5. LOW IMPACT DEVELOPMENT DESIGN STANDARDS

Low Impact Development (LID) requires a shift in stormwater management away from conveying runoff to a small number of downstream points through hydraulically efficient infrastructure toward retaining and using the runoff as close as possible to the source of the runoff. The use of distributed stormwater management infrastructure should be evaluated during site planning and site design.

During site planning, the planner must consider the site's natural hydrology when locating proposed improvements. The planner should identify hydrologic features including existing flow paths, areas with higher permeability soils, and riparian areas. Objectives of LID are to minimize the impact to these areas and to attempt to mimic natural hydrologic processes in impacted areas.

Another goal of site planning is to design the development to function within the smallest possible footprint.

Once site layout is completed, the designer must consider the appropriateness of other LID practices that can be constructed to reduce runoff discharge rates and volumes by slowing down flow and retaining runoff for beneficial use.

This chapter provides minimum criteria for constructed LID practices proposed during site design.

5.1 Low Impact Development General Requirements

1. Projects shall retain the first 0.5 inch of rainfall that flows off of impervious and disturbed surfaces (first-flush retention). The applicant shall demonstrate that the required retention volume, calculated by Table 2.1, is provided within stormwater harvesting basins or within a detention basin.

2. Site planning shall occur to minimize disturbed, compacted and connected impervious surfaces and to protect and enhance regulated riparian habitat, regulatory floodplains and other high permeability areas.

3. Where present, connections between impervious and disturbed areas shall be minimized.

4. LID practices shall be distributed throughout the project site.

5. Inspection and maintenance protocols are required for all projects using LID practices. The inspection and maintenance protocols shall be reviewed and approved by the Floodplain Administrator prior to approval of the tentative plat or development plan.

6. To allow for inspection and maintenance, LID practices shall be legally and physically accessible.

7. Upon completion of construction of all LID practices, an As-built Certification shall be prepared and submitted to the Floodplain Administrator and to the entity responsible for maintenance. The As-built Certification shall be used by the responsible party when performing periodic inspections and when restoring the LID practices to design specifications, if required. The Floodplain Administrator may use the As-built Certification during enforcement actions.

8. When LID practices are to be maintained by a private entity, such as a homeowners association, this responsibility shall be described in the association's Covenants, Conditions and Restrictions which shall refer to the inspection and maintenance protocol and As-Built Certification.

5.2 Low Impact Development General Prohibitions

1. Although the use of stormwater and rainwater harvesting facilities on private residential lots is encouraged, any retention volume on private residential lots shall not be counted towards the first-flush retention or detention requirement.

2. The volume of rainwater harvesting cisterns or other practices that do not allow for infiltration of runoff to occur shall not be counted towards satisfying the first-flush retention requirement.

5.3 Stormwater Harvesting Basins

5.3.1 General Standards for Stormwater Harvesting Basins

The following standards are applicable to all stormwater harvesting basins.

1. Stormwater harvesting basins shall be located so that the basin can effectively capture and retain stormwater.

2. Stormwater harvesting basins shall be designed to retain no more than 9 inches and no less than 6 inches of stormwater. The depth is measured from the lowest elevation on the basin floor to the 100-year water surface of the basin.

3. Minimum freeboard for stormwater harvesting basins is 3 inches.

4. Basin floors shall allow for uniform ponding across the entire basin.

5. When terraced cells are proposed, each cell of a terraced basin may be considered separately when determining basin depth, and each cell shall allow for uniform ponding.

6. Stormwater harvesting basins shall be constructed entirely below finished grade, except when designing basins within existing natural flow paths. Alternative designs require approval by the Floodplain Administrator.

7. All side slopes of a stormwater harvesting basin shall be 3:1 or flatter unless the side slope is rock lined.

8. Except for Rainfall Only Non-contributing Basins, stormwater harvesting basins shall be designed with an inlet. The inlet shall meet the following criteria:
   a. The inlet shall be located to accept flow from the contributing watershed.
   b. Inlet erosion protection shall be placed at a width sufficient to encompass flow expansion downstream of the inlet. Non-grouted rock shall consist of minimum 4-inch rock hand-placed in 2 layers on filter fabric level with finished grade. Grouted rock shall be embedded into the concrete a minimum of ½ the rock diameter with flat faces placed to provide a level surface. Other inlet protection as approved by the Floodplain Administrator may be utilized.
   c. Rock berms or other pervious rim 4 to 6 inches high shall be placed at the downstream end of the inlet to provide a sediment trap, as shown in Figure 5.1.

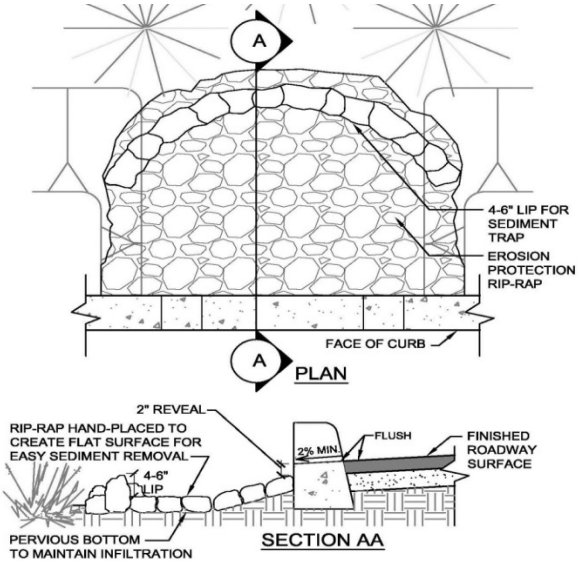

Figure 5.1 Sediment Trap

d. When a stormwater harvesting basin is located adjacent to a parking area, the inlet shall be sized to prevent ponding greater than 1 foot deep during the 100-year event within the parking area.

9. When an outlet is proposed, the outlet shall meet the following criteria:
   a. The outlet shall be located where it does not pose a hazard to pedestrian circulation or create an adverse impact to structures, infrastructure or adjacent properties. The outlet discharge shall not exceed the capacity of downstream infrastructure or Balanced or Critical Basin discharge requirements.
   b. Outlet erosion protection shall be provided as follows:
      i. For outflows onto earthen surfaces, outlet protection shall be provided at a width sufficient to encompass flow expansion downstream of the outlet. When rock is not grouted, it shall consist of minimum 4-inch angular rock hand-placed in 2 layers on filter fabric. Grouted rock shall be embedded in concrete a minimum of ½ the rock diameter; or
      ii. For outflows onto pavement, a 4-inch thick concrete cut-off wall shall be placed at the outlet extending to the basin floor.

10. When stormwater harvesting basins with terraced cells are proposed, internal check dams to pond water shall be provided.
    a. The minimum freeboard shall be measured from the top of the check dam to the lowest finished grade adjacent to each cell.
    b. Check dams shall be keyed in a minimum 12 inches into the side of the basin.

11. For safety and access purposes, stormwater harvesting basins shall have the following setbacks, as measured from the top of the basin slope:
    a. Minimum 1 foot from a sidewalk or other pedestrian access path and from off-street parking areas.
    b. Minimum 2 feet from back of curb or edge of pavement for streets with on-street parking.
    c. Minimum 6 inches from back of curb or edge of pavement for streets with no on-street parking.
    d. Minimum 10 feet from structures, or minimum setback specified in a geotechnical report for the project.
    e. Minimum 4 feet from the property boundary or other access space for maintenance access.

12. Landscaping within stormwater harvesting basins is encouraged with the following conditions:
    a. All areas within a stormwater harvesting basin except for check dams may be used for planting area.

b. Planting domes or other raised areas on the basin floor are acceptable as long as retention volume is maintained.
c. Hydroseeding is allowed within a stormwater harvesting basin. The seed mix shall have plant species from the Approved Plant List provided in Appendix B of the Pima County Regulated Riparian Habitat Mitigation Standards and Implementation Guidelines available on the Rules and Procedures page of the District's web page.
d. Original design volume shall be maintained over the life of the project.

13. LID practices in subdivisions shall be located in Common Area, easement designated for drainage, or other publicly accessible space.

5.3.2 Stormwater Harvesting Basin Prohibition

1. Invasive non-native plants located within a stormwater harvesting basin are not allowed and must be removed if found within the basin. A list of the invasive non-native plants can be found in Appendix E of the Pima County Regulated Riparian Habitat Mitigation Standards and Implementation Guidelines available on the Rules and Procedures page of the District's web page.

5.4 Roadside Stormwater Harvesting Basins

When a roadside stormwater harvesting basin is proposed to be located within a public right-of-way, a right-of-way use permit shall be obtained prior to construction as required.

When a roadside stormwater harvesting basin is proposed to be located adjacent to a private street, the basin should be located within Common Area or within a drainage easement.

Whether the location is public right-of-way or private property, site design shall include careful consideration of the location of utilities and access points.

The following standards apply to stormwater harvesting basins that are located adjacent and parallel to a street for the purpose of collecting runoff from the street:

1. Curb openings for roadside stormwater harvesting basins shall meet the following criteria:
   a. Curb openings shall be separated from driveway aprons and other curb openings by a minimum distance of 10 feet;
   b. Curb openings shall be located a minimum of 20 feet from an end of a curb return (corner);
   c. Curb openings proposed on existing curbs (retrofit) shall be made by a saw cut method; and
   d. Curb openings shall be a maximum of 2 feet in width with 45-degree sloped sides.

e. The bottom of the curb cut shall be a minimum 4 inches below any other point along the edge of the basin.

2. Basin side slopes shall be 3:1 or flatter.

3. The maximum water storage depth shall be 9 inches, and freeboard depth shall be a minimum of 3 inches.

A typical cross section is provided in Figure 5.2.

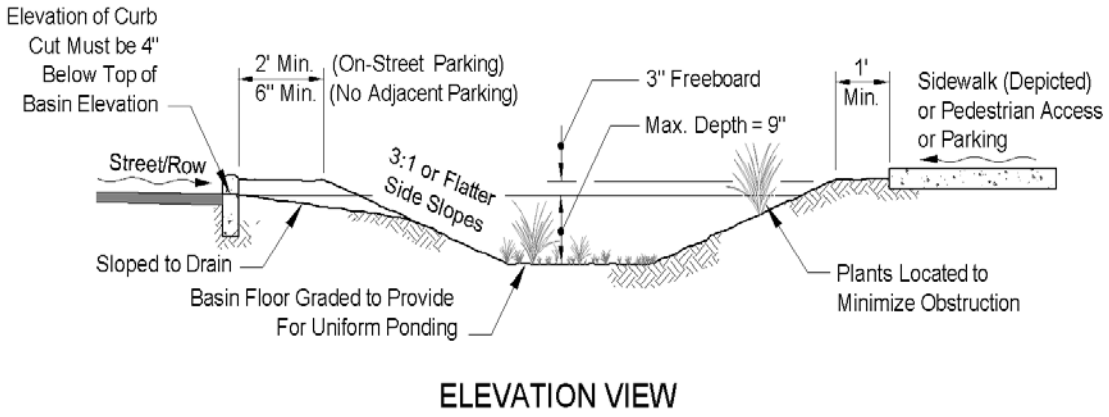

Figure 5.2 Roadside Stormwater Harvesting Basin

5.5 Stormwater Harvesting Basins Adjacent to Parking Areas

When stormwater harvesting basins are proposed adjacent to parking areas, the top of the basins shall be separated horizontally from edge of the parking area by a minimum of 1 foot.

5.6 Non-contributing Basin Standards

Non-contributing Basins are basins designed to retain the full 100-year stormwater volume and can be excluded from calculations to determine post-development peak discharges. Non-contributing Basins shall be designed to meet the following standards:

1. The maximum water storage depth shall be 9 inches.

2. A minimum of 3 inches of freeboard shall be provided for Non-contributing Basins.

3. Non-contributing Basins shall be located where they do not pose a safety hazard or create an adverse impact to adjacent properties and structures.

4. Basin bottoms shall provide for uniform ponding.

5. Side slopes shall be 3:1 or flatter.

6. For Expanded Area Non-contributing Basins, the ratio of the upstream drainage area to the pervious basin bottom shall not exceed 2:1.

7. The use of parking and access lane areas for retention and freeboard is allowed for Expanded Area Non-contributing Basins.

Figure 5.3 illustrates a concept for Expanded Area Non-contributing Basins, capturing the full volume from adjacent parking areas, which have drainage areas meeting the upstream drainage area ratio of 2:1.

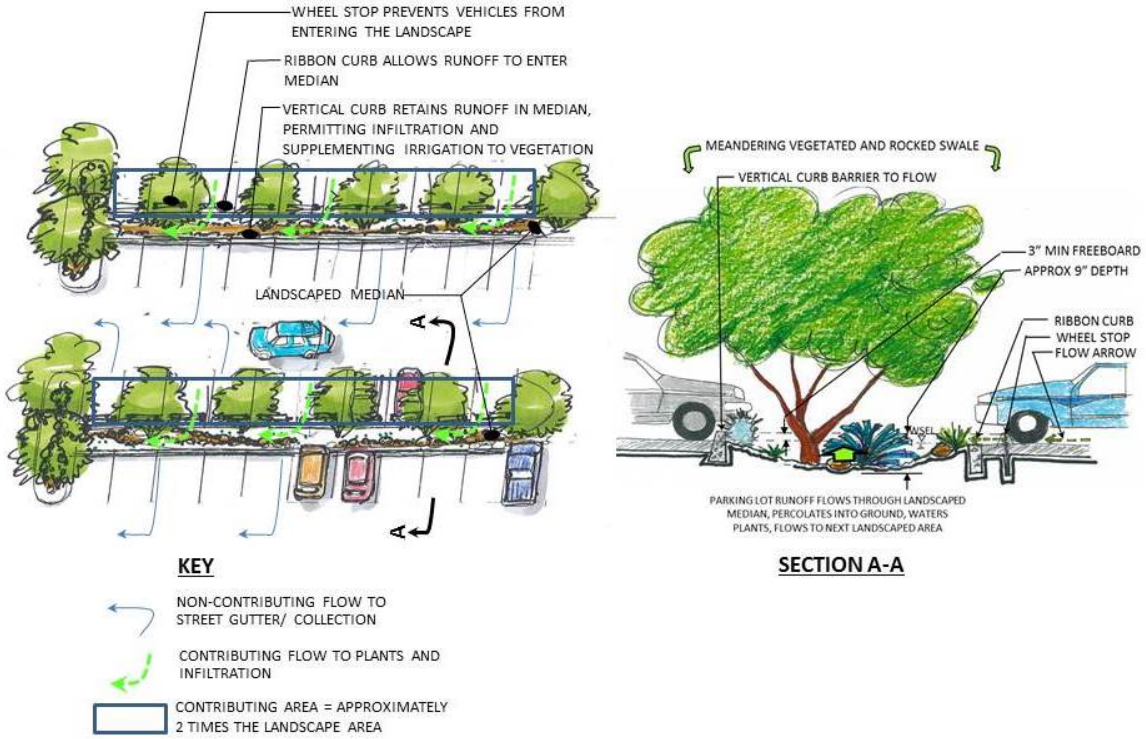

Figure 5.3 Expanded Area Non-contributing Basin in a Parking Lot Median

5.7 Bioretention Basin

Bioretention basins are engineered basins consisting of an over-excavated area that is replaced with a constructed soil medium to aid in runoff storage and infiltration.

1. The bioretention basin shall consist of:
   a. A subbase of a 6-inch to 24-inch layer of coarse aggregate (gravel) that is washed to remove fine material; and
   b. A soil media barrier placed between the subbase and a constructed soil medium. The Floodplain Administrator may approve use of a filter fabric or other subbase containment if conveyance requirements must be met.
   c. A constructed soil medium that is a mixture of sand (85% ASTM C-33 sand by volume) and organic material (15%) such as peat, top soil, mulch, or compost which has been mixed in a drum mixer. The constructed soil medium shall be 16 inches to 36 inches deep. Alternative soil media require prior approval by the Floodplain Administrator.

2. The bioretention basin shall have a flat-topped surface that is depressed a minimum of 6 inches and a maximum of 12 inches below adjacent finished grade. Side slopes shall be 3:1 or flatter.

3. Because soil bearing capacity within a potential zone of saturation may be reduced, bioretention basins shall be set back horizontally from a structure a minimum of 5 feet, unless an appropriate alternative setback is justified by a geotechnical engineer registered in the State of Arizona prior to approval of the tentative plat or development plan.

4. Bioretention basins shall include a sediment trap located at the downstream end of the inlet, as shown in Figure 5.1.

5. A vertical inspection pipe shall be provided in order to assess the effectiveness of the bioretention basin. The pipe shall be perforated 4-inch PVC or equivalent and shall extend from the bottom of the gravel sub-base to the top of the constructed soil medium with a removable cap. See Figure 5.4.

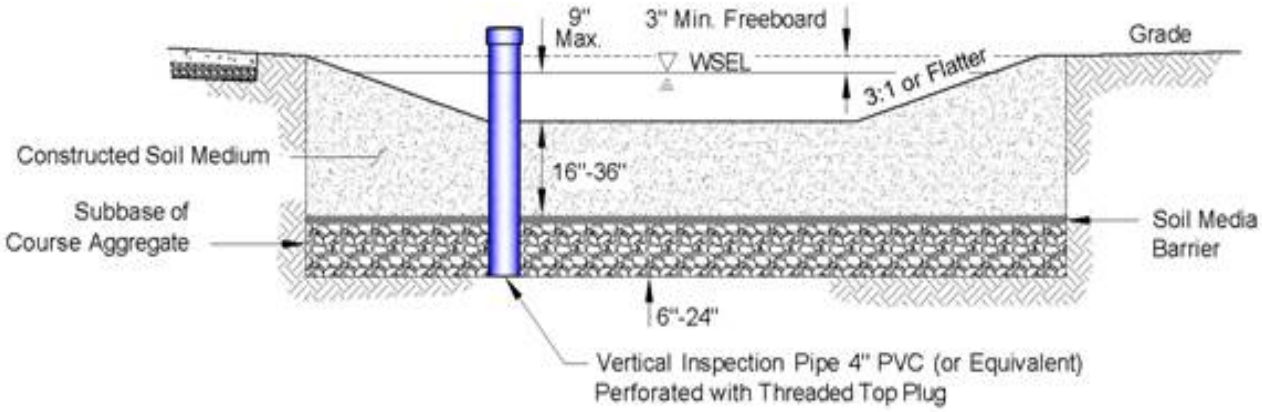

Figure 5.4 Bioretention Basin

5.8 Retention within a Detention Basin

A retention area for first-flush retention or stormwater harvesting may be constructed within a detention basin. Areas not designated for retention may be used for landscaping or riparian habitat mitigation. The following standards, illustrated in Figure 5.5, apply:

1. A maximum of 9 inches of retention is allowed. The depth is measured from the lowest elevation on the basin floor to the lowest outlet invert elevation.

2. The retention area shall connect the basin inlet to the outlet, and meet the following criteria:
   a. The width of the retention bottom area shall be a minimum of 4 feet to allow for maintenance of this area;
   b. Any plantings or invasive vegetation in the retention area are prohibited and shall not obstruct maintenance activities or compromise the design volume.
   c. The use of check dams in the retention area in order to create cells of uniform depth is allowed.
   d. The retention area floor shall provide for uniform ponding.
   e. Retention areas shall have 3:1 or flatter earthen side slopes.

3. If vegetated areas on terraces above the retention area are proposed, the following apply:
   a. Berms to harvest stormwater are allowed on the terraces.
   b. If bermed, terraces shall provide for uniform ponding. Planting terraces shall be elevated to the top of the retention area.

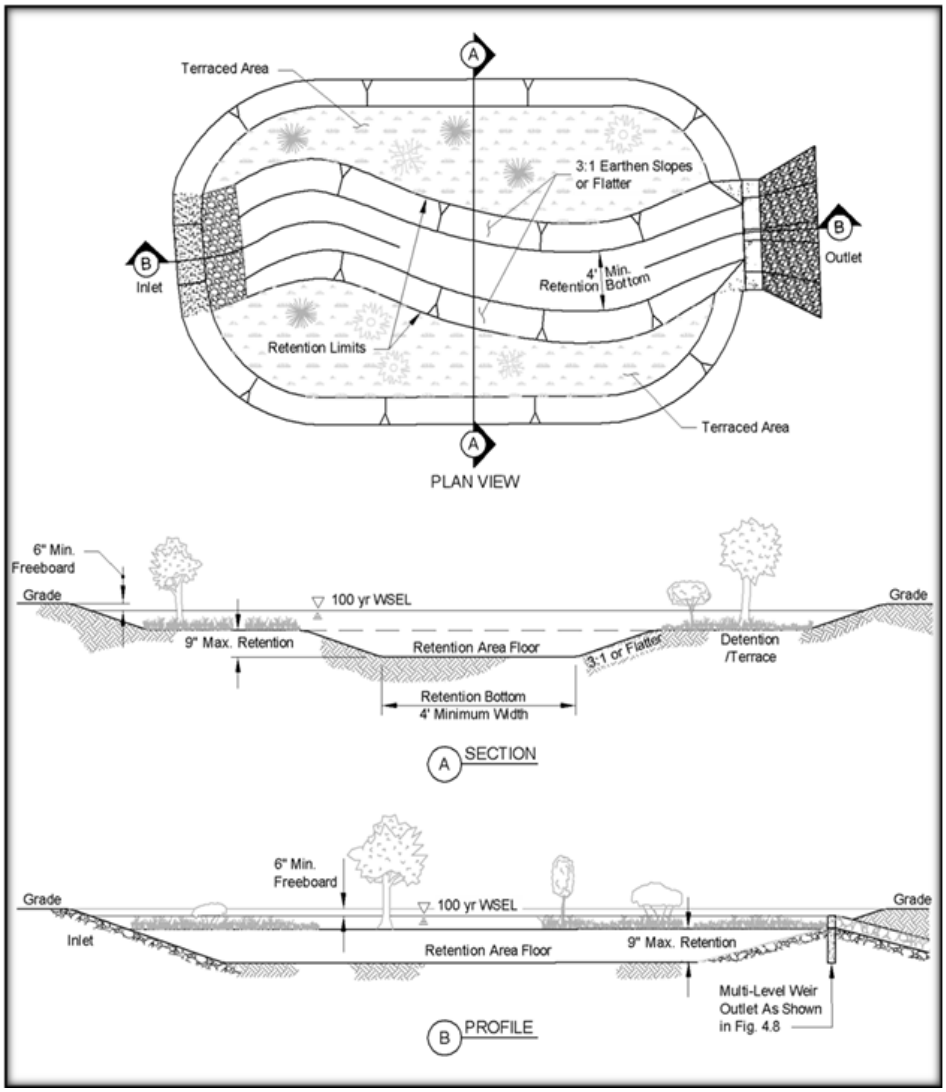

Figure 5.5 Terraced Detention Basin with Retention

5. 9 Pervious Pavements

Pervious pavements can be used to infiltrate or store water. Because pervious pavement systems include a permeable paving surface and a subsurface material that can hold water, they can reduce runoff peak and volume. Use of pervious pavements for commercial and residential projects may require a variance from the transportation department of the governing jurisdiction. Pavement design should be performed when pervious pavements are proposed for areas of vehicular use. Acceptable types of pervious pavement installations are provided below.

5.9.1 Porous Gravel

Porous gravel is well-suited for industrial applications that do not pose a risk to groundwater and rural, low-traffic uses. A low-traffic commercial parking area is shown in Photo 5.1, and a gravel cross section is shown in Figure 5.6.

Photo 5.1 Porous Gravel Installation

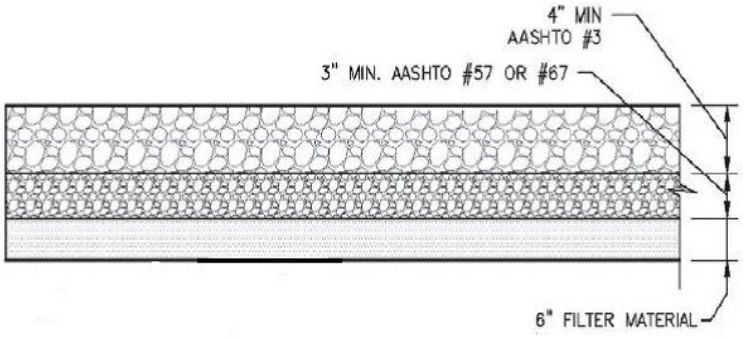

Figure 5.6 Porous Gravel Cross Section

5.9.2 Concrete Grid Pavement

Concrete grid pavement consists of a concrete matrix with a minimum of 20% of free-draining surface area. A concrete grid installation is shown in Photo 5.2, and a grid cross section is shown in Figure 5.7.

Photo 5.2 Concrete Grid Pavement Installation

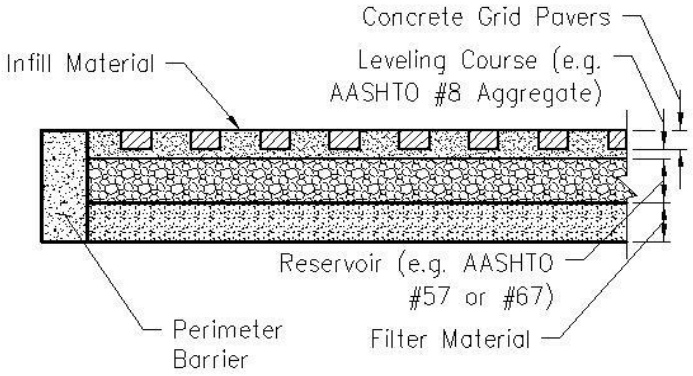

Figure 5.7 Concrete Grid Cross Section

5.9.3 Permeable Interlocking Concrete Pavement

Permeable interlocking concrete pavement (PICP) consists of impervious concrete blocks placed to allow a minimum of 5% of open surface area. A PICP installation for parking adjacent to a street is shown in Photo 5.3, and a paver cross section is shown in Figure 5.8.

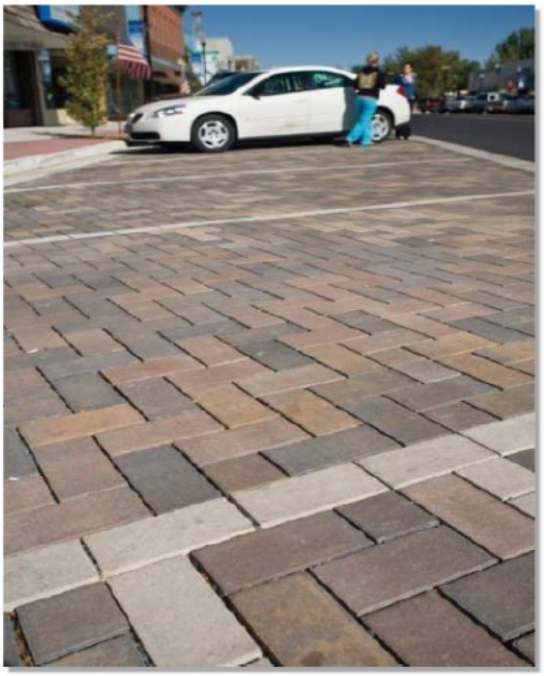

Photo 5.3 PICP Installation

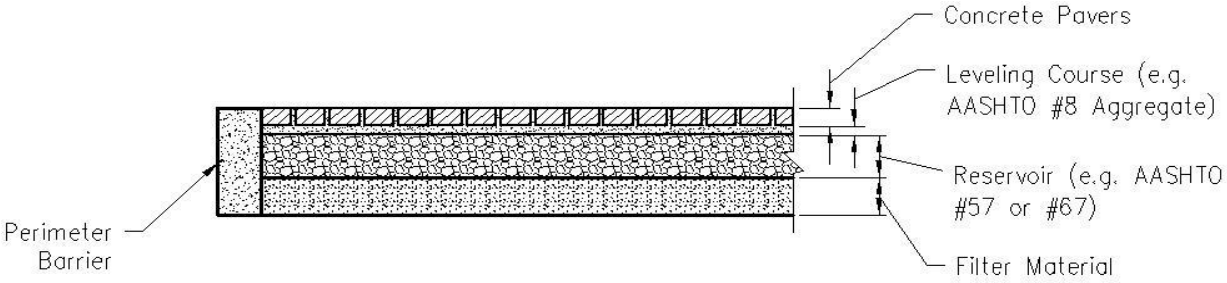

Figure 5.8 PICP Cross Section

5.9.4 Pervious Concrete

Pervious concrete allows water to infiltrate because it does not contain fine aggregate. A pervious concrete installation is shown in Photo 5.4, and a concrete cross section is shown in Figure 5.9.

Photo 5.4 Pervious Concrete Installation

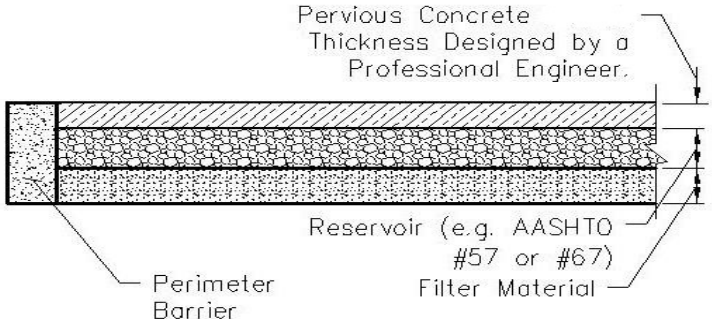

Figure 5.9 Pervious Concrete Cross Section

Specifications for other types of pervious pavement installations may be approved by the Floodplain Administrator.

5.9.5 General Standards for Pervious Pavements

Pervious pavements are suitable for low speed vehicular use areas, such as parking lots, as well as sidewalks and other pedestrian use areas. To date, most pervious pavements are not as well suited for higher speed moving live loads such as traffic on roadways.

The following standards apply to pervious pavements:

1. Pervious pavements shall be protected from materials that can clog interstices, such as oil, grease and sediment during construction and during the life of the project.

2. A geotechnical report by a registered Arizona civil engineer shall specify appropriate setbacks from structures and foundations, bedding materials and other structural site elements and affirm that the soil under the pervious pavement is suitable for infiltration.

3. The primary components of a pervious pavement system shall include a permeable paving surface, a reservoir material, such as crushed rock, and a filter material. A leveling course is required for concrete grid and PICP systems.

4. The leveling course shall consist of American Association of State Highway and Transportation Officials (AASHTO) #8 aggregate or approved equal.

5. Aggregate that forms the reservoir layer shall be uniformly graded and shall conform to the AASHTO material size standard #67 or #57, or other size standard which may be approved by the Floodplain Administrator. AASHTO #57 or #67 materials can be assumed to have a reservoir porosity of 0.4. The reservoir volume should be considered for design of pavement drainage areas, but the volume shall not be counted toward detention or retention requirements because imperfect maintenance can result in blockage of infiltration.

6. Filter materials remove pollutants and are required for pervious pavement systems. A granular filter without a geotextile is required, unless an alternate design is approved by the Floodplain Administrator. A 6-inch thick filter layer consisting of materials conforming to the gradation presented in Table 5.1 below shall be installed as the bottom layer of pervious pavement systems.

Table 5.1 Pervious Pavement System Filter Material Gradation

Sieve Size	Mass Percent Passing Square Mesh Sieves
19.0 mm (3/4")	100
4.75 mm (No. 4)	60 – 100
300 µm (No. 50)	10 – 30
150 µm (No. 100)	0 – 10
75 µm (No. 200)	0 - 3

5.10 Practices that Increase the Time of Concentration

Peak discharge rates may be reduced through the use of site design which allows for increased infiltration. This can be accomplished by increasing the length of the flow path, by flattening slopes, and by roughening the surface. When these practices are proposed, the following standards apply.

5.10.1 Lengthened Flow Path Standards

Lengthened flow paths shall occur in swales or channels which meet the following criteria. A channel or swale qualifies as a conveyance designed to lengthen flow path when it provides a longer flow path than the shortest, most linear, most direct route between upper and lower portions of a site watershed.

1. Swales and channels shall meet current channel design standards, including freeboard.

2. When 100-year flow velocities are 3 feet per second or less, earthen swales are allowed. Earthen swales may be allowed for higher 100-year velocities when a project site soils sieve analysis prepared by a geotechnical engineer registered in the State of Arizona is submitted, along with acceptable engineering justification of a higher value based on acceptable methods such as those provided in the Federal Highway Administration's Highways in the River Environment or those adopted by the Natural Resources Conservation Service.

3. When 100-year flow velocities are greater than 3 feet per second, swales shall be rock lined unless an engineering analysis justifies that no erosion protection is necessary.

4. Swales may be lined with angular rock with a D_{50} of at least 4 inches to roughen the flow path.