4.8 Evapotranspiration and Evapotranspiration/Infiltrative Systems

Description

An evapotranspiration (ET) system is composed of a sand and gravel bed contained within an impervious lining, which receives septic tank effluent and in which evaporation through the system's surface and plant transpiration are the sole means of effluent removal. All forms of ET systems function best where the climate is dry and hot. Preferably, the difference between the site precipitation and evapotranspiration provides water loss of 2 inches per month on average.

An ET system that allows some wastewater to infiltrate the subsurface can be allowed under the proper site conditions and source attributes. This is an evapotranspiration/infiltrative (ETI) system. An ETI system has more restrictive site and design constraints due to the additional wastewater discharge path into the surrounding soils.

Due to the complex water balance calculations for system sizing, coupled with liner design and construction details, these systems must be designed by a suitably qualified professional engineer (PE) or professional geologist (PG). Construction requires the services of a licensed Complex Alternative System Installer as specified in IDAPA 58.01.03.006.01.b.

Because they have impermeable liners, ET systems are classified among the non-discharging wastewater systems, along with evaporative lagoons and vault toilets. This is different from ETI systems, which do discharge a small amount of wastewater to the soil. Sites with soils that have percolation rates greater than 120 minutes/inch (min/in) ($3.5x10^{-4}$ cm/sec), and have site attributes that meet both the minimum vertical and minimum horizontal setback distances for Type C soils, may be suitable for installation of a properly designed and constructed ETI system.

Conditions for Approval

1. The site must not be subject to flooding.
2. Ground water:
    a. For ET systems, high ground water, seasonal or normal, must not come within six (6) inches of the bottom of the impervious liner.
    b. For ETI systems, vertical separation distances must meet the minimum distance requirement for Type C soils; see Table 2-7 in the Soils and Groundwater section.
3. Soil:
    a. ET systems may be approved where soils:
        i. Are very thin, or
        ii. Soils are classified unsuitable as defined in Rule (IDAPA 58.01.02.008.02.b).
    b. ETI systems are restricted to sites with soils that are classified as "Unsuitable" through use of the soil texture method (Table 2-2), exhibit unacceptably low infiltration (Table 2-10), and the site attributes meet Type C-2 soil depth requirements (See Table 2-7 in the Soils and Groundwater section). Unacceptably

low infiltration rate soils have percolation rates greater than 120 min/in ($3.5*10^{-4}$ cm/sec), see Table 2-10 in the Soils and Groundwater section.

4. The adjusted growing season (March-October) site evapotranspiration must exceed the 10 year return frequency annual precipitation. Some sites may have attributes that provide evapotranspiration losses year round. These beneficial site attributes may allow an ET or ETI system to be sized based on annual evapotranspiration rates (January-December). Permit applications proposing use of annual evapotranspiration must document the site attributes that justify this alteration. Attributes that may qualify a site for annual evapotranspiration losses include, but are not necessarily limited to:

    a. The site receiving full sun exposure year round, and

    b. The site having a growing season exceeding 210 days, and

    c. The site lacks features causing snow drifts to settle over the system, and

    d. The system uses cool season growing grasses and other plants. (http://www.purdue.edu/envirosoft/lawn/src/grass/cool.htm)

5. The slope must not exceed twelve (12) percent.

6. The setback distance from surface water for ET systems may be reduced to 100 feet if the system is constructed with a minimum of a 30-mil (0.030 inch) PVC or 60-mil (0.060 inch) HDPE liner. Horizontal setback distances to surface water for an ETI system must adhere to those for Type C soils (100 feet per IDAPA 58.01.03.008.02.d).

7. Both ET and ETI systems must have a minimum of 100 feet separation to any domestic or public well.

8. ETI systems may require an augmented soil liner to limit infiltration and ensure proper system function when the soils exhibit moderate to strong vertical soil structure or are very gravelly/very stony. Infiltration should be limited to no more than 10% of the home’s wastewater flow. Infiltration rates of 85,000 min/in ($5x10^{-7}$ cm/s) or more will typically be necessary to inhibit wastewater infiltration sufficiently for proper system operation. This restriction is required to balance water losses prior to system maturation. At system maturation, a fully developed biomat will further inhibit wastewater infiltration into the soil, and allow the ETI system to operate using evaporation and plant transpiration.

    The soil’s infiltration rate will need to be determined. Table 4-1 identifies acceptable soil infiltration specifications depending upon soil type and configuration. Soils with infiltration rates greater than $5x10^{-7}$ cm/s (85,000 min/in) will need to have an augmented soil liner.

Table 4-1. Dual-Ring Infiltrometer testing specifications.

Soils Type	*ASTM Method*	*Soil Infiltration Rates (cm/s)*
Coarse sand to unsuitable clayey soils	*ASTM D 3385*	*$1x10^{-2}$ to $1x10^{-6}$*
Amended soil and compacted clay liners	*ASTM D 5093*	*$1x10^{-5}$ to $1x10^{-7}$*

System Design Criteria

1. Equation 4-1 gives the calculation for horizontal area.

Equation 4-1. ET/ETI System Horizontal Area (square feet [ft^2]):

(a) ET system: $T_{ETarea} = \frac{nV}{(GS_{ET} - P)}$ **(b) ETI system:** $T_{ETIarea} = \frac{nV}{(GS_{ET} + I - P)}$

Where:

T_{ETarea} & $T_{ETIarea}$ = Total horizontal area in square feet.

n = Peaking factor, varies from 1 to 1.6, per EPA/625/R-00/008, TFS-31.

V = Annual volume of received effluent, in cubic feet.

GS_{ET} = Annual growing season (March-October) reference evapotranspiration, adjusted for the vegetation planted on the bed, in feet. Suitable sites may use annual (January-December) plant-specific reference evapotranspiration values, in feet.

P = Annual precipitation, in feet, with a return frequency of 10 years.

I = Annual infiltration volume, in cubic feet.

2. Total Bed Depth (D_{bed}). Total bed depth will be determined from a water mass balance beginning in October (see Table 4-2). Credit for evaporation occurring between November and February may be allowed on a site-specific basis as specified in Approval Condition 4. Total bed depth criteria include:

    a. The total vertical distance from the ground surface to the impermeable liner, for an ET system, or to the bottom of the excavated native soil, for an ETI system, should not exceed 4 feet.

    b. The vertical distance from the ET or ETI bed's surface to the top of the laterals must be 1 foot.

    c. The vertical distance from the top of the laterals to the highest saturated effluent elevation should be no less than 0.5 feet.

See Figure 4-5, Cross-Section of Evapotranspiration System.

3. One or more stand pipes are required to provide access for operations and maintenance activities, troubleshooting, and installation of a high water alarm.
4. A high water alarm is required. This high water alarm shall indicate when the effluent level in the ET or ETI system reaches the bottom of the laterals, which is an indication that the system is malfunctioning or is overloaded. The alarm shall be both audible and visible. The alarm relay shall be latching, requiring the owner/operator/service personnel to physically inspect the effluent level and take corrective action in order to reset the alarm.

System Sizing Procedure

1. Determine annual precipitation with a 10 year return frequency. Start with annual precipitation data from Idaho Climate at *http://www.wrcc.dri.edu/summary/climsmid.html* in feet per month. Perform a frequency analysis using the log Pearson III method described at *http://water.oregonstate.edu/streamflow/analysis/floodfreq/index.htm#log*. A web-based calculator for this method can be found at *http://onlinehydro.sdsu.edu/onlinepearson2.php*.
2. You will need to determine the Monthly Precipitation Contribution (MPC). The MPC is calculated by dividing a month's long-term monthly average for the climatological site in question by the long-term average annual precipitation for that site. The MPC values multiplied by the 10 year return frequency annual precipitation will yield the monthly precipitation rates. Record these monthly precipitation values in column A of the Water Mass Balance table (Table 4-2).

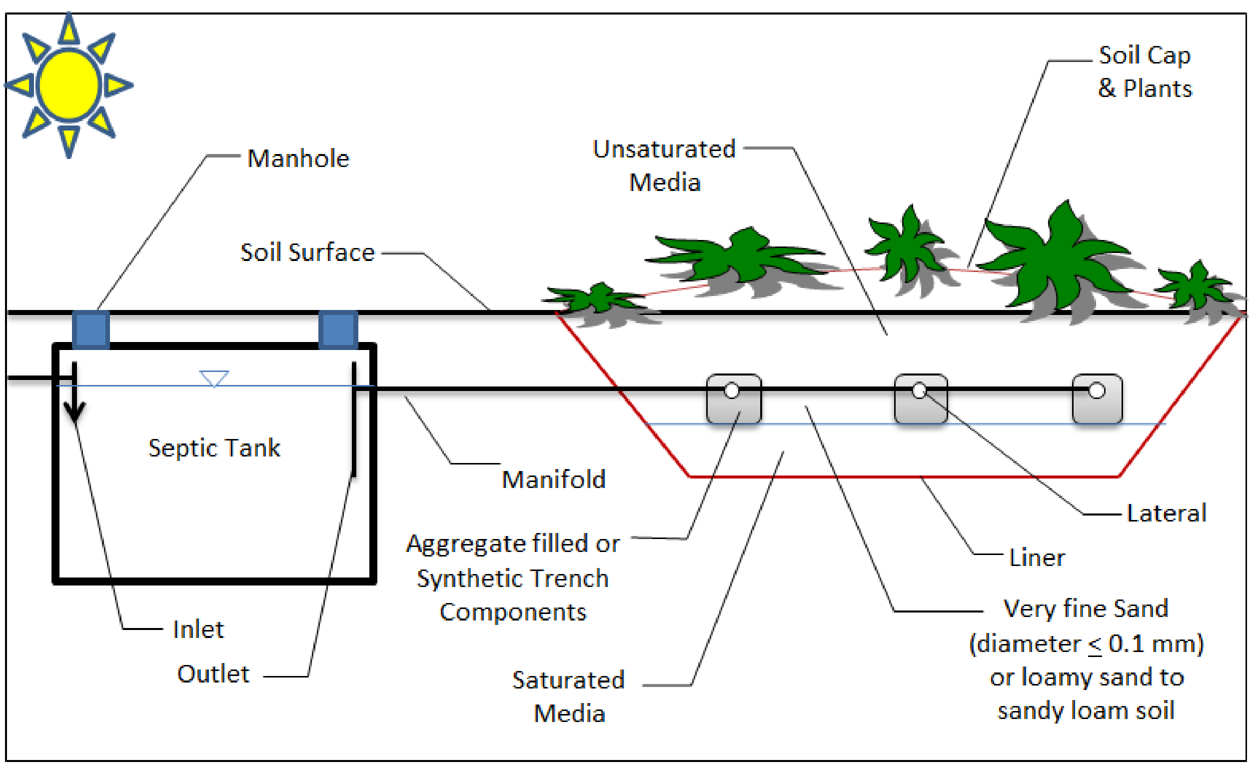

Figure 4-5. Cross-Section of Evapotranspiration System

3. Calculate the monthly effluent depth, in cubic feet/month/square foot of surface area, by using Equation 4-2. Record the monthly effluent depth in column B of the Water Mass Balance Table (Table 4-2).

Equation 4-2. ET/ETI Vertical Effluent Depth (ft): $$B = \frac{X \, {}^{Gallons}\!/_{Day} * Y \, {}^{Days}\!/_{Month} * 0.1337 \, {}^{ft^3}\!/_{Gallon}}{T_{area} \, ft^2}$$

Where T_{area} (ft^2) is the area derived from Equation 4-1(a), for an ET system, or Equation 4-1(b), for an ETI system.

4. Determine evapotranspiration in feet per month from the average growing season (March-October) reference evapotranspiration (ETr) rate for the weather station nearest the proposed project. Resources which provide this information include the Agrimet network at *http://www.usbr.gov/pn/agrimet/monthlyet.html* and the Kimberley Research and Extension station for the University of Idaho at *http://www.kimberly.uidaho.edu/ETIdaho/*.

   The ETr value may need to be adjusted for the water use efficiency of typical plant species used on the ET bed; this is done by multiplying the ETr value by a crop coefficient of 0.7. Equation 4-3 shows this calculation. If the UI Kimberly ET_{pot} dataset for grasses is used, and the system is to be covered with grass, then the crop coefficient need not be used. Record the monthly adjusted ETr or ET_{pot} values in column C of the Water Mass Balance Table (Table 4-2).

Equation 4-3. Plant Water Efficiency Adjustment: $$C = 0.7 * ETr \quad or \quad C = ET_{pot}$$

5. For ETI systems, calculate the amount of wastewater that is allowed to infiltrate the soil each month. This amount will not be allowed to exceed 10% of the monthly wastewater contribution. The infiltrative loss is restricted to 10% in order to assist the ETI system in developing a biomat within the first year. Any greater infiltration rate will allow large fluctuations in the ETI system effluent level, thereby inhibiting the development of a biomat, and yielding an undersized system once the biomat is established. A mature ETI system will have a biomat that inhibits effluent infiltration, limiting a mature system to using the soil evaporation and plant transpiration in order to function properly. Limiting monthly discharges to the soil to 10% of the monthly wastewater volume will also ensure that the system sized is large enough to function properly when it has a mature biomat inhibiting infiltration. Record these monthly infiltration values in column D of the Water Mass Balance Table (Table 4-2).

6. Determine the change in the system's effluent depth (both ET and ETI). To calculate the change in storage use the values previously recorded in Table 4-2 in the appropriate column; effluent depth in column B, evapotranspiration in column C…

   For ET systems Δ Storage = effluent depth + [precipitation - $\text{evapotranspiration}_{adjusted}$].

   For ETI systems Δ Storage = effluent depth + [precipitation - $ETr_{adjusted}$]-infiltration.

Calculate the Change in Storage (E) using Equation 4-4. Record monthly Change in Storage values in Column E (Table 4-2).

Equation 4-4. ET/ETI System Monthly Storage Depth (ft):

$$E_{Mar} = B_{Mar} + A_{Mar} - C_{Mar} - D_{Mar}$$
$$E_{Apr} = \ldots$$
$$E_{Oct} = B_{Oct} + A_{Oct} - C_{Oct} - D_{Oct}$$

7. Determine the cumulative storage for each month by adding the change in storage for that month and the previous month's cumulative storage, as shown in Equation 4-5. Calculate the cumulative storage (F) using Equation 4-5. These values are found in columns E and F of Table 4-2. Record the cumulative storage values in column F (Table 4-2) ,

Equation 4-5. ET System Cumulative Storage Depth (ft) :

$$F_{Oct} = E_{Oct}$$
$$F_{Nov} = F_{Oct} + E_{Nov}$$
$$F_{Dec} = F_{Nov} + E_{Dec}$$
$$\ldots$$
$$F_{Sept} = F_{Aug} + E_{Sept}$$

8. Determine the total bed depth required to prevent overflow. Since the bed is filled with sand, the total bed is not available for storage. An acceptable value for sand porosity is 35% (0.35). Calculate the saturated bed depth (G) using Equation 4-6. Record the saturated bed depth values in column G (Table 4-2).

Equation 4-6. ET System Saturated Bed Depth (ft):

$$G_{Oct} = \frac{F_{Oct}}{0.35}$$
$$\ldots$$
$$G_{Sept} = \frac{F_{Sept}}{0.35}$$

Select G_{max}, the largest value of saturated bed depths in column G of Table 4-2. This is the maximum effluent depth that the system will experience during the annual cycle.

9. Finally, calculate the total bed depth, D_{bed}, by adding 1.5 feet, as specified in ***ET and ETI System Design*** criteria 2.a.i and 2.a.ii, to the maximum saturated bed depth (G_{max}). If the total bed depth is greater than 4 feet, then the area of the ET/ETI bed should be increased to add the volume required to keep the ET/ETI bed maximum depth at 4 feet or less.

   If site and climate constraints warrant, the system bed depth may be increased to no greater than 6 feet from system surface; this may be accomplished by placing the bottom of excavation at 4 feet below ground surface and then mounding the system above ground surface. In such cases, the system liner is required to be extended above ground surface, adequately secured, to retain all effluent, and covered with topsoil. A pump will most likely be required to lift the septic tank effluent up into the laterals in the bed.

Construction

1. An appropriately sized septic tank must be placed prior to the ET or ETI system to provide primary clarification. Septic tanks must meet the volume requirements specified in Rule (IDAPA 58.01.03.007.07.a).
2. Lining:
    a. An ET system must be lined with an impervious liner approved by the Department. Synthetic liners must be placed on at least 4 inches of bedding sand that is free of sharp stones. The liners must be bonded per manufacturer's recommended procedures. Leak testing, as specified below, is required.
    b. An ETI system may need soil augmentation in order to decrease the infiltration rate to a value that allows no more than 10% of the daily wastewater volume to disperse into the underlying soils. Soil augmentation may be achieved by compaction, bentonite clay augmentation, or addition of soil-cement. In all instances, the liner must be designed, and construction overseen, by a PE or PG.
3. The bed should be filled with ASTM C-33 sand. The sand should be crowned at 2% to 3% to establish a slope for precipitation and snow melt runoff.
4. Distribution laterals may be placed in drain rock trenches that measure 1 foot by 1 foot and are constructed in the sand layer, or may be constructed with gravelless trench components. The piping should be looped, and spaced in order to provide uniform effluent distribution. See Figure 4-5.
5. The drain rock trenches shall be wrapped in geotextile in order to keep the sand from migrating into the void spaces provided by the drain rock.
6. A 4 to 6 inch layer of sandy loam topsoil must be placed directly on the sand of the bed, matching the slope specified for the ASTM C-33 sand.
7. An 8 inch minimum diameter standpipe shall be installed in the center of the bed. The standpipe shall extend down to the splash plate and shall extend above the topsoil a minimum of 6 inches. The purpose of the standpipe is to monitor effluent levels in the bed, provide access for maintenance pumping to reduce the salinity levels in the bed, and to provide access for emergency situations to prevent surfacing of effluent. If the ET or ETI system has an aspect ratio (AR), which is the ratio of length (L) to width (W), greater than two (2), then multiple standpipes will be required. The distance between any two standpipes should be approximately the width of the system. This may result in multiple standpipes. See Figure 4-6 for suggested stand pipe configurations.

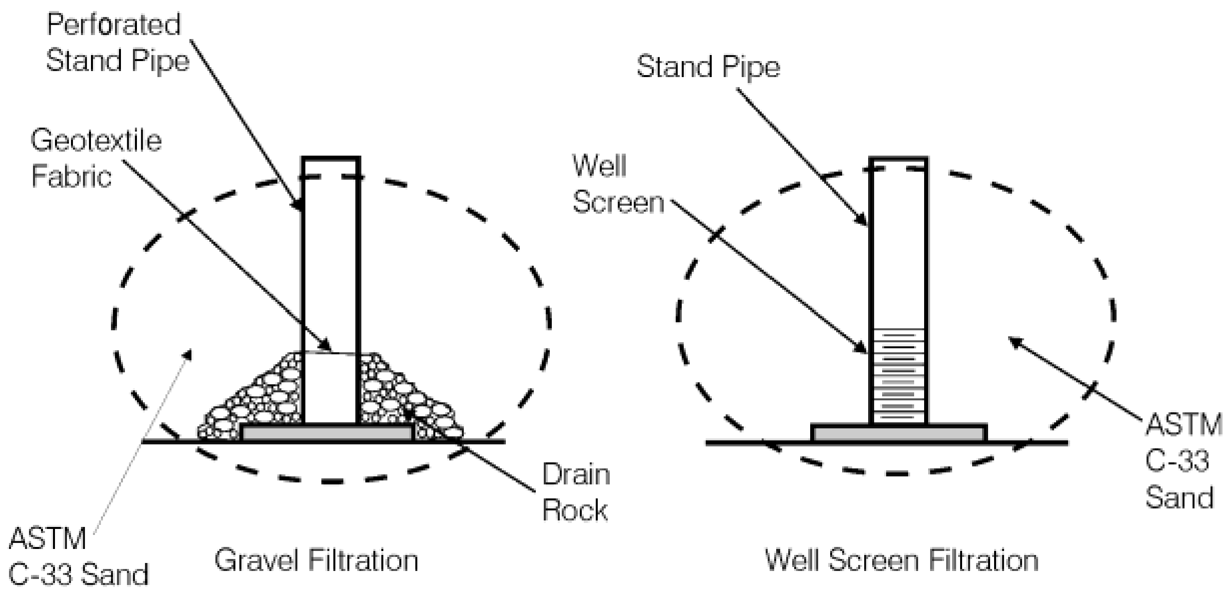

Figure 4-6. Two Examples of Properly Constructed Stand Pipes

8. The finished bed should be planted with a combination of both shallow- and deep-rooting perennials. The species chosen, particularly the deep-rooted species should be tolerant of elevated salinity levels. Small shrubs, large trees, and other woody deep-rooted plants are prohibited. Plants should be planted prior to system use, and according to an acceptable planting schedule that will minimize plant die-off due to lack of water, excessive heat or cold, or other detrimental condition.
9. The ET or ETI system should be fenced, or placed in a location that prevents small children or pets from accessing its surface.

Leak Testing

1. The ET system's liner must be leak-tested after the bed is filled with ASTM C-33 sand. This test is required to verify that the integrity of the ET system's synthetic liner has not been compromised during construction. Additionally, in an ET system, this test will verify that the synthetic liner seams have been assembled properly. The liner must pass the leak test in order to successfully pass the final inspection and receive authorization to be put into use by the Health District.
2. The leak test consists of filling the ET system with water to the inlet invert. Water may be any available water that is not classified as wastewater as specified by Rule (IDAPA 58.01.03.003.36). Allow the water to stand in the ET system for at least 5 days. This will allow time for any trapped air to be absorbed into the water. Refill the system to the inlet invert after the resting period if necessary.
3. Measure and record the elevation observed in a standpipe from an identified datum. An acceptable datum may be a predetermined point on the top edge of the standpipe. Clearly mark the selected datum for future reference and use.
4. Allow the system to lie undisturbed for at least 48 hours.

5. Return after the 48-hour dormancy period and measure the water elevation from the datum.
6. Passing criteria for an ET system is:
   a) ET system: The water elevation in an ET system shall not drop by more than one-eighth (1/8”) inch in a 24-hour period.
7. Pump out the water via the stand pipe(s) at the end of the leak test.

Operations and Maintenance Requirements

1. Fertilizing the system is not required.
2. Irrigation of the system is not required, but may be allowed during prolonged droughts or periods of excessive heat to maintain a healthy plant population. At no time should irrigation become a significant contributor to the liquid in the system. This will hydraulically overload the system resulting in surfacing effluent.
3. Monthly monitoring and recording of the system’s effluent depth is required for the first year. In subsequent years, effluent depth can be monitored and recorded quarterly. Measured effluent depths shall be submitted to the appropriate Health District annually.

   Unexpectedly low or high effluent depths shall be immediately reported to the Health District. The Health District shall assist the owner in finding the appropriate corrective action. This reporting is required because:

   a) A lack of expected effluent may indicate a leaking system.
   b) Excessive effluent, indicated by an active high water alarm, may indicate excessive water usage, leaking toilet, or excessive irrigation of the system.
4. Periodic surface maintenance may be required for any of the following reasons:
   a) In the summer, if the surface contains grasses, they should be mowed periodically, and the clippings removed and disposed of with other yard refuse.
   b) Autumn maintenance may include gently spreading leaves over the surface, and allowing the resident flora to die back. Removal of the refuse is not necessary. A thin layer of leaves will provide a thermal blanket that will keep the system from freezing during the winter.
   c) No maintenance is foreseen for winter operation.
   d) Spring maintenance may require removal of cover to allow the new growth the best opportunity to access light.
5. A pool test kit may be used to monitor effluent salinity. It is recommended that salinity tests be conducted at the end of the summer or early autumn. Record the value along with the effluent depth. Plants showing signs of stress may indicate excess salinity in the system.
6. Periodic pumping and flushing of the system may be required to prevent salinity build up. Excessive salinity will inhibit plant growth, and could reduce evaporation from the system.

The system should be pumped concurrently with the septic tank maintenance every three (3) to seven (7) years. Backflushing with clean water may be necessary to dissolve residual salts. A second pumping of the system could further reduce the system's salinity.

Use Table 4-2 for calculating water mass balance. Start with the first month in which storage will be positive. In Idaho, that is usually October. Calculations for each column in Table 4-2 are discussed below.

Table 4-2. Water Mass Balance for an ET or ETI system

Month	A. Precipita-tion Rate	B. Effluent Depth	C. Evapotrans-piration	D. Infiltration (ETI only)	E. Change (Δ) in Storage	F. Cumulative Storage	G. Saturated Bed Depth
Oct.							
Nov.							
Dec.							
Jan.							
Feb.							
March							
April							
May							
June							
July							
Aug.							
Sept.							

Additional System Considerations

1. Ion exchange water softeners, those that use salt (sodium or potassium chlorides), are not recommended for discharge to ET or ETI Systems due to excessively quick salt buildup. If an ion exchange water softener is used in the home, pumping and flushing of the system may be required multiple times a year to prevent stressing the plants and building up an impermeable salt layer inside the system.
2. Unless the net evaporation (the difference between total precipitation and evaporation) is very large, the size required for evapotranspiration systems may be impractical. At Kuna, Idaho, where the net evaporation is 25 inches per year, a system for a 3-bedroom home may exceed 10,000 square feet and have either a diameter exceeding 120 feet or be a square of about 105 feet on a side.
3. No substantiating evidence is currently available to support reduction in area required for ET or ETI designs below that which is provided herein.
4. Sources for identifying and obtaining plants recommended for populating the ET system surface may include, but not be limited to:

    a) The NRCS,

    b) University of Idaho Agricultural Extension,

    c) Rocky Mountain Native Plant Company, 3780 Silt Mesa Rd, Rifle, CO 81650

Example Evapotranspiration System Calculation

The sections below discuss each column found in Table 4-1, Water Mass Balance for an ET or ETI system.

Calculations for the Precipitation Rate (Column A)

1. Go to the Desert Research Institute's Idaho climate summary Web site at *http://www.wrcc.dri.edu/summary/climsmid.html*.

   Once there, select one of the 152 statewide sites located nearest the proposed system's site. The first Web page for the location is the Period of Record Monthly Climate Summary. In your own notes, record the 12 monthly average total precipitation values and the annual average precipitation value from this page. As shown in Equation 4-7, divide each month's average precipitation by the annual average and record the resulting value as the Monthly Precipitation Contribution (MPC).

Equation 4-7. Monthly Precipitation Contribution (Column A in Table 4-1):

$$MPC_{Jan} = Monthly\_Average_{Jan} \Big/ \sum_{X=Jan}^{Dec} Monthly\_Average_X$$

$$MPC_X = \ldots$$

$$MPC_{Dec} = Monthly\_Average_{Dec} \Big/ \sum_{X=Jan}^{Dec} Monthly\_Average_X$$

2. In the left column of this Web page, scroll down the left side and click Monthly Totals, which is under the subheading Precipitation and subheading Monthly Precipitation Listings. This will provide the Monthly Total Precipitation table (in inches) for the selected site's period of record. Evaluate the provided monthly average data, omitting any annual total if any one (1) month shows more than 3 days of data missing. Identify the remaining years of acceptable data, count the total number of valid points (# of acceptable annual average values) and then go to the Web site at *http://onlinehydro.sdsu.edu/onlinepearson2.php*, which provides assistance with calculating Flood frequency by the Log Pearson III method 2 (online Log Pearson III calculator provided by San Diego State University). To use the calculator, follow these steps:

   a) Select "U.S. Customary" units.

   b) Indicate the number of years of average annual precipitation data you have.

   c) Enter the data, using commas and no spaces to separate values, in the window that requests you to "Enter flood series Q." The number of annual data values you provide must equal the number of years you entered in step b.

   d) Click the Calculate button. Your results will appear in a new window. Your input data will appear first, followed by the results. Find and record the $Q_{10\text{-}yr}$ value.

3. Multiply the $Q_{10\text{-}yr}$ value by each month's MPC, calculated in step 1 above. Record each of these values in column A of the Water Mass Balance table (Table 4-1) in the corresponding month's row.

Calculations for Effluent Depth (Column B)

Monthly accumulation of wastewater:

1. Obtain the average daily wastewater flow for the home as specified in Rule (IDAPA 58.01.03.007.08); i.e., X = 3 bedroom home = 250 GPD. Add or subtract 50 GPD for each bedroom according to Rule 58.01.03.007.08.
2. Multiply:

   a) The home's average daily wastewater flow (X [GPD]) by the number of days in the month under consideration, yielding gallons per month.

   b) Convert each month's result to ft^3/month by multiplying by 0.1337 ft^3/gallon.

   c) Multiply the ft^3/month value by your chosen Peaking Factor (PF) [$1.0 \leq PF \leq 1.6$].

   d) Divide this product by the initial estimated ET or ETI system area (T_{ETarea} or $T_{ETIarea}$) as calculated in Equation 4-1.
3. Record the resulting effluent depth for the month under consideration in column B of the Water Mass Balance table (Table 4-1).

Calculations for Evapotranspiration (Column C)

Evapotranspiration values can be obtained from either the AgriMet Web site, from the Pacific Northwest Cooperative Agricultural Weather Network, or from the University of Idaho's Kimberley Research and Extension Station Web site.

1. If you choose to use data from AgriMet follow the directions below, otherwise skip to step 2:

   a) Because the values supplied are in inches/month, divide each month's value by 12 inches/foot (in/ft) to obtain feet/month.

   b) Use only the data for March through October and multiply each monthly value by the 0.7 adjustment factor to account for vegetation different from alfalfa. Alfalfa is the crop used to develop the AgriMet data.

   c) Record the result for each month in that month's row under column C in the Water Mass Balance Table (Table 4-1).
2. If you choose to use data from the Kimberly Research and Extension Station data, follow these steps:

   a) Access the datasets at *http://www.kimberly.uidaho.edu/ETIdaho/*. Select a weather station and click "Submit Query."

b) Select a crop, typically either:

   i) Grass – Turf (lawns) – irrigated or

   ii) Pasture Grass – high maintenance.

c) Select the potential daily ET_c (ET_{pot}).

a) Use the Monthly Mean values. The values supplied are in millimeters per day (mm/day).

   i) Multiply each value by the number of days in that month to obtain mm/month.

   ii) Divide the mm/month value by 25.4 mm/inch to obtain inches/month.

   iii) Divide the inches/month value by 12 inches/foot to obtain feet/month.

b) Record the result for each month in that month's row under column C in the Water Mass Balance Table (Table 4-1).

Calculations for Infiltration (Column D)

Calculate the allowed monthly infiltration by multiplying the daily wastewater generation rate by the number of days in the month and multiplying again by 0.10. Record each value in the corresponding month in column D.

Calculations for Change in Storage (Column E)

Calculate the change in storage (Δ Storage) for each month. This will require that you add the Precipitation, column A, to the effluent generated in the house, column B. Finally, subtract the Evapotranspiration, column C, and Infiltration, if present, column D. Record the result for each month in column E.

Calculations for Cumulative Storage (Column F)

1. To complete column F first start by copying the value for October from column E into column F.
2. Add the column E value for the next month to the previous month's value in column F. Record this value in column F.
3. Repeat the previous step for all 12 months.

Equation 4-8 gives the calculation for cumulative storage.

Equation 4-8. Cumulative Storage (Column E in Table 4-1):

$$
\begin{aligned}
F_{Oct} &= E_{Oct} \\
F_{Nov} &= F_{Oct} + E_{Nov} \\
F_{Dec} &= \ldots \\
F_{Sept} &= F_{Aug} + E_{Sept}
\end{aligned}
$$

Calculations for Saturated Bed Depth (Column G)

1. As shown in Equation 4-9, divide each month's Cumulative Storage value in column F by the porosity of the bulk material that the system is made of. Typically, the ASTM C-33 sand has a porosity of 35% (0.35). If the monthly value in column F is less than zero (0), put zero in G.

Equation 4-9. Saturated Bed Depth (Column F in Table 4-1): $G_{Oct} = F_{Oct}/0.35$

2. Identify the largest value in column G. This should occur in the spring, just prior to the start of the growing season. This value must be less than two and one-half (2.5') feet in order to accommodate the one and one-half (1.5') feet of overburden top soil and not exceed a maximum system depth of four (4') feet.
3. If the maximum depth is greater than two and one-half (2.5') feet, increase the system's surface area and recalculate.
4. If the maximum depth is less than two and one-half (2.5') feet, decrease the system's surface area and recalculate.
5. Repeat this process until a surface area is identified that yields a saturated bed depth of two and one-half (2.5') feet for the site's specific precipitation and evaporation characteristics when coupled with the future home's proposed wastewater generation rate.
6. If a suitably sized ET or ETI system is not determined, then

   a) Vary the Peaking Factor, but do not go below a Peaking Factor of one (PF ≥ 1).

   b) Vary the number of bedrooms in the home.

Table 4-2 shows sample calculations for a three-bedroom home discharging 250 GPD in the Caldwell, Idaho area into an ET System.

Table 4-1. Sample Water Mass Balance Calculations

Month	A. Precipi-tation Rate (feet)	B. Effluent Depth (feet)	C. Evapo-transpira-tion (feet)	D. Change in (Δ) Storage (feet)	E. Cumu-lative Storage (feet)	F. Saturated Bed Depth (feet)
Oct.	0.086	0.087	0.232	-0.059	-0.059	0
Nov.	0.135	0.086	0.000	0.221	0.162	0.46
Dec.	0.142	0.089	0.000	0.231	0.393	1.12
Jan.	0.152	0.089	0.000	0.241	0.634	1.81
Feb.	0.118	0.080	0.000	0.198	0.832	2.38
March	0.122	0.089	0.167	0.044	0.876	2.50
April	0.108	0.086	0.327	-0.133	0.743	2.12
May	0.111	0.089	0.449	-0.249	0.494	1.41
June	0.088	0.086	0.544	-0.370	0.124	0.35
July	0.030	0.089	0.609	-0.490	-0.366	0
Aug.	0.031	0.089	0.497	-0.377	-0.743	0
Sept.	0.058	0.086	0.368	-0.224	-0.967	0

Since this system eliminates all discharged wastewater prior to years end, and a maximum saturated bed depth of 2.5 feet appears in March, the system's size is acceptable. The lack of a saturated layer during the heat of the summer indicates that supplemental irrigation (sprinkler) will be required to maintain healthy plants.

Table 4-3 shows sample calculations for a three-bedroom home discharging 250 GPD in the Caldwell, Idaho area into an ETI system.

Table 4-2. Sample Water Mass Balance Calculations

Month	A. Precipi-tation Rate (feet)	B. Effluent Depth (feet)	C. Evapo-transpira-tion (feet)	D. Infiltration (feet)	E. Change in (Δ) Storage (feet)	F. Cumu-lative Storage (feet)	G. Saturated Bed Depth (feet)
Oct.	0.086	0.165	0.237	0.0088	0.0056	0.0056	0.006
Nov.	0.135	0.160	0.041	.0085	0.246	0.252	0.719
Dec.	0.141	0.165	0.014	.0088	0.283	0.535	1.53
Jan.	0.152	0.165	0.016	.0088	0.292	0.827	2.36
Feb.	0.119	0.149	0.033	.008	0.226	1.053	3
March	0.121	0.165	0.110	.0088	0.167	1.22	3.48
April	0.108	0.160	0.306	.0085	-0.047	1.17	3.35
May	0.111	0.165	0.44	.0088	-0.173	1	2.86
June	0.088	0.160	0.485	.0085	-0.246	0.754	2.15
July	0.030	0.165	0.52	.0088	-332	0.422	1.2
Aug.	0.032	0.165	0.461	.0088	-0.273	0.932	2.66
Sept.	0.058	0.160	0.353	.0085	-0.143	0.789	2.25

Since there is an excess remaining at the end of the year, this system's area will have to be increased and the calculations repeated. This process is continued until an area is identified that yields no excess effluent in the system at the end of the year.