Scope

Install gutters and downspouts on homes to direct rainwater down and away from the home, to reduce the chances of saturating the soil around the foundation.

- Install adequately sized gutters and downspouts.
- Connect the downspouts to piping that will carry the water to a sloping final grade ? 5 ft. from the foundation or to an underground catchment system ? 10 ft. from the foundation that is not connected with the foundation drain system (EPA Indoor airPLUS).
- Or, install a rainwater harvesting system that includes a drainage system to handle overflow.
- Or, construct a grade-level rock bed with a waterproof liner and drain pipe to collect water that drains from the roof.

ENERGY STAR does not require gutters for homes that have a slab-on-grade foundation or are in a dry climate. (See the Compliance Tab for other ENERGY STAR exceptions.)

For homes without gutters, install protection from water splash damage (per EPA Indoor airPLUS) in one of the following ways:

- Extend the foundation walls at least 16 in. above final grade; OR
- Provide a drip line that is horizontally 16 in. away from the edge of the foundation wall; OR
- Use cladding material that can tolerate regular wetting and install a well-sealed, continuous drainage plane that extends at least 16 in. above the final grade (e.g., brick veneer or stone cladding with self-adhering moisture control membrane).

See the Compliance Tab for related codes and standards requirements, and criteria to meet national programs such as DOE’s Zero Energy Ready Home program, ENERGY STAR Certified Homes, and Indoor airPLUS.
A few inches of rain falling on the roof of a house can produce several thousand gallons of water runoff (EPA 2015). This runoff must be channeled away from the building foundation to keep the basement or crawlspace dry and to prevent water from seeping into the building interior where it may create moisture problems. If not drained away from the house, the immense volume of water coming off the roof can quickly saturate the soil surrounding the building and wick through the foundation to the interior. (See Figure 1.) Once inside, this moisture can lead to a variety of problems, including mold and rot. Moisture in homes is both a cause of indoor air quality problems and an important factor affecting the durability of the building (Lstiburek and Brennan 2001).

![Figure 1 - If not drained away from the house, the volume of water coming off a roof in a large rainstorm can quickly saturate the soil and wick through the foundation into the interior of the building.](buildingscience.com)

As a whole-house best practice, it is important to design the house exterior with climate-appropriate flashing, overhangs, gutters, downspouts, and drainage planes to shed rainwater and conduct it away from the house (Baechler et al. 2010). A system of gutters and downspouts is particularly important to keep water away from the building foundation in areas with expansive and/or collapsible soils.

Expansive soils swell when they get wet and can put extreme pressure on foundations, even to the point of causing cracking or uplift of foundation materials. Collapsible soils are loose soils that shrink in volume when they become wet, causing the ground to collapse. At the very least, when these soils get wet around a building, they can create a trough that collects water, increasing the likelihood of that water seeping into the foundation. In extreme cases, some collapsible soils can sink to the point of dislodging or cracking a building foundation (Colorado Geological Survey 2011). The assessment of whether the soil is expansive or collapsible needs to be completed by a certified hydrologist, soil scientist, or engineer.

**Controlling Roof Runoff**

As outlined in the scope, builders have four options for dealing with rain water runoff from a roof:

- Install gutters and downspouts that terminate at least 5 feet away from foundations. OR
- Install gutters and downspouts that terminate to an underground catchment system at least 10 feet away from foundations. OR
- An alternative option to gutters is to deposit rainwater to a grade-level rock bed with a waterproof liner and a drain pipe where water terminates on a sloping finish grade at least 5 feet from the foundation. OR
- If a rainwater harvesting system is installed, properly design the drain to adequately manage the overflow and meet discharge-distance requirements.

**Gutters System Basics**

Gutter systems consist of two parts: 1) gutter channels that run horizontally along the roof edge to collect runoff and 2) the downspouts that carry the collected water down to grade level. Gutters or other drainage systems are needed in all but the driest climates of the United States. In cold climates, gutters will freeze and should be avoided. Instead, in cold climates, grade-level drainage systems should be installed (as described below).
Gutter channels are typically available in 4-, 5-, and 6-inch sizes. They are referred to be their shape; there are K-style gutters (also known as "ogee" because the shape resembles this molding type) and U-style gutters (or half round), as shown in Figure 2. The style is principally aesthetic; there is no substantial difference in performance. A larger size will conduct more water at a faster rate, provided there are enough downspouts to drain the gutter channels (EPA 2015).

![K-style gutter](image1) ![U-style gutter](image2)

**Figure 2** - Standard gutter styles found in building supply centers include the "K" and "U" styles. The difference is purely aesthetic.

Both styles are readily available in vinyl, aluminum, galvanized steel, and copper. All materials weather well, although copper and galvanized steel have the advantage of withstanding impacts from ladders and tree branches better than vinyl and aluminum, which can crack or dent.

Install gutters along the roof eaves so they slope at least 1/16 inch per foot of run. This will provide positive drainage to direct water toward the downspouts.

Downspouts conduct water from the roof to grade-level. They should terminate at least 5 feet from the foundation, or to an underground catchment system located at least 10 feet from the foundation (Figure 3).

**Figure 3** - Unless downspouts are connected to an underground catchment system or storm sewer system, they should drain to daylight at least 5 feet from the foundation.

**How to Install Downspouts**

1. Install downspouts every 20 to 50 feet along the gutter. The more closely downspouts are spaced along the gutter, the more water can be conducted away during peak rainstorms.
2. Connect the end of the downspout to lateral piping made from non-perforated flexible ABS or Schedule 40 PVC pipe.
3. Extend the lateral piping at least 5 feet from the building. Use a level and tape measure to ensure that the pipe is pitched away from the foundation at a minimum 5/8-inch per foot (a 5% slope).
4. Terminate the lateral pipe to daylight (or to a catchment system or storm sewer). It is critical that a daylight drain empty onto a sloped grade that directs water away from the building and does not allow water to drain back towards the building. A splash block placed at the end of the lateral pipe will help control erosion to this location (EPA 2012).

**How to Install a Downspout Drain**

1. Install drains for the gutters and downspouts that terminate to an underground catchment system at least 10 feet away from foundations or direct water to an underground storm sewer or other approved discharge point. Use a non-perforated, smooth or corrugated plastic pipe as the drain.
2. If a rainwater harvesting system is installed, properly design the drain to adequately manage the overflow and meet the discharge-distance requirement of 10 feet.

3. Connect and seal the pipe directly to the downspout.

4. Bury the drain pipe at a slope consistent with the final grade around the home (i.e., sloped ? 0.5 inch per foot away from home for ? 10 feet). Do not connect the gutter drain pipe to the perforated foundation drain pipe; this practice will soak the foundation (see Figure 4).

![Figure 4](image-url)  
*Figure 4 – Use proper site grading, footing drains set in coarse gravel, gravel beneath the slab, free-draining plus impermeable backfill, and a polyethylene vapor barrier to protect the foundation from water intrusion.*

**Grade-Level Drainage System.**

In cold and very cold climates, where snow can accumulate on roofs, the water in gutters can freeze. Therefore, gutters should be avoided in cold and very cold climates. Instead, install a grade-level drainage system that conducts roof run-off away from the foundation, as shown in Figure 5.
How to Install Grade-Level Drainage

1. Design and install the foundation so that there will be 8 to 16 inches of foundation wall showing between the ground at grade level and the first course of siding. This will prevent splash back from damaging siding materials.

2. Install a perimeter foundation drain at the footing level as described in the guide Footing Drain Pipe. The standard foundation drainage system shown in the graphic above consists of Schedule-40 perforated piping and clean stone that is isolated from the surrounding soils by filter fabric.

3. Backfill the foundation drainage system with a well-draining backfill material.

4. Stop backfilling 16 to 18 inches from grade level. 3a) Lay a piece of EPDM rubber roofing or other impervious membrane in the trench to isolate the grade-level drainage system from the foundation drainage system. 3b) Lay landscape fabric and 1 or 2 inches of clean rock or gravel in the pipe. 3c) Install Schedule-40 PVC or ABS perforated pipe, or similar perimeter drainage piping with the perforations facing down. This piping should extend past the corner of the foundation at least 5 feet and drain to daylight or connect to a catchment system or storm sewer. 3d) Backfill around the drainage pipe with 4 to 6 inches of addition clean stone and wrap the filter fabric over the rock with 4 to 6 inches of overlap. Bring the sides of the EPDM isolation membrane up the sides of the trench to create a contained channel so water is drained off by the perforated piping and does not overflow and saturate the foundation backfill.

5. Install an additional 4 to 6 inches of clean stone over the landscape fabric (EPA 2012).

Underground Catchment System

As an alternative to draining roof runoff to daylight, the downspout can connect to a catchment system, storm sewer, or rainwater harvesting system. Figure 6 depicts one type, known as a drywell, that can be installed, but many types of both underground and above-grade catchment systems are available. When designed to collect roof runoff and properly drain overflow, rainwater harvesting systems, which retain the water in a tank for use in watering landscaping, may also be used to meet roof drainage requirements.
Figure 6 - A roof runoff catchment system, such as the drywell shown here, must be located at least 10 feet from the building foundation.

How to Install a Catchment System

1. Connect downspouts to lateral piping that extends at least 10 feet from the foundation.

2. Provide overflow protection to alleviate the water load during peak rain events. Locate overflow pipe at a branch in the downspout, or tee-off near the top of the catchment basin. If it branches off the downspout, as shown in this illustration, it must extend at least 5 feet from the building foundation and drain to daylight.

3. 3a. Install a clean-out in the catchment basin. In a drywell, as shown here, this clean-out consists of a perforated pipe through the center of the gravel that allows the basin to be flushed out periodically. The clean-out should also connect to the lateral pipe to allow leaves and other debris to be removed.

3b. Isolate the catchment basin with a geotextile filter fabric to prevent soil intrusion from clogging the system.

3c. Fill the basin area with coarse gravel. One to 1½-inch gravel is typical. Small gravel will tend to clog too quickly (EPA 2012).

A Note about Kick-Out Diversers for Climates with Heavy Rainfalls

In climate zones that have heavy rainfalls which can overwhelm gutter capacity, a diverter (also known as “kick-out flashing”) should be integrated with the house wrap. Step-by-step instructions for kick-out diverters can be found in the guide Step and Kick-Out Flashing at Roof-Wall Intersections and in Chapter 12 of Baechler et al. (2010).
Ensuring Success

Gutters and downspouts need to be sized to accommodate anticipated water loads. The number of downspouts will depend on the cross-section dimension of the downspout material. Allow 1 square inch of downspout cross-section for every 100 square feet of roof area. Place downspouts at least 20 feet apart but no more than 50 feet apart. Foresight in the design of the building façade may be necessary to accommodate this downspout spacing (JLC 2003). Lateral piping at the end of each downspout should also be given careful design consideration because typically a 5-foot lateral channel will get in the way of lawn mowing and other yard activities.
Climate

The following are some climate-specific considerations:

- **Hot-Dry and Mixed-Dry Climate.** Gutters are not necessary in dry climates. However, do install a wide roof overhang to keep the drip line from occasional rainwater and melted snow away from the structure and do slope the grade away from the building.

- **Hot-Humid and Mixed-Humid Climates.** In areas with heavy rains, increase gutter and rain leader capacity \(\text{(Baechler et al., 2011a; Baechler et al., 2011b)}\). Install kick-out diverter flashing to prevent high-water volumes from spilling over the gutter and running down the wall. Step-by-step instructions for kick-out diverters can be found in the guide \text{Step and Kick-Out Flashing at Roof-Wall Intersections}.\!

- **Marine Climate.** In areas with potentially high winds and heavy rains, increase gutter and rain leader capacity to accommodate heavy rain and large roof areas. Use metal rather than vinyl gutters and downspouts in areas susceptible to forest fire \(\text{(Baechler et al., 2010)}\).

- **Cold and Very Cold Climates.** Avoid the use of gutters in high snow load locations. Use metal rather than vinyl gutters and downspouts in areas susceptible to forest fire \(\text{(Baechler et al., 2011c)}\).

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Gutters and downspouts are not required in Dry (B) climates as shown in the IECC climate zone map (2009 IECC Figure 301.1 and Table 301.1).
Training

Right and Wrong Images

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Compliance

The Compliance tab contains both program and code information. Code language is excerpted and summarized below. For exact code language, refer to the applicable code, which may require purchase from the publisher. While we continually update our database, links may have changed since posting. Please contact our webmaster if you find broken links.

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Water Management System Builder Requirements

3. Water-Managed Roof Assembly.
3.2 For homes that don’t have a slab-on-grade foundation and do have expansive or collapsible soils, gutters & downspouts provided that empty to lateral piping that discharges water on sloping final grade ? 5 ft. from foundation, or to underground catchment system not connected to the foundation drain system that discharges water ? 10 ft. from foundation. Alternatives & exemptions in Footnote.3, 13, 14

Footnote 3) Not required in Dry (B) climates as shown in 2009 IECC Figure 301.1 and Table 301.1.

Footnote 13) The assessment of whether the soil is expansive or collapsible shall be completed by a certified hydrologist, soil scientist, or engineer.

Footnote 14) Any of the following are permitted to be used as alternatives to Item 3.2: a) a roof design that deposits rainwater to a grade-level rock bed with a waterproof liner and a lateral drain pipe that meets discharge requirements per Item 3.2; b) a rainwater harvesting system that drains overflow to meet discharge requirements per Item 3.2; or c) a continuous rubber membrane (e.g. EPDM) that is aligned with the foundation wall from final grade to 8 in. below grade and then slopes 0.5 in. per ft. away from the home for at least 5 ft., with Group I Soils (as defined in Footnote 8) covering the membrane to within 3 in. of final grade.

Please see the ENERGY STAR Certified Homes Implementation Timeline for the program version and revision currently applicable in your state.

DOE Zero Energy Ready Home (Revision 07)

Exhibit 1 Mandatory Requirements.

Exhibit 1, Item 1) Certified under the ENERGY STAR Qualified Homes Program or the ENERGY STAR Multifamily New Construction Program.

Exhibit 1, Item 6) Certified under EPA Indoor airPLUS.

EPA Indoor airPLUS (Revision 04)

1.7 Gutters, Downspouts and Site Drainage.

- Provide extra protection for water splash damage on homes meeting one of the following ENERGY STAR exceptions for gutters and downspouts: slab on grade homes, homes that deposit rainwater to a grade-level rock bed with a waterproof liner and drain pipe, or homes that use a continuous rubber membrane system. Protection for water splash damage shall be met by one of the following:
  - Extend the foundation walls at least 16 in. above final grade; OR
  - Provide a drip line at eaves that is horizontally 16 in. away from the edge of the foundation wall; OR
  - Use cladding materials that are decay and rot resistant and can tolerate regular wetting extending at least 16 in. above final grade and install a well-sealed, continuous drainage plane per manufacturer’s instructions.
  - Advisory: The use of self-adhering moisture membranes directly on exterior sheathing should be limited in these applications to encourage drying potential of moisture vapor through the wall assembly. A moisture resistant, non-perforated, and vapor permeable housewrap is preferred. (However, this may not be true for all wall assemblies where 50% or more of the insulation is outboard the structural assembly.)

Exceptions to Indoor airPLUS requirements: Dry climates, as defined by 2015 IECC Figure 301.1. Homes with rainwater harvesting systems that are designed to properly drain overflow, meeting discharge-distance requirements outlined in ENERGY STAR Builder-W Item number 3.2.

The Indoor airPLUS Construction Specifications document notes that completion of the ENERGY STAR Water Management System checklist now satisfies the following Indoor airPLUS requirements:

- Direct roof water away from the house using gutters and downspouts that empty into lateral piping on a sloping finish grade (Builder-W 3.2); OR
- Direct roof water to an underground catchment system not connected to the foundation drain system that discharges water ? 10 ft. from foundation (Builder-W 3.2).
Case Studies

   - **Author(s):** PNNL
   - **Organization(s):** PNNL
   - **Publication Date:** September, 2013
   - Case study of a DOE Zero Energy Ready Home in west Connecticut that scored HERS 39 without solar PV. The 3,000 ft² two-story home has R-33 double-walls, R-72 flat roof with closed-cell foam and blown cellulose, an ERV, and LED lighting.

   - **Author(s):** PNNL
   - **Organization(s):** PNNL
   - **Publication Date:** September, 2013
   - Case study of a DOE Zero Energy Ready Home in Downers Grove IL that scored HERS 35 without PV. This 3,600 ft² custom home has advanced framed walls with R-23 dense-packed fiberglass plus R-13 rigid polyiso, a sealed attic with open-cell spray foam, a pier foundation, and 95% efficient gas furnace.

References and Resources*

   - **Author(s):** Baechler, Gilbride, Hefty, Cole, Adams, Butner, Ortiz, Love
   - **Organization(s):** Pacific Northwest National Laboratory, Oak Ridge National Laboratory
   - **Publication Date:** September, 2011
   - Report describing measures that builders in mixed-humid climates can use to build homes that have whole-house energy savings of 40% over the Building America benchmark with no added overall costs for consumers.

   - **Author(s):** Baechler, Gilbride, Hefty, Cole, Williamson, Love
   - **Organization(s):** Pacific Northwest National Laboratory, Oak Ridge National Laboratory
   - **Publication Date:** September, 2010
   - Report providing builders in marine climates with guidance for building homes that have whole-house energy savings of 40% over the Building America benchmark with no added overall costs for consumers.

3. **Building America Best Practices Series Volume 12: 40% Whole-House Energy Savings in the Cold and Very Cold Climates**
   - **Author(s):** Baechler, Gilbride, Hefty, Cole, Love
   - **Organization(s):** Pacific Northwest National Laboratory, Oak Ridge National Laboratory
   - **Publication Date:** February, 2011
   - Guide describing measures that builders in the cold and very cold climates can take to build homes that have whole-house energy savings of 40% over the Building America benchmark with no added overall costs for consumers.

4. **Collapsible Soils Case Histories**
   - **Author(s):** Colorado Geological Survey
   - **Organization(s):** Colorado Geological Survey
   - **Publication Date:** April, 2011
   - Information sheet discussing building foundation problems caused by settling soil in Colorado.

5. **JLC Field Guide to Residential Construction**
   - **Author(s):** Journal of Light Construction
   - **Organization(s):** Journal of Light Construction

6. **READ THIS: Before You Design, Build or Renovate**
   - **Author(s):** Lstiburek, Brennan
   - **Organization(s):** Building Science Corporation
   - **Publication Date:** December, 2006
   - Document with important building science considerations, designed for members of the residential construction and remodeling industries, as well as owners and managers who work in affordable housing.
7. Water Management System Builder Checklist Guide
   Author(s): U.S. Environmental Protection Agency
   Organization(s): EPA
   Publication Date: February, 2011
   
   Guide describing details that serve as a visual reference for each of the line items in the Water Management System Builder Checklist.

*Publication dates are shown for formal documents. Dates are not shown for non-dated media. Access dates for referenced, non-dated media, such as web sites, are shown in the measure guide text.

Contributors to this Guide
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