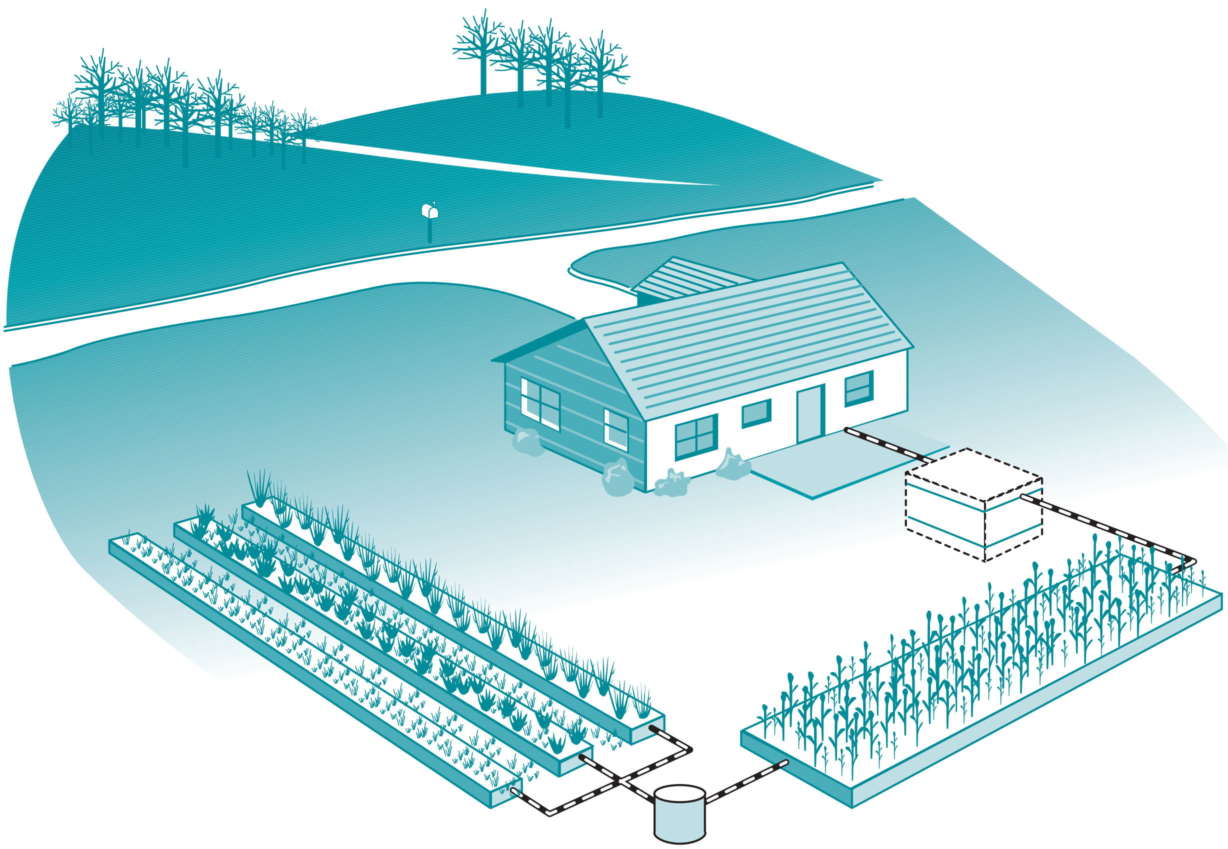
Kansas State University

Rock-Plant Filter Design and Construction for Home Wastewater Systems



Kansas State University Agricultural Experiment Station and Cooperative Extension Service

A rock-plant filter, also called constructed wetland, is a term applied to a system designed to accomplish specific treatment tasks for wastewater, mimicking natural wetlands. Natural wetlands are environments where plant roots are submerged in water or saturated soil all or most of the time. They have several unique and desirable properties. Natural wetlands allow flows to expand and contract while removing and assimilating nutrients and other contaminants. Wetlands are sometimes referred to as the purifier in the environment.

Rock-plant filters have been developed, researched and promoted to treat wastewater. These systems include areas, usually lined with impermeable materials, where wetland plants are grown in wastewater. Since about 1980, they have received attention as a viable method for treatment of both municipal and industrial wastewaters and for remediation of contaminated sites. Wastewater supplied to these wetlands has previously been treated by wastewater ponds, extended aeration, activated sludge, or some other method to stabilize the wastewater. The wetland provides added treatment to improve quality of the effluent by removing nutrients and reducing suspended solids.

Rock-Plant Filter Concept for Individual Homes

Rock-plant filters have been adapted for treatment of wastewater from individual home septic tanks and other small flow sources. A few systems in the Midwest predate 1990, but most rock-plant filters in Kansas and surrounding states have been installed since 1993. These treatment filters may be used in a wide variety of soil conditions from clay pans with almost no downward water movement to more sandy soil in low areas.

The purpose of this bulletin is to describe rock-plant filters and define where they are most appropriately used for treatment of wastewater from individual homes. It presents the best currently available design and construction information to help the designer (such as a sanitarian or engineer), contractor, and others design and install workable, long lasting, and effective home onsite wastewater treatment systems. Guidelines for rock-plant filter operation, maintenance and repair for the homeowner or system operator are presented in a companion bulletin, *Rock-Plant Filter Operation, Maintenance and Repair,* (MF-2337). Though information presented here is based on current knowledge, continuing research and added experience will result in improvement and future changes in design, material selection, installation, operation, and maintenance.

Constructed wetlands for individual home wastewater treatment and absorption may include:

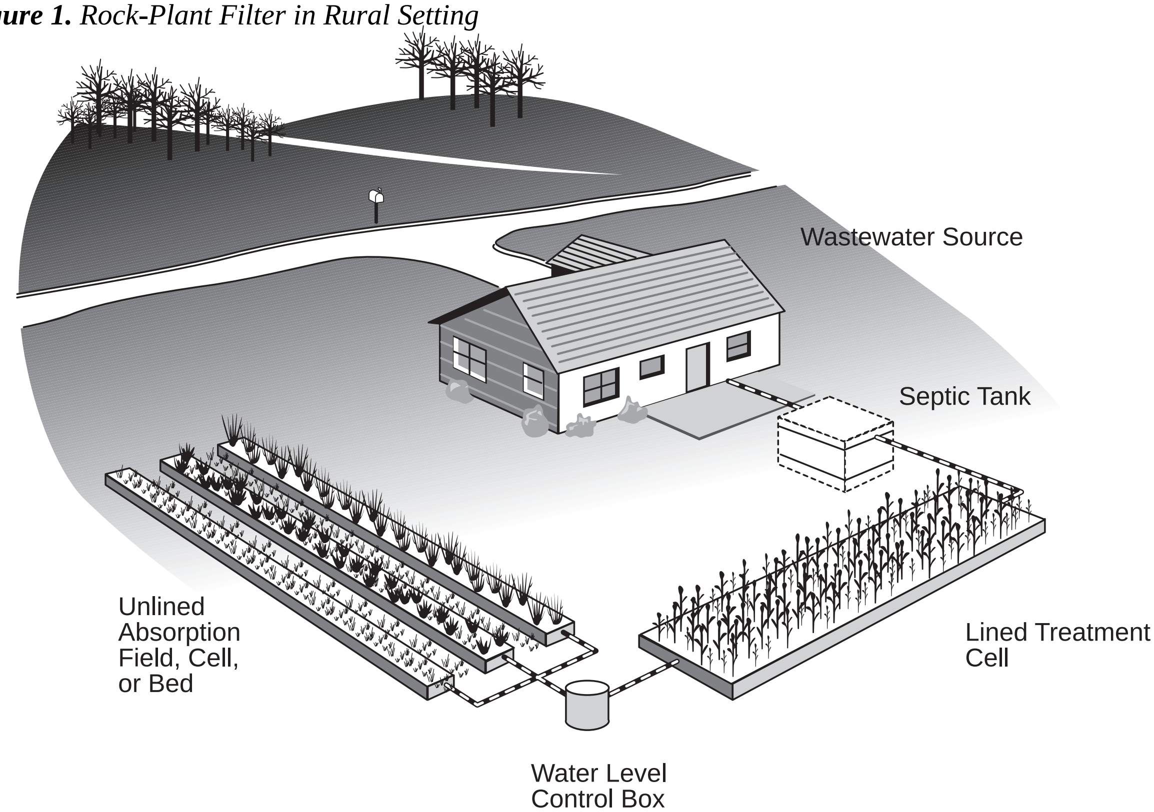
- open wastewater surface with depths up to about 2 feet and wetland plants,
- lined rock beds with submerged wastewater flow and wetland plant root systems (rock-plant filter),
- unlined sand or gravel cells for additional treatment and absorption following either an open or submerged cell.

Because open pools of insufficiently treated domestic sewage must be fenced to keep children and animals out of the water, submerged flow systems almost exclusively are used for individual homes. Submerged flow systems (rock-plant filters) have the water level at least 2 inches below the surface and thus do not require fencing. Most states' guidelines addressing constructed wetlands for onsite systems specify submerged flow systems.

A rock-plant filter system for domestic wastewater treatment will consist of a properly functioning septic tank, a lined treatment cell filled with rocks and wetland plants (the rock-plant filter), a water level control structure, an unlined absorption cell filled with sand and wetland plants or a subsurface absorption system, and possibly a seasonal overflow basin, where soil conditions require it. (See Figure 1.) The materials used should be high quality with a long useful life and corrosion resistant to extend the life of the system.

Septic Tank. The rock-plant treatment cell receives wastewater from a well designed, carefully constructed, and properly maintained septic tank. The septic tank must not leak and must remove solids to prevent them from plugging the rock bed. A septic tank effluent filter is highly recommended. This filter reduces solids delivered to the wetland, provides an added measure of protection to assure septic tank effluent quality, and reduces the organic load from the septic tank.

Figure 1. *Rock-Plant Filter in Rural Setting*



Lined Treatment Cell. The lined treatment cell with wetland plants provides essential wastewater treatment. The amount of treatment achieved through the treatment cell depends on the detention time (time required for flow through the cell), organic load, and treatment parameters such as oxygen and water temperature. Though significant treatment is provided by the lined treatment cell, effluent quality, especially for bacteria content, is not high enough to allow surface flow from the site.

Absorption Field. Following the rock-plant filter, a system must be provided to handle the effluent leaving the cell. This system may be unlined sand-filled laterals, conventional chamber laterals, or a sand bed. The size and type of the absorption area will need to be determined on a site-by-site basis depending on site and soil properties. The design will be based on the expected flow from the lined cell, the hydraulic capacity of the soil, and site conditions such as depth to groundwater.

Overflow Basin. In addition to the absorption field, an overflow basin may be needed in some locations to contain wet season flows resulting from extra rainfall and very poor internal drainage of the soil. The overflow basin has a larger surface area than the treatment and absorption cells together. It would be 1½ to 2½ feet deep with a flat bottom and includes wetland plants that can tolerate dry periods. This overflow basin would work seasonally, containing drainage from the absorption cell during very wet periods, but would dry out in the summer.

During periods of perched water tables caused by wet weather or heavy rains, water levels will rise in the unlined cell and surface discharge may occur in some locations. Surface discharge is illegal without a discharge permit and neither Kansas Department of Health and Environment (KDHE) nor local governments issues discharge permits for individual home systems. For this reason, the system design must have enough capacity to prevent surface discharge.

Where Rock-Plant Filters Are an Alternative

A site assessment is essential to identify site information such as lot size, topography, soil conditions, groundwater conditions, and other factors that affect onsite system design. Though in

Table 1. Design Parameters for Lined Rock-Plant Treatment Cells

Bedrooms	Design Flow (gpd)[A]	Design Flow 1 Day Detention	Volume (ft^3) 5 Day Detention	Total Cell Volume (ft^3)[B]	Surface Area (ft^2) @ 18" water depth	Example Cell Size (ft^3)[C] @ 1:4 ratio	Minimum Flow Needed[D]
2	300	40	200	600	400	10×40	60
3	450	60	300	900	600	12×50	90
4	600	80	400	1200	800	14×57	120
5	750	100	500	1500	1000	16×63	150

[A] *Gallons per day*
[B] *Volume of wastewater and rock, assuming porosity of rock-plant bed of 0.33*
[C] *Dimension ratio of width to length. Product equals surface area.*
[D] *Daily flow needed to meet 0.25 in/day evapotranspiration during summer.*

some locations there is an obvious best choice, many sites have conditions such that there are two or more good wastewater treatment choices. In addition to site conditions, installation costs, operation, maintenance and repair requirements, and owner preference are also important in selecting the best-suited wastewater treatment and disposal method. Rock-plant systems depend on growing plants, and care is usually given by the owner.

Rock-plant filters, like most other onsite treatment methods, are not the best alternative for wastewater treatment in all locations. They are best adapted to sites that have clay subsoil, high or seasonal perched water tables, and/or are located in low areas. However, rock-plant filters should not be located in a 100 year floodplain. Conditions such as these require enhanced treatment of wastewater before it is absorbed by the available soil.

Alternatives for advanced treatment include aeration systems, mounds, rock-plant filters, and sand filters. If the site allows gravity flow between parts of the system, a rock-plant filter is the only enhanced treatment method that operates without electricity.

Many areas of the eastern third of Kansas have conditions that are well suited to rock-plant systems. Some areas of central Kansas also may have conditions well suited to rock-plant filters. Because of low precipitation and high evaporation, very few areas of western Kansas would be well suited to rock-plant filters.

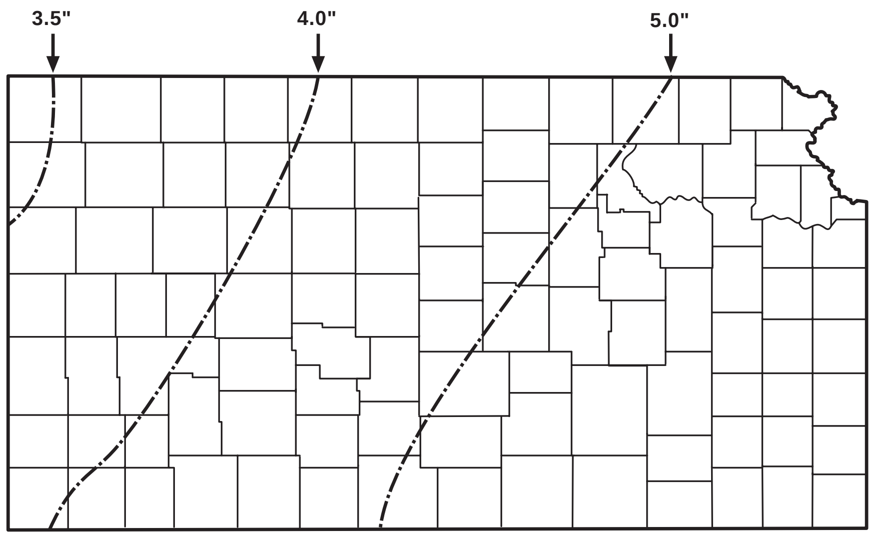
Because rock-plant systems depend on growing plants, the motivation of the owner to make a rock-plant filter work correctly is a key factor in the successful operation of the system. Rock-plant filters are best suited to owners who enjoy the pleasure and challenge of actively working with natural, plant-based systems for the protection of health and environment.

Wastewater Flow

Wastewater design flow is based on 75 gallons per person per day or 150 gallons per bedroom per day assuming two people per bedroom. Table 1 shows recommended design parameters and example cell sizes for two- through five-bedroom houses. Wastewater flow can vary widely based on plumbing fixtures, appliances, and personal habits of the occupants. It is essential that enough flow be generated to meet evapotranspiration losses of the treatment cell.

Maintaining Water Balance. Evapotranspiration consumption of water by plants can reach 25 gallons per 100 square feet (0.4 inches per day) of surface for a windy hot day. If there is no inflow or rain, evapotranspiration lowers the level of water in the spaces between the rocks nearly 1¼ inch each day. Rock-plant systems may need added water especially for a big home with few people. Precipitation received directly on the wetland offsets the need for water to replace that which has evaporated. Precipitation totaling 1.2 inches on the example cells in Table 1 equals the daily design flow and offsets water evaporated in 3 or 4 days.

Figure 2. *10-Year 24-Hour Rainfall (inches)*



10 Year - 24 Hour Rainfall (Inches)
Source: U.S. Weather Service Technical Note 40

A four bedroom house may need 120 to 200 gallons of discharge each day to meet evapotranspiration needs. Unlike soil that has water holding capacity, the rock-plant bed has only the open spaces in the bed. During periods when the house plumbing is not used, water must be added to supply the plants' needs. A garden hose may have to run a half hour or more, depending on size of the system, for each day the system is not used or rain does not replenish water consumed.

Preliminary Treatment

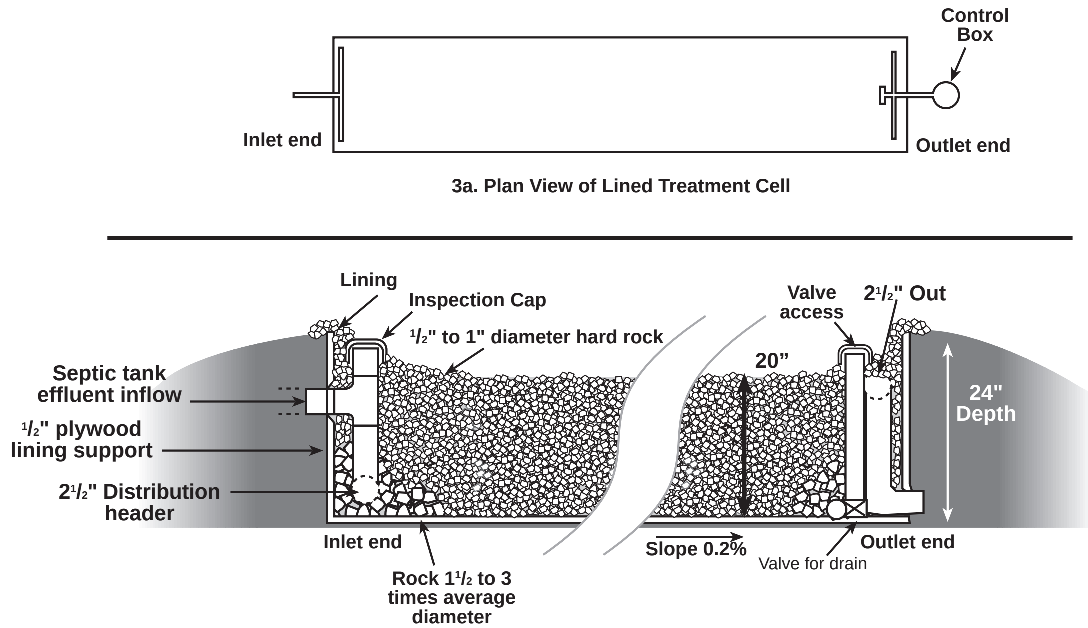
A septic tank is normally used to provide the preliminary treatment of removing solids and thus protecting the treatment cell. A properly sized, correctly installed, and adequately maintained septic tank should produce a nearly clear effluent. Effluent must be withdrawn between the floating scum layer and the bottom sludge layer to prevent solids from being carried into the rock-plant cell. The treatment cell performs best when the highest quality effluent is received. Low solids content of the effluent prevents plugging of the rock-root voids in the treatment cell. The septic tank must be pumped on a regular, appropriate schedule (typically every 3 to 5 years) to perform well.

The septic tank must be watertight so it does not leak. Tanks that leak may contaminate groundwater. During wet periods excess water will enter the tank and overload downstream system components. Leaking tanks may not develop good stratification, so a good layer of clear liquid does not form.

The septic tank should comply with all aspects of design, manufacturing and placement specifications presented in Kansas Department of Health and Environment *Bulletin 4-2, Minimum Standards for Design and Construction of Onsite Wastewater Systems*, K-State Research and Extension bulletin, MF-2214. Tanks that do not meet these specifications have a much higher rate of failure and shortened service life for the tank and remaining components.

A septic tank effluent filter helps ensure clarity of the effluent and protects the rock-plant filter from carryover of solids. Such filters substantially reduce suspended solids entering the rock-plant filter and provide a measure of protection in event of malfunction or failure of the tank. The effluent filter also provides a modest reduction in biochemical oxygen demand (BOD) which benefits the

Figure 3. *Lined Rock-Plant Treatment Cell*



3a. Plan View of Lined Treatment Cell

3b. Longitudinal Section of Lined Treatment Cell

treatment cell, by reducing the organic load entering the treatment cell which helps achieve a higher quality effluent leaving the treatment cell.

Lined Treatment Cell

The lined treatment cell accomplishes much of the treatment provided by a rock-plant filter system. In Kansas this treatment cell should be large enough to contain a 5-day design flow of wastewater from the household. Because the rock-plant filter has an open top, any precipitation adds hydraulic load causing an immediate outflow, assuming the system is in use and not leaking so it is at the design operating depth. A 10-year 24-hour storm in Eastern Kansas is 5 to almost 6 inches of rain (see Figure 2) and is nearly enough to fill the rock bed if there is no water in it initially. If the cell is full, this rain can wash out much of the wastewater. Rainwater will be very high quality compared with the normal wastewater.

Cell Design. A rock-plant treatment cell with 20 inches of rock depth and a design water depth of 18 inches will achieve the 5-day detention times using sizes shown in Table 1. The ratio of width to length of the lined cell should be about 1:4. The depth of the rock bed and water level can be reduced or increased but surface area of the rock bed will need to be enlarged or reduced, respectively, to maintain at least as much detention time. To ensure plant roots throughout the bed, the depth should not exceed 24 inches. The lined cell bottom should be dug into the land surface no more than about 60 percent of the total cell depth. Plan view and lengthwise section view of the rock-plant cell are shown in Figure 3.

Piping. The pipes between the septic tank, the lined cell, and the absorption cell should be 2 to 4 inches in diameter. PVC pipe, as used from the house to the septic tank, is suitable. Schedule 40 pipe should be used between the house and the septic tank, the septic tank and the lined treatment cell, and the lined cell and the water level control box. Schedule 40 pipe should also be used in the lined treatment cell. The influent and effluent headers in the lined cell should be at least 2 inches in diameter. (Headers that are 2.5 inches in diameter are shown in Figure 3b.) Holes that are ½ inch in diameter should be drilled every 6 inches in the headers on at least two sides.

Inlet Position. The inlet header should be placed 2 to 4 inches above the bottom of the cell in a bed of at least ¾ inch diameter rounded rock as shown in Figure 3.

Outlet Position. Placing the outlet near the top of the cell covered by 2 inches of rock allows rainwater to easily flow to the outlet. If the outlet is placed at the bottom, a rain would displace wastewater causing a drastic change in quality of the cell contents. This may partly explain the wide variation in effluent quality observed from some individual home wetland treatment cells. A shutoff valve and at least 3 feet of perforated pipe at the bottom will allow easy drainage of the cell for service (see Figure 2). The drain outlet exits the treatment cell at the bottom edge of the sidewall at the outlet end.

Cell Construction. Measure and mark location of the 4 corners of the treatment cell. Using an engineers level, mark cuts at each corner location to assure that the cell is level from side to side and slopes the desired 0.2 percent from inlet to outlet end (outlet end should be below the inlet 0.1 foot in 50 feet or a minimum of 0.1 feet). This slope allows the treatment cell to easily be drained if needed.

Excavate the cell area no deeper than 60 percent of the cell depth making sure elevation and slope are as designed. Material removed should be stockpiled for backfill and construction of berms around the outside of the cell. The finished surface of the berms should slope away from the cell in all directions so surface runoff cannot enter the system. Usually 6 to 8 inches above the natural surface is adequate to prevent surface inflow. However, a treatment cell located at the toe of a slope or where drainage concentrates will require a higher berm or a diversion channel for protection.

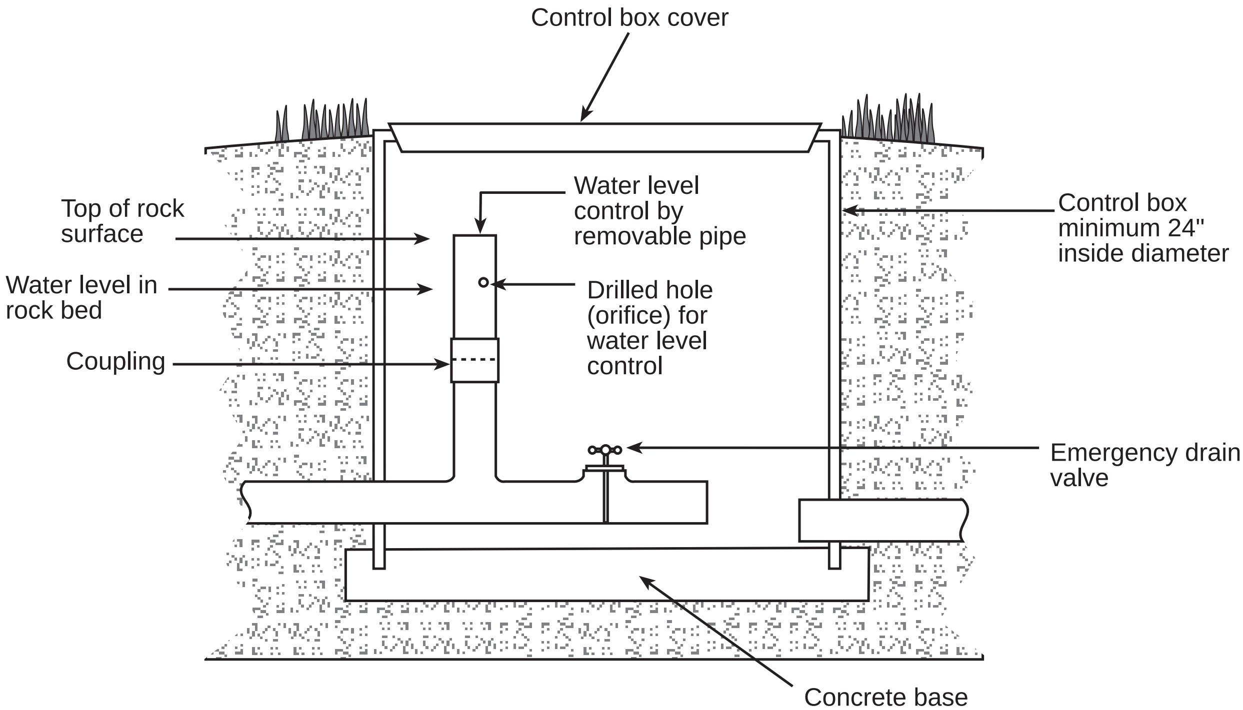
Grade and Smooth the Cell Floor. The cell floor supports the lining and should be smooth, compacted, and uniform without any sharp or protruding objects that could damage the liner. Manufacturers specify the largest material that can be placed adjacent to the lining (usually ¼ inch). If the exposed bottom material can be easily shaped and smoothed to a uniform firm surface, nothing needs to be added. However, if the exposed bottom contains stones, rocks or gravel larger than ¼ inch in diameter, the bottom should be over-excavated an additional 2 inches and a 2-inch sand layer added to protect the lining. Sand should be compacted and smoothed to a uniform grade.

Wall Support for Lining. A wooden frame to support the lining material during construction is easily built using untreated plywood (½ inch thick recommended). This framework is an easy and effective way to hold the lining in place while filling the cell and backfilling around the outside. Four or more wooden stakes on the outside of the frame should anchor and hold each plywood frame panel. A 2 × 4 at the seams on the outside serves the dual purpose of anchoring the frame and joining plywood sheets. Tape the inside of the plywood joints with duct tape or equivalent to prevent damage to the liner. Measure and check elevations again after installing the plywood frame. The wood supporting structure is only needed during construction, so exterior-grade material is not necessary. After installation, deterioration of the wood will occur but the material inside and outside the lining remains in place and loss of the wood support will not interfere with the function of the cell.

Lining Design. The treatment cell lining should be at least 30 mil thick of a single sheet of material such as EPDM rubber, polyethylene (PE) or polyvinyl chloride (PVC). In choosing the material, the installation of inlet and outlet openings needs to be considered. Polyethylene must be bonded with heat and PVC or EPDM can be bonded with heat or solvent glue.

The lining must be watertight when installed and must remain watertight throughout a minimum 30-year useful life. Care must be taken to be sure that the lining is protected during installation and that it is installed following manufacturer's recommendations. The liners, especially those made of PVC, should be protected from exposure to sunlight by rock or landscaping timbers. A lining that

Figure 4. *Water Level Control Box*



leaks will lose water, which can cause the cell to dry out during low use or non-use periods. Likewise shallow groundwater may flow into the cell during wet periods creating a hydraulic overload.

Perhaps the most critical part of lining placement is sealing the opening around the pipe at the inlet and outlet end, since both must penetrate the lining. Trying to stretch the liner over the pipe can tear the liner, forming a leak before the system is used or create a weakness that can easily leak in the future. Two options to form a watertight opening are to use a bulkhead fitting, also called a tank adapter, or a "sock" made of the lining material bonded to the lining and then clamped to the pipe.

Bulkhead fittings are available from plumbing supply companies. They screw firmly onto the liner and the inlet or outlet pipe can be screwed into the hole in the fitting.

A sock at least 4 inches long must be fabricated and bonded to the lining so a watertight leakproof connection can be made. This sock is difficult to form and install in the field without proper equipment. It may be preferable to have the sock formed and bonded to the lining by the dealer before the lining is delivered. Equipment to make a good bond in the field is expensive and subject to damage or malfunction. Precise dimensions are needed to correctly position these socks

Table 2. *Recommended Size and Number of Orifices: Outlet Control Standpipe*

	Orifices		
Surface Area ft^2	Number	Size (in)	Approximate flow[A] (gpm)
400	1	5⁄16	0.4
600	2	1⁄4, 5⁄16	0.6
800	2	1⁄4, 3⁄8	0.8
1000	3	1⁄4, 5⁄16, 5⁄16	1

[A] At 1 inch of head above center of orifice. These flows are about 20 percent of a storm intensity of ½ inch per hour on the treatment cell area.

at a remote location and then deliver the lining to the site. The plywood frame may have to be adjusted for the socks to be correctly positioned in the cell. The socks are clamped to the inlet and outlet pipes with stainless steel clamps. Polyurethane sealant is applied before the clamp is secured to make a permanent watertight connection.

The lining should be carefully positioned so it fits the treatment cell framework and around the inlet and outlet without stretching or bunching. When the inlet and outlet pipes are placed and before any fill material is added, adjustments in the lining can easily be made.

Inlet and Outlet Pipe Placement. The rock fill to be used around the pipe inlet and outlet must not damage the lining. When these rocks are large or have sharp edges, measures to adequately protect the lining must be taken. This could be a geotextile fabric protective material or a 2-inch layer of smaller rock or sand. Inside the lining, rounded gravel from alluvial deposits up to ¾ inch diameter should be acceptable next to the lining.

If crushed rock having sharp edges is used, the maximum size placed adjacent to the lining should be ¼ inch. A geotextile fabric cover can be used to protect the lining from crushed material up to ¾ inch size. After the inlet and outlet pipes have been installed and positioned in the framework to avoid stretching or bunching of the lining, enough rock is placed to hold these pipes securely in place while the remainder of the cell is filled. The stone surrounding the inlet and outlet pipes should be smooth, rounded material and at least ¾ inch in size. After the pipes are held in place by placement of rock, the entire cell can be filled.

Treatment Cell Rock. The treatment cell is ready for rock placement after the inlet and outlet pipes have been installed and anchored. Instructions for using special sized rock around the inlet and outlet pipes and next to the liner have been discussed above. The rest of the lined cell should be filled with hard rock that is ½ to 1 inch in diameter.

As rock fill is placed inside the cell, soil backfill also must be placed outside the lining frame. The difference between the inside and outside fill heights should not be more than 4 inches at any time. First add 4 inches to the inside then 8 inches outside, then 8 inches inside and alternate. Material placed outside must be compacted in place to provide solid support for the lining frame.

When placing soil outside the frame, be careful not to get soil, organic debris, or other foreign material in the rock bed. Clean any soil from the equipment each time before handling rock. Finish the top edge of the treatment cell with soil sloped up on the outside of the cell away from the lining a couple of inches and then mound rock over the lining wall. See Figure 3 for section detail.

Outlet Control Box

Immediately downstream of the treatment cell is an outlet control box that maintains the desired water level in the lined treatment cell (see Figure 4). This structure has the inflow near the bottom and the outflow at the bottom at least an inch lower than the inflow.

Because water seeks a level surface, the level in the treatment cell is easily controlled and adjusted by the height of the standpipe in the outlet box. Different methods of water level control have been used including a swivel pipe, a flexible hose, and a rigid standpipe. A swivel pipe or hose is easily adjustable, but must be anchored by a chain of noncorrosive material like stainless steel or brass.

The preferred method of water level control is a vertical standpipe with the top the same level as the rock surface. The water level within the rock cell is controlled by orifices drilled in the rigid pipe at the desired water level height. This controls wastewater level in the rock bed, but allows the level to rise during heavy or extended rains. When rainfall occurs at a higher intensity than the drilled holes can discharge, the water level rises in the rock cell. When it reaches the rock surface (also the top of the standpipe), it can then flow over the surface to the outlet header. This allows much of a high intensity rain to pass through the treatment cell without displacing much of the cell's wastewater contents. A rain with an intensity of ½ inch per hour will add about 3 gallons per minute (gpm) for a 600 square foot cell (3 bedroom) and 5 gpm for a 1,000 square foot cell (5 bedroom). A rain of this intensity and orifice discharge of 0.6 gpm (3 bedroom) will rise 2 inches to the rock surface in a little over 2 hours. When the water level reaches the top of the standpipe and begins overflowing, further rise will be small and will depend on rainfall intensity.

The water level in the cell pipe can be adjusted by trimming the length of pipe or replacing the short section of pipe with different outlet hole placements or length. Table 2 shows the recommended number of orifices, size of orifices, and estimated orifice discharge for various treatment cells and numbers of bedrooms.

The outlet control box must be large enough to provide easy access around the level control pipe. This usually means 24 inches in diameter or larger. The floor of the outlet control box should be shaped to drain freely so no water is retained in the box. The outlet box needs to be protected from freezing by a tight fitting lid and soil and/or insulation around the box and lid.

Absorption Field

The absorption field or cell's function is to absorb the wastewater flow plus any precipitation that falls on the treatment system less evapotranspiration that may occur. In most years, evapotranspiration will exceed rainfall annually, even in eastern Kansas. However, there will be years when rainfall will be much greater than average and will exceed evapotranspiration. In most years, there will be months when precipitation will add to the hydraulic load and there may be other months when evapotranspiration losses will reduce the total flow that must be absorbed.

In soils with high clay and slowly permeable subsoil and thus poor internal drainage, the bottom of the absorption cell trench or bed must be shallow, above the clay layer. If the absorption cell extends into the tight clay, much less water can be absorbed and during high rainfall periods, seasonally perched water on top of the clay can flow into the absorption cell actually increasing total water. This means the absorption cell must usually be very shallow (less than a foot deep) into the more permeable surface soil. Because of differences in soil and material availability there are different absorption cell designs that may be used. The absorption cell should be above the surrounding soil so surface runoff flows away from the cell. This prevents runoff from adding to the total system load.

Chamber Absorption System. A chamber system is not a "wetland cell." It is one type of absorption field lateral. The chamber system has the advantage of maximizing storage of excess hydraulic loads that might occur during high wastewater production periods or excess rainfall. Standard 3-foot wide chambers can store more than 12 gallons per linear foot of chamber length. Perennial grasses or wetland plants that can tolerate being dry for extended periods are a good choice to be planted over a chamber system.

Sand Absorption Bed. This wetland absorption cell is similar to a standard absorption bed, but uses sand rather than rock as the fill. It may be square or rectangular. A bed would be most suitable where the subsoil does not have severely restricted drainage. The bed minimizes surface area required, but also minimizes the perimeter area. Sand should be medium or coarse, 2 to 4 millimeters average diameter, and washed to remove fines. Unlike a standard absorption bed, a distribution pipe network would not extend the length of the bed. Wastewater should be introduced through a header pipe across the inlet end of the bed similar to the treatment cell. To prevent sand from getting into the pipe and to allow water to exit freely, a 4 inch layer of 1/2 inch or larger gravel is used around the inlet pipe.

Sand Absorption Lateral. A second type of sand absorption cell is composed of narrow trenches no wider than 4 feet with undisturbed soil strips 4 feet or more wide between the sand trenches. Again these resemble an absorption lateral except there is no distribution pipe the length of the cells. Wastewater is introduced through a header at the inlet of each trench. The length of these cells should not exceed 60 feet. The total bottom area for sand trenches should be the same as for the sand bed. Trenches should be used where subsoil has poor or very poor drainage. Trenches increase the perimeter area substantially compared to a bed but can about double the total area required for the absorption system.

Sand Absorption Cell Cover. Sand absorption cells, either bed or lateral, should be covered with 4 to 6 inches of topsoil that has good soil structure and the surface sloped toward the edges. A layer of untreated building paper or 4 inches of straw should cover the sand before placing the topsoil. Loam or silt loam topsoil with strong soil structure should be used. Silt soil with little soil structure should not be used, as it will work through the sand, filling the voids. If the sand is left uncovered, the extra hydraulic load from rainfall must be included in the design. It is recommended that the sand be covered with soil so when the soil is saturated, rainfall will run off and not contribute to the design flow.

Plants that can tolerate extended wet periods should be selected for the absorption cell. However, wetland plants for the absorption cell should also be able to tolerate some dry weather. There will usually be periods each year when there will not be enough water to keep the total area wet.

Construction of Absorption Cell. Construction of the absorption cell follows much the same procedure as any soil absorption lateral. In high-clay, restrictive-drainage subsoil, the bottom of the absorption cell must not extend into the clay. It is better to leave at least 4 inches or more of permeable topsoil at the bottom of the absorption cell. Sand absorption cells can be level or may slope a small amount, less than 0.5 percent, away from the inlet. The length of sand absorption cells should not exceed 60 feet. Chamber lateral length is only limited by the requirement to keep the bottom and top level. The surface of soil cover should be sloped to the sides to allow runoff to flow away.

Overflow Basin

Almost any adequately designed absorption cell, whether bed or lateral, will handle dry weather absorption adequately. For some soil conditions such as a perched water table, the absorption cell may not have adequate capacity during wet conditions. These soils cannot absorb a wastewater load very practically, yet surface discharge is still not an option. In this case, a shallow overflow basin should be added to contain the excess during wet weather.

At the outlet end of the laterals, a manifold collection pipe is added to collect excess water near the top of the sand absorption cell. Depending on the design of the absorption cell and the overflow basin, a second water level outlet control may be installed.

The effluent will have traveled through a septic tank, a lined treatment cell, and a sand absorption cell. Flow should have taken nearly 2 weeks to complete the process. Quality of effluent exiting the sand absorption cell should be very high, but surface discharge is not permitted. If it is needed, an overflow basin must be built to contain the discharge and prevent surface runoff.

The surface area of the overflow basin should be equal to or larger than the treatment and absorption cells combined. It should be 1½ to 2½ feet deep with a flat bottom. Flow enters the basin from a manifold collection system from the outlet end of the absorption cell. This prevents the water from surfacing and backing up into the treatment cell.

The overflow basin should be planted with wetland plants that can tolerate dry periods because the basin would be dry except during the wet season. The bottom of the basin is at the top of the subsoil. Soil excavated from the basin should be used to make a berm around the edge that contains flows and prevents surface inflow. Avoid construction of the overflow basin during wet periods when the soil will easily compact and smear.

Wetland Plants

Plants for the lined treatment cell must be able to thrive in a rock bed with 12 to 18 inches of wastewater. They must also be adapted to the growing conditions of the particular site of the rock-plant filter. The selection of the plants also will depend on what plants are available. Finding plants that are successful in each rock-plant filter may take experimentation. Table 3 lists some plant species that can be considered. Not all of them may be available locally.

When planting a rock-plant filter, use at least three different kinds of plants to help determine what will grow successfully. A variety of plants also can add visual interest to the system. A possible starting combination for general Kansas conditions is arrowheads, bullrushes/rushes, and sedges. The irises in Table 3 are good options for flowering plants. Care of the plants is described in the companion publication, *Rock-Plant Filter Operation, Maintenance and Repair*, MF-2337 .

Caution. These systems are for treating wastewater. No plants that produce food for consumption should be used: Don't try to grow carrots, lettuce, or other food crops in your rock-plant filter treatment or absorption cells.

Table 3. *Plant Species Suitable for Rock-Plant Filters*

Common Names	Botanical Name	Height (feet)	Root Depth (inches)	Comments
Arrow Arum, Tuckahoe	*Peltrandra virginica*	3.3	8–15	
Arrowhead, Duck Corn	*Sagittaria sagittifolia*	2		
Arrowhead, Duck-potato	*Sagittaria latifolia*	0.5–2	10–12	
Blue Water Iris, Blue Flag, Wild Iris	*Iris versicolor*			
Bog Arum, Water Arum, Wild Calla	*Calla palustris*	0.5–0.75	9–10	
Bull Rush, Bulrush	*Scripus americanus*		12	
Calla Lily, Common Calla	*Zantedeschia aethiopica*			
Canna Lily	*Canna flaccida*	1.3–5.9	10–12	
Cardinal Flower	*Lobelia cardinalis*	2.6	6–8	
Cattail, Broad-leaf	*Typha latifolia*	3–6	6–12	Invasive
Cattail, Narrow-leaf	*Typha angustifolia*		6–12	Invasive
Chairmaker's Bulrush	*Acorus americanus*			
Cyperus Sedge	*Carex pseudocyperus*	2.6		
Elephant Ear	*Calocasia esculentia*			
Flowering Rush	*Butomus umbellatus*	2–3	12–24	
Giant Reed	*Phragmites australis*		18	Very invasive
Great Blue Lobelia	*Lobelia siphilitica*			
Horsetail	*Equisetum hyemale*	1–3.3	6–8	Invasive
Japanese Water Iris	*Iris laevigata*	2.6		
Marsh Marigold	*Caltha palustria*	1	6	
Pickerel Weed	*Pontederia cordata*	0.8–4.9	15	
Plantain Lily	*Hosta species*	0.5–4		
Rushes	*Juncus species*	0.5–6		
Rushes	*Scirpus species*	3–4		
Sedges	*Carex species*			
Soft Rush	*Juncus effusus*	1.5–2.5		
Softstem Bulrush	*Scirpus validus*	3.3–5	7	
Sweet Flag (Calamus)	*Acorus calamus*	2–2.5	6–7	
Umbrella Sedges	*Cyperus species*	2-6		
Yellow Water Iris, Yellow Flag, Water Iris	*Iris pseudacorus*	0.8–3.3	8	

Plant Spacing. Space the plants according to recommendations for the particular species. If no instructions are available, plant them no closer than 1 foot apart in all directions. For larger plants a spacing of 18 to 20 inches apart is probably better.

Some of the plants listed in Table 3 are marked “invasive.” These plants have the tendency to grow rapidly and push out other species. Unless those plants are of special interest to the homeowner, other species may be tried first. If more vigorously growing plants are needed, the invasive species can be tried as substitutes. However, some invasive species may spread beyond the bounds of the treatment area.

Plant Availability. Plants should be good quality stock. Plants can be obtained from the wild, from local nurseries, or by mail order. If wild plants are used, be sure that they are obtained without environmental damage and only after receiving appropriate authorization from the owner of the location where they grow. Additional information on plants is available from the local county K-State Research and Extension office.

Safety Considerations

Remember that the water in the rock-plant filter is partially treated wastewater and may contain pathogens. Wear rubber gloves when “gardening” in contact with the wastewater. Thoroughly wash any skin or clothing that has come in contact with the wastewater. Promptly treat any open cuts with an antiseptic.

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