

# Raised Wicking Beds

Steve Higgins, Biosystems and Agricultural Engineering

A raised bed is an excellent addition to many backyard gardens. A modification of this design may be of interest to gardeners. A raised wicking bed is a self-contained method for growing vegetables, fruits, herbs, and flowers. The bed provides a built-in water reservoir that allows plants to water themselves. The design is ideal for individuals who are new to gardening, but experienced gardeners will find it helpful as well. The greatest benefit of this system is that it provides control of the water supply to the plants within the defined area.

## The Science behind Wicking Beds

In this design, water for plant growth is provided by a reservoir located in the base of the bed. Wicking beds use capillary action to provide plants with water to the root zone. Capillary action is the rise of liquid created by increasing surface tension, which allows water to defeat gravity and move up. The smaller the particles that make up the matrix, the greater the ability to defeat gravity. Even though the water table may be at one level, capillary action can move water up approximately 4 inches above the water table. Having a moisture zone and a source of water creates an ideal environment for growing plants. Plants will increase surface tension within the soil matrix as they draw water up through their roots. This creates the condition where the plant is continuously connected to the water reservoir. During the growing season, mature plants will naturally obtain water through rainfall events, by capillary action, or after the roots reach the water reservoir. Overwatering and underwatering are remedied by the plants' ability to self-regulate their water requirement.



## Advantages

The advantages of a wicking bed are:

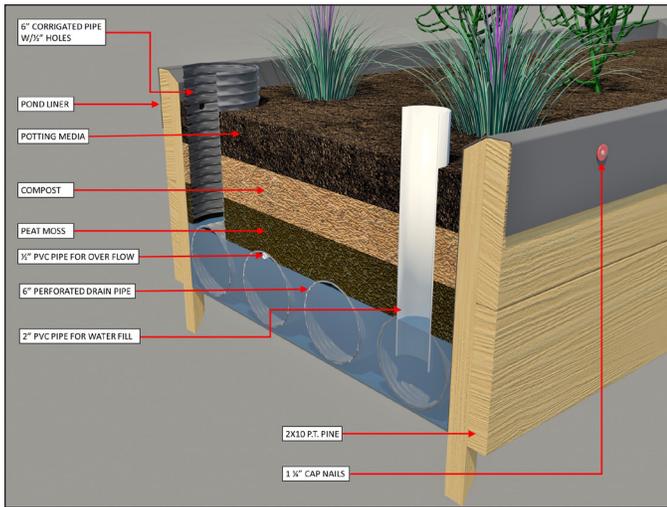
- It is a self-contained system for growing and maintaining plants.
- The height of raised beds makes them more ergonomic for growing, maintaining, and harvesting.
- The output per unit area makes them ideally suited for individuals with limited space.
- Since wicking beds draw water from the bottom up, the soil surface is drier, which reduces weed competition, evaporation, and foliar disease infection.
- Watering from the bottom up promotes water efficiency and conservation by reducing evaporation from the surface of the soil and runoff.
- The water reservoir (Figure 1) can detain and capture water from rainfall events and reduce nutrient loss.
- Plants receive a more consistent water source and won't suffer drought stress because it is always available in the reservoir.
- Gardeners with limited time can use large capacity reservoirs to extend their watering schedule.

- Raised bed gardens can be started earlier in the spring than traditional garden beds since they are not insulated by the earth and the soil warms sooner.
- Beds that are constructed higher than 16 inches inhibit infestation by rabbits.

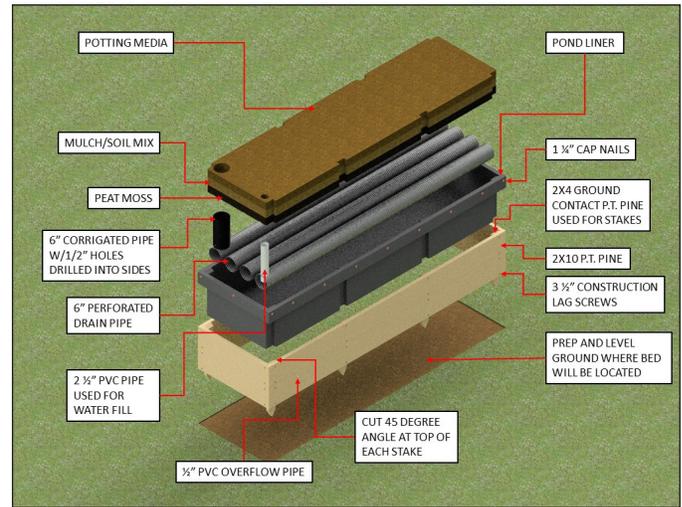
## Disadvantages

The disadvantages of wicking beds are:

- They are more expensive to create than traditional gardens or beds.
- In the fall, beds may freeze sooner than non-raised beds because the beds are not insulated by the ground.
- A raised bed has a limited soil and nutrient holding capacity. Therefore, side-dressing with fertilizer may be needed during the growing season.
- Because water is not flowing through regularly, salts can build up to a level that can damage plants.
- With a large shared water reservoir, root pathogens, such as water molds, can spread easily within the bed.



**Figure 1.** Cross-section of a wicking bed garden. James Ash.



**Figure 2.** Components of a raised wicking bed. James Ash.

## Components

The components needed to construct a raised wicking bed (Figures 1 and 2) are:

**Raised beds frame:** Raised bed frames can be fabricated using many different materials ranging from wood, plastic, concrete, stone, and steel.

**Pond liner:** A liner is needed to create the water reservoir and protect a wood frame constructed bed from the decaying effects of wet soil. Do not use thin plastic sheeting that will degrade in sunlight.

**Planting media:** The texture and structure of the planting media is critical to provide the drainage and aeration needed to produce optimum water movement conditions. Peat moss, compost, and potting mix are all porous media that promote drainage of water. Conversely, a dense or “heavy” soil with a high clay content has the potential to cause plant roots to stay wet too long, leading to potential disease issues.

**Pipe:** Several types of perforated and solid pipes and tubes that are integral to this system.

**Perforated pipe:** A water reservoir is created by perforated pipes that provide the structural integrity to support the soil above it. The perforations provide the free flow of water while occupying a minimal amount of surface area. Standard perforated pipe sizes of 4-inch and 6-inch diameter are ideal for this application. A single layer, or stacked configuration, using any pipe size, can be used to create the desired water volume.

**Fill tube:** A solid PVC pipe provides a direct route to fill the water reservoir. The minimum diameter for the fill tube should be 1.5 inches (Schedule 40 PVC), which will accommodate a garden hose fitting, whereas a 2-inch diameter PVC pipe provides convenience for seeing the water level at depth. A cap should be used to cover the fill tube opening to discourage breeding mosquitoes.

**Overflow tube:** An overflow or drain tube can be fabricated from a .5-inch vinyl tube or PVC pipe (Figures 1, 5, and 6). This tube provides a route for excess water to flow and prevent the planting media from becoming saturated.

**Kitchen composter (optional):** The addition of a composting tube can provide a means of adding nutrients to the bed, while providing raw material to beneficial microorganisms and decomposers, which promote soil health. This kitchen composter tube can also be used as a conduit for adding supplemental water into the system.

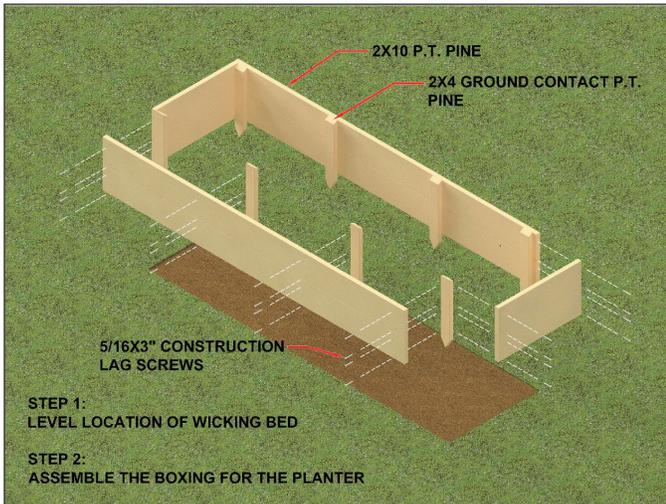
## Fabricating a 3 Foot by 10 Foot Raised Wicking Bed Site Preparation

Most plants require a minimum of six to eight hours of sunlight per day. Be sure to locate your bed garden in an area with full sun. The site should be easily accessible and organized to provide a central location within a reasonable distance from water sources, maintenance equipment storage, and harvesting and processing areas.

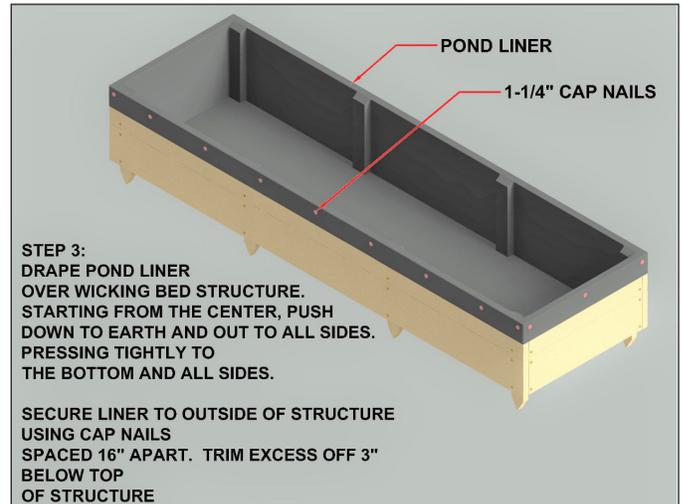
A level surface should be provided by excavating any grass, organic matter, or topsoil. The bed should not be positioned where it will block or act as a dam of upland flow or drainage. Beds are typically constructed no more than 4 feet wide; this width allows for an easy reach into the bed from either side. An aisle of 2 to 4 feet is maintained between beds to allow easy access with tools and equipment (such as wheelbarrows, hose reels, chairs or stools, and wheelchairs).

Assemble the bed as shown using construction lag screws (Figure 3). Cut the stakes to a 30-degree angle flush with the top and approximately 4 inches into the ground. Clamp stakes to 2x10s and use a 3/16- to 7/32-inch drill bit to pre-drill a hole for the lag screws. Keep the stake clamped until at least two lag screws are in place. Allow a 1.5-inch space at each end for end boxing to be set flush with side boxing. Once boxing is assembled, use a wood block and heavy hammer to drive stakes. Starting at one end, set block on top of boxing at stake locations. Drive stakes into the ground about 1 to 2 inches at a time, moving from one stake to the other working your way toward the other end of the boxing. Move back and forth from one end to the other until boxing is level and flush with the prepared ground.

**NOTE:** The fabricator has the option of placing the stakes on the inside or outside of the raised bed. Inside stakes place stress on the pond liner, whereas outside stakes may interfere with harvesting and maintenance.



**Figure 3.** Assembling the raised bed on excavated ground (P.T. = pressure treated). James Ash.



**Figure 4.** Installing the pond liner. James Ash

Pond liners are typically constructed using butyl rubber or PVC, which are designed to be somewhat resistant to punctures. However, make sure that there is nothing on the surfaces (sides or bottom) that could puncture or tear the pond liner. Place the liner in the bed (Figure 4). Drape the expected overhang down the outside of one of the raised bed's sides. Move to the other side and repeat by draping the expected overhang over the outside. Do the same for each end. Use any seams or creases to align the pond liner squarely in the bed. Remove any wrinkles by smoothing out the bottom and then pressing smoothly up the sides. Create folds in the corners to organize the pond liner. Adding water slowly to

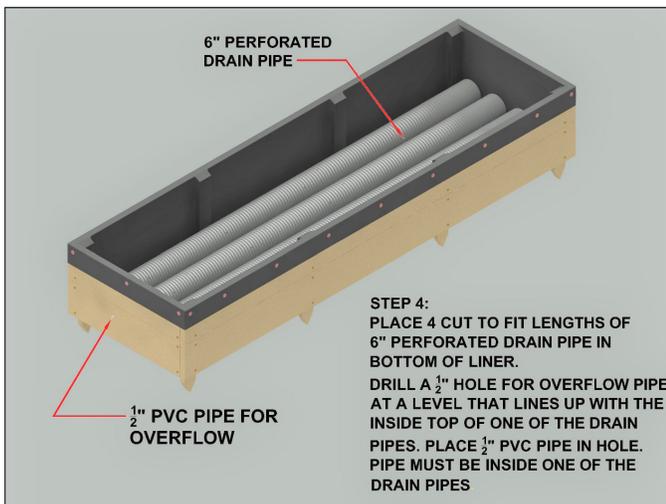
the raised bed is a useful technique for working out the wrinkles and getting the liner to fit snugly in the edges and corners.

**NOTE:** The fabricator has the option of protecting the pond liner by installing a pond sub-liner or by using a section of woven geotextile fabric or thick cardboard.

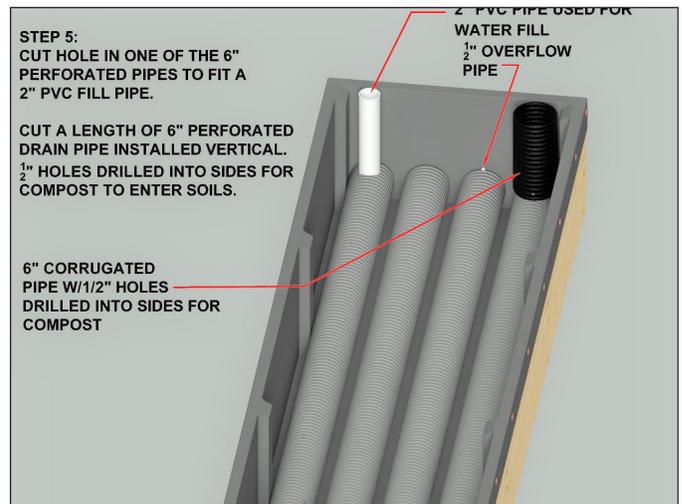
Cut the perforated drain pipe to fit. Mark the location of the drain pipe on the outside of the bed and drill a hole for the drain tube. The location should match the inside apex of one of the perforated pipes (Figure 5). Insert the drain tube into the drilled hole until it presses on the pond liner. Using a utility knife, create an X on the pond liner, over the end of the drain tube. Push the drain tube through

the opening. If done correctly this will provide an adequate seal. A better seal can be provided by applying drain tape to the inside of the raised bed.

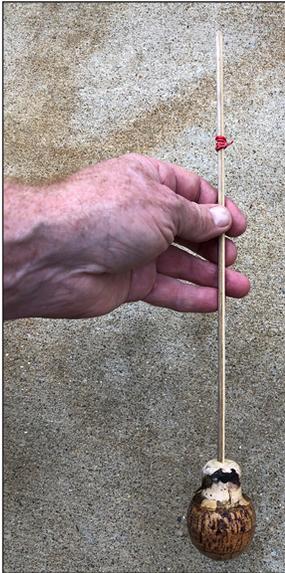
**NOTE:** The location of the drain tube should be planned to separate the drain tube in relation to the location of the fill tube. Having the fill and drain tubes on opposite ends would provide the greatest separation distance. However, access is more important. It might take a few minutes to fill a reservoir depending on variables such as the volume needed to fill the reservoir and water pressure. Therefore, monitoring would be accomplished more efficiently if they were located on the same end.



**Figure 5.** Installing the perforated pipe and overflow drain.



**Figure 6.** Installing the fill tube and kitchen composter.



**Figure 7.** Homemade water level gauge.



**Figure 8.** A compost tube fashioned from a piece of 6-inch corrugated drain pipe with holes drilled to create access.



**Figure 9.** The placement of a compost tube and water fill tube along one end of a wicking bed.

Install the fill tube using the appropriate hole-saw to match the pipe diameter (Figure 6). The location of the fill tube is important from the standpoint of access. Being able to fill the bed with water without obstructions makes access easier. The distance between the fill tube and overflow should be at least 12 inches, or you may not be able to tell the water level accurately.

Filter fabric should be placed at each end of the bed to seal the end of the perforated pipes and the fill tube.

### Water Level Gauge

A water level gauge can be used to determine and monitor the volume of water in the reservoir. A water level gauge can be fabricated by placing a bamboo skewer into the end of a bottle cork and adding a bead of hot glue to secure the two (Figure 7). A red twist tie is used to mark the level of water needed for the drain tube to flow.

### Kitchen Composter (Optional)

The kitchen composter is a utility device that can serve multiple purposes (Figure 8). The opening that it creates can be used for dumping buckets of water to fill the reservoir or for inserting earth worms into the subsoil to create soil health (Figure 9). The opening can also be used for placing compostable scraps, on a limited scale, to feed earth worms and other soil

decomposers. A clay pot is used to cover the opening of the compost tube to deter gnats, flies, and other flying pests, which could become a nuisance. (Figures 9 and 10). Stones and pebbles, which are periodically found when digging, gardening, and cruising through the garden, are placed in the clay pot. The stones work as a screen, which allows the composting material to exchange air with the atmosphere while excluding flying insects. The clay pot also has utility in that it becomes the receptacle for any stones that are discovered in the bed and surrounding area. The rocks can eventually be washed and used as a resource for another project.

The composter is created by .5-inch or larger holes in the side of a 6-inch plastic drain pipe (Figure 8). Drilled holes should not extend above the soil line. The pipe should be buried along one of the sides of the raised bed, where it will be accessible once the plants have grown. An ideal length of pipe rests on the perforated pipe used to create the water reservoir and extends approximately 5 inches above the edge of the raised bed (Figure 9).

Removing the clay pot and brown plastic cup exposes the composter and water reservoir fill tube (Figure 9). Floating inside the fill tube is a water level gauge (Figure 7). This gauge provides a quick and easy way of determining the volume of water in the reservoir. The cover for the

water reservoir fill tube was fabricated by painting a plastic drink cup. The cup reduces the potential of creating a breeding ground for mosquitoes while providing room for the gauge to operate.

**NOTE:** A PVC cap may make a more appropriate cap for the water fill tube compared to a plastic cup, which might blow away. However, they cost more and if placed too tightly have the potential to pull the water fill tube out of the soil.

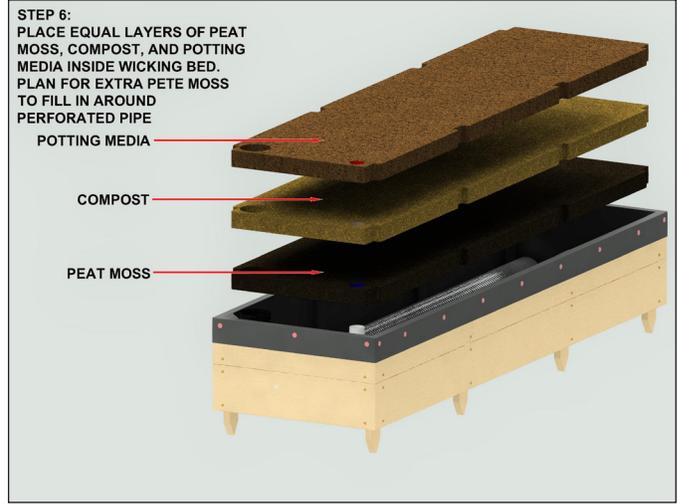
Creating the planting media or soil matrix is accomplished by layering equal amounts of fill material. The approximate volume of fill material may be calculated by using simple math. For example, a 3 foot by 10 foot by 1 foot deep raised bed displaces 30 cubic feet of volume. Dividing 30 cubic feet by 3 layers of soil requires approximately 10 cubic feet of each of the fill materials.

Peat moss and compost are typically marketed in cubic feet, which makes determining the number of bags easy. However, bagged potting media is typically marketed by the quart, where one quart is equivalent to 0.033 cubic feet.

The fill materials placed in the bed will settle (Figure 11). The extent depends on the moisture and structure of the fill materials. Air voids, which are displacing much of the volume, can be removed by filling the reservoir with water and by



**Figure 10.** Kitchen composter and water fill tube with covers. Direct access to the kitchen composter and water fill tube is provided from the porch.



**Figure 11.** Layers of planting media used to create the soil matrix for a wicking bed. James Ash.

adding water to the surface of the peat moss layer. Bagged peat moss has a very low moisture content to a point of being hydrophobic. Adding water after the peat moss has been placed will allow it to subside, while reducing dust when spreading and leveling. Moistening the peat moss will also prevent a perched water table from developing.

The compost layer can be created using backyard compost or purchased compost or manure. Backyard compost may have some mineral or garden soil included, which is acceptable, as long as the clay content remains low. The final layer should be mostly potting media, possibly with some compost.

## Operation and Maintenance

Seeds, seedlings, and transplants should be watered at the soil surface until the plant's root system reaches the moisture provided by the water reservoir. Once the plant is mature, the plant's roots will reach and utilize the water reservoir. Over the course of the growing season and as plants get bigger, they will require more water to be added to the reservoir. Filling the reservoir is accomplished by placing water into the fill tube.

Gardeners may want to avoid topping off the reservoir prior to imminent rainfall events to avoid flushing of nutrients and wasting water. Providing a 1-inch (approximately) reservoir buffer will not harm mature plants and may be a good practice to provide capacity for harvesting

### Materials List for 3 x 10-foot Wicking Bed (height - approximately 19")

Material	Qty	Cost/Unit	Total
Boxing (pressure treated pine)			
2 x 10 x 10'	4	28.27	\$113.08
2 x 10 x 12'	1	32.98	\$32.98
2 x 4 x 8' (ground contact p.t. pine)	2	7.98	\$15.96
Pond Liner			
8' x 14' (minimum)	1	@150.00	\$150.00
Construction Lag Screw			
5/16" x 3" (30 count box)	2	11.86	\$23.72
Roofing Nails w/Plastic Cap			
#12 x 1"	1	7.97	\$7.97
6" Corrugated Drain Pipe			
20' perforated	2	35.86	\$71.72
2" Schedule 40 PVC			
24" length	1	4.96	\$4.96
<b>TOTAL:</b>			<b>\$420.39</b>

Prices as of 2020, excludes planting media.

rainfall events. Conversely, a full reservoir after seeding, during emergence, and after transplanting will raise the moisture level in the bed and allow plant roots to travel a shorter distance to reach water. Once established, if no rain event has occurred, the gardener may need to add water to the system every four to seven days.

Water used for filling the reservoir can be obtained from a rainwater harvesting system or city water. Rain harvesting using barrels is another sustainable and productive gardening project. See [Building a Rain Barrel](#) (HENV-201).

Adding earthworms, acquired from the yard or garden, to the raised bed will facilitate the composting process. Their

castings can contribute to the fertility of the bed, while their tunnels provide soil structure.

During the growing season, plants will need adequate nutrition. General information regarding fertilizing can be found in the publication [Home Vegetable Production in Kentucky](#) (ID-128).

At the end of the season, gardeners may notice that the soil level has lowered, requiring a topdressing of additional fill material before the next growing season.

A cover crop should be planted at the end of the growing season to protect and enhance the soil media. Gardeners can refer to [Winter Cover Crops for Kentucky Gardens and Fields](#) (ID-113) for more information.

## Summary

A raised wicking bed can be an effective and efficient piece of garden infrastructure that many gardeners can enjoy. A raised wicking bed is a self-contained method for growing vegetables, fruits, herbs, and flowers. A built-in water reservoir allows plants to self-irrigate. This design uses accessible hardware and basic skills to create a raised wicking bed. The scalable design is ideally suited for individuals who are new to gardening as well as seasoned gardeners.

## References and Further Reading

- [Building a Rain Barrel \(HENV-201\)](#)
- [Gardening in Small Spaces \(ID-248\)](#)
- [Home Vegetable Production in Kentucky \(ID-128\)](#)
- Jumikis, Alfreds R. 1984. Soil Mechanics. Krieger Publishing Company. Malabar, Florida.
- [Winter Cover Crops for Kentucky Gardens and Fields \(ID-113\)](#)