

4. When 100-year water depths exceed 2 feet and pedestrian circulation occurs within 5 feet of the top of a basin, a security barrier shall be constructed. Pedestrian circulation includes ingress/egress to structures, sidewalks, parking or other accessory structures.
5. When vehicle maintenance access is required, a gate or bollards shall be provided at the appropriate location.

#### **4.11.2 Security Barrier Prohibitions**

1. The use of vegetation as a security barrier is prohibited.
2. Security barriers shall not restrict the hydraulic capacity of basin inlet and outlet structures.

### **4.12 Perimeter Walls**

#### **4.12.1 Perimeter Wall Standards**

1. When perimeter walls have openings that allow flow to enter into a basin, erosion protection that meets the minimum standards of Section 4.8 for inlets shall be provided.
2. When a wall is proposed within 5 feet of the horizontal location of the 100-year water depth, a report from an engineer registered in the State of Arizona shall be provided prior to approval of the construction permit that contains at least the following:
  - a. The appropriate minimum setback from the top of slope; and
  - b. Specific structural design requirements with details.

#### **4.12.2 Perimeter Wall Prohibitions**

1. Perimeter walls shall not block maintenance access.
2. Perimeter walls shall not restrict the hydraulic capacity of inlet or outlet structures.
3. Perimeter walls are not allowed on embankments.

### **4.13 Underground Storage**

#### **4.13.1 Underground Storage Standards**

1. Design considerations shall include underground storage location and emergency flow conveyance to assure foundation stability and safe conveyance of flow in the event of blockage or failure of an underground storage system.

2. All stormwater collected during a storm event shall be removed within the disposal time specified in Section 4.5.
3. Underground storage shall have inlets and outlets which meet the design standards found in Sections 4.8 and 4.9.
4. Underground storage systems shall provide 1.5 times the required 100-year detention volume. The additional 50% of the volume can be provided on the surface so that issues with improper drainage are observable.
5. Minimum underground storage chamber size shall be 5 feet, unless manholes are provided for inspection and maintenance.
6. To provide for safe discharge of flow when the volume of an underground storage system is exceeded, an overflow outlet shall be provided which discharges to a drainage path which can convey flow away from structures, electrical equipment, pedestrian pathways, handicap-accessible ramps, hazardous materials, and other areas where stormwater is likely to create damage to health, welfare or property.
7. A separate covenant which specifies, or Conditions, Covenants and Restrictions (CCRs) which include, inspection and maintenance responsibilities shall be recorded when a project includes an underground storage system. An example covenant can be found in Appendix G. The covenant or CCRs shall be reviewed and approved by the Floodplain Administrator prior to approval of the development plan or plat. For separate covenants, a properly executed covenant shall be provided to the Floodplain Administrator for recording prior to approval of the development plan. For CCRs, Floodplain Administrator approval is required prior to plat approval, and the CCRs will be recorded by the Development Services Department.
8. Prior to approval of the tentative plat or development plan, a report from an engineer registered in the State of Arizona shall be provided that contains at least the following:
  - a. Appropriate building setbacks from the underground storage system related to structural integrity;
  - b. Certification that the load bearing capacity of the soils underlying the underground storage structure is adequate and the soil complex is appropriate bed material;
  - c. Structural design details; and
  - d. Other design recommendations if appropriate.

#### **4.13.2 Underground Storage Prohibitions**

1. Where underground storage is proposed, failure or blockage of the system shall not pose a hazard to public safety or property.
2. Infiltration as a means of disposal is prohibited, without prior approval of the Floodplain Administrator.
3. Providing first flush retention underground is prohibited.

#### **4.14 Setbacks**

##### **4.14.1 Setback Standards**

1. For maintenance access, a minimum 4-foot setback from basins and appurtenances, including basin outlets and outer toes of embankments but not including outlet protection, to the project boundary or to the limit of other access space shall be provided.
2. Because soil bearing capacity within a potential zone of saturation may be reduced, structures shall be set back at least 15 feet from a basin, unless an appropriate alternative setback is justified by an engineer registered in the State of Arizona prior to approval of the tentative plat or development plan.
3. When a wall is proposed within 5 feet of the horizontal location of the 100-year water surface elevation, a report from an engineer registered in the State of Arizona shall be provided prior to approval of the construction permit that contains at least the following:
  - a. The appropriate setback; and
  - b. Specific structural design requirements with details.

#### **4.15 Elevation Requirements**

1. Any electrical equipment, excluding submersible pumps, within the basin shall be elevated 1 foot above the 100-year water surface elevation of the basin, unless an engineer registered in the State of Arizona certifies that the electrical equipment when inundated does not pose any hazard to public health or safety.

#### **4.16 Maintenance Access**

##### **4.16.1 Maintenance Access Standards**

1. Maintenance access is required for all basins, and the access must be shown on the plans and described in the project drainage report.

2. In order to provide maintenance access, a minimum 4-foot setback from basin appurtenances and outer toes of embankments, not including outlet protection, to the project boundary or to the limit of other access space, such as right-of-way, shall be provided. An example of a setback from a property line is shown in Figure 4.1.

#### **4.17 Landscaping other than Riparian Habitat Mitigation**

##### **4.17.1 Landscaping Standards**

1. Vegetation may be planted on a basin floor or on a basin side slope that is 3:1 or flatter except in areas within a 20-foot radius of the basin inlet, outlet or maintenance access ramp. Plants on the perimeter of a basin shall not obstruct drainage entering or exiting the basin.
2. Plants which can withstand inundation shall be selected.
3. Plants shall be spaced to allow access for maintenance.
4. Trees located adjacent to a required security barrier shall be placed an appropriate distance from the barrier to assure that the tree at maturity does not reduce the structural integrity of the security barrier.
5. Hydroseeding is allowed on the basin floor and 3:1 or flatter side slopes. Plant species used in the seed mix shall be selected 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.

##### **4.17.2 Landscaping Prohibitions**

1. Any vegetation within the 20-foot radius described in Section 4.17.1 is prohibited.
2. Landscaping shall not be located within maintenance access ramps.
3. The use of decomposed granite or rock less than 4 inches in diameter on the basin floor is prohibited, except paths within multi-use basins.
4. Invasive non-native plants located within a basin are not allowed, except turf grass within multi-use basins.

## **4.18 Pumps**

### **4.18.1 Pump Standards**

1. The use of a pump may be allowed if site constraints prevent the basin from having positive drainage. Site constraints may include topography, existing infrastructure and conflicting code requirements. Approval to use a pump shall be obtained from the Floodplain Administrator prior to the first submittal of the tentative plat or development plan.
2. If a pump is proposed, the detention system shall provide an emergency spillway directed to a local watercourse that does not cause an adverse impact to the watercourse or neighboring properties and one of the following:
  - a. Additional basin volume to contain the entire volume of the 100-year post-developed hydrograph from the drainage area contributing to the basin; or
  - b. A back-up pump with an emergency power source. If an emergency back-up generator is proposed, the generator shall be elevated 1 foot above the 100-year water surface considering total pump failure or shall be waterproofed.
3. Service equipment (excluding components whose design requires submersion) shall be set at an elevation 1 foot above the unattenuated 100-year water surface elevation, considering total failure of the pump system.
4. Outlets shall be designed to meet the requirements found in Section 4.9.
5. Pumps shall be in an accessible location for routine maintenance and emergency service.
6. Basins with a pump shall meet the storage time standards found in Section 4.5.
7. The collection system shall discharge into a separate sump that screens the water before entering the pump sump. The sump location and dimensions shall be shown on the plan set.
8. A clogging factor of 2.0 shall be used for the trash rack/screen design.
9. The pump shall be designed to pass 3-inch solids.
10. A pump shall be provided with an automatic control switch with a vertical float mechanism as well as a manual control.
11. A potable water supply with hose bibs shall be provided to aid in removal of silt and trash.

12. Each pump shall have an alarm system for high water and low water alarm with, at minimum, the following:
  - a. A light that provides a visual alert;
  - b. The name and phone number of a responsible party clearly displayed on the pump housing and alarm system;
  - c. Housing that is vandal proof and weather resistant; and
  - d. Other Floodplain Administrator recommendations as appropriate.
  
13. A separate covenant which specifies, or Conditions, Covenants and Restrictions (CCRs) which include, inspection and maintenance responsibilities shall be recorded when a project includes a pump. An example covenant can be found in Appendix G. The covenant or CCRs shall be reviewed and approved by the Floodplain Administrator prior to approval of the development plan or plat. For separate covenants, a properly executed covenant shall be provided to the Floodplain Administrator for recording prior to approval of the development plan. For CCRs, Floodplain Administrator approval is required prior to plat approval, and the CCRs will be recorded by the development services department.
  
14. The project's drainage report shall provide the following information:
  - a. Emergency back-up plan;
  - b. Drainage exhibit showing drainage flow under clogged conditions; and
  - c. Maintenance Plan with at minimum the following:
    - i. Maintenance schedule;
    - ii. Type of maintenance activities; and
    - iii. Exhibit showing the location of the pump, alarm systems and other equipment.
  
15. A pump system analysis shall be submitted for Floodplain Administrator review and approval with the tentative plat or development plan. The analysis shall include:
  - a. Site Data
    - i. Contributing drainage area(s);
    - ii. Location of outfall;
    - iii. Capacity of outfall; and
    - iv. Inflow hydrograph(s).
  
  - b. Pump System Components
    - i. Specifications for the model and type of pump(s) proposed including pump curves (single pump and parallel operation). Overloading the pump anywhere on the pump curve is not permitted.
    - ii. Location and specifications for intakes and catch basins;
    - iii. Controls and alarm system;
    - iv. Debris handling;
    - v. Location of potable water supply; and
    - vi. Location and design of emergency overflow.

c. Hydrologic/Hydraulic Analysis

- i. Headloss calculations for the entire system, including maximum and minimum Total Dynamic Head (TDH) and flow rate;
- ii. Net positive suction head (NPSH) and pump level settings for on, off and alarm positions; and
- iii. Inflow and outflow hydrographs and accumulated inflow and outflow curves (mass flow curves). The use of HEC-HMS is not appropriate for the design of pump systems. A real-time procedure which routes the design inflow hydrograph using pump on and off elevations and actual pump performance curves must be used.

**4.18.2 Pump Prohibition**

1. The pump's discharge rate shall not exceed the pre-developed conditions 2-year peak discharge rate.

**4.19 Dry Wells**

**4.19.1 Dry Well Standards**

1. When site constraints justify use of a dry well or dry wells to dispose of detention volume, approval to include a dry well or dry wells in basin design shall be obtained from the Floodplain Administrator prior to the first submittal of the tentative plat or development plan. When requesting the approval, the engineer must submit field investigation results and a preliminary site plan.
    - a. The field investigations shall include:
      - i. Logs for soil borings to the anticipated depth of the dry well; and
      - ii. Determination of depth to groundwater in the proposed locations of drywells;
    - b. The preliminary site plan shall include at minimum:
      - i. The location of the proposed dry well(s);
      - ii. The location of proposed structures with building footprints;
      - iii. Parking lot layout including pedestrian circulation; and
      - iv. The general drainage scheme.
  2. Where dry wells are proposed as the sole method of outflow, the basin shall be designed to retain the total of the 100-year storm.
  3. Where a dry well is proposed, failure of the system shall not pose a hazard to public safety or property.
-

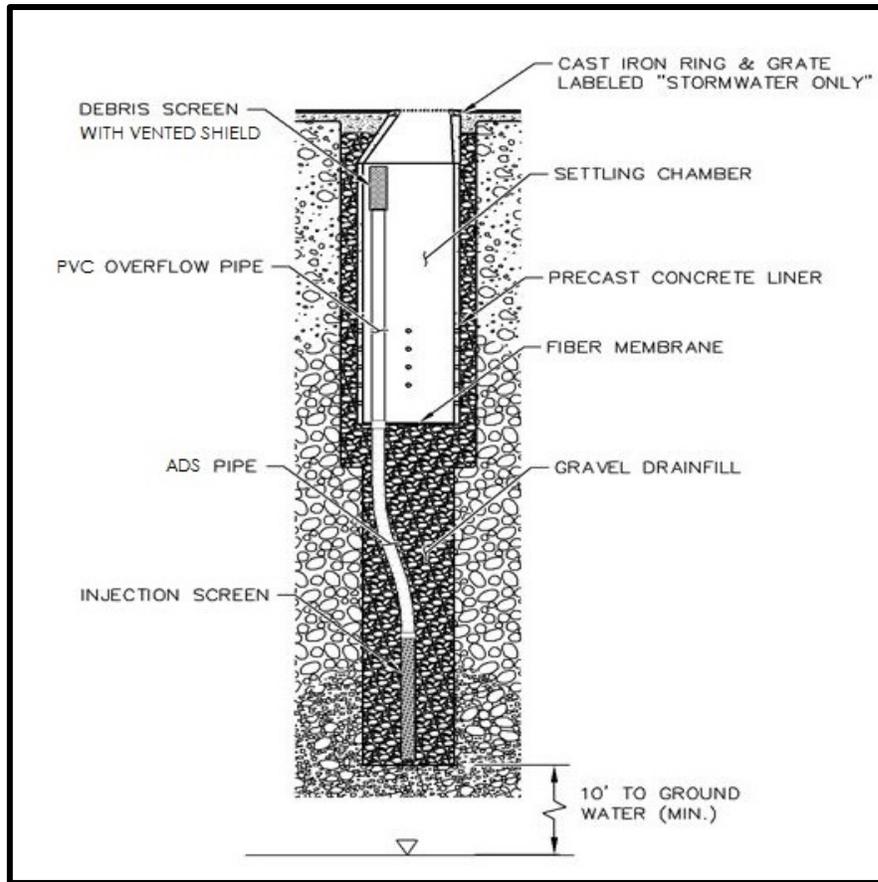
4. Dry wells shall be registered with the Arizona Department of Environmental Quality (ADEQ) and designed, operated, and maintained in conformance with the most current ADEQ guidelines.
5. To design the dry well(s), either a percolation test or an evaluation of the soils from the boring logs shall be used to determine a stabilized infiltration rate.
6. De-rating is required to compensate for deterioration of the percolation capacity over time and to provide a factor of safety for silting and grate obstruction. Test results shall be de-rated, using Equation 4.1, based on the in-situ soil conditions.

Equation 4.1       $P_d = \frac{P_r}{D_r}$

Where:     $D_r$       =      The de-rating factor.  
              $P_d$       =      The design percolation rate in inches/hour,  
              $P_r$       =      The measured or assumed percolation rate in inches/hour, and

- a. The following de-rating factors shall be used:
    - i. A de-rating factor of 2 for coarse-grained soils (cobbles, gravels and sands),
    - ii. A de-rating factor of 3 for fine grained soils (silts and loams), and
    - iii. A de-rating factor of 5 for clay soils.
  - b. The design disposal rate for a dry well, after application of the de-rating factor, should not be less than 0.1 cfs per well nor more than 0.5 cfs.
  - c. A sufficient number of drywells shall be provided to drain the basin with the storage time required pursuant to Section 4.5.1
  - d. Dry wells not performing to the original design standards shall be refurbished or replaced by the owner or a representative.
7. Dry wells shall be located into a permeable porous stratum to provide a minimum distance of 10 feet between the water table or an impermeable layer and the base of the injection screen and shall be a minimum distance of 100 feet from any water supply well.
  8. When dry wells are proposed, the basin floor shall be sloped to the dry wells at a minimum of 0.5% to assure that all wells are utilized for lower water levels.
  9. Multiple drywells shall be spaced a minimum of 100 feet apart.
  10. A dry well shall be located a minimum of 20 feet from the basin inlet.

11. If landscaping is proposed on the basin floor, the dry well inlet shall be raised at least 3 inches and may be raised up to 9 inches above the basin bottom elevation for first flush retention.
12. The dry well shall be accessible for routine maintenance and inspection and shall be protected from damage by vehicles.
13. The design of a dry well shall include provisions for trapping sediment within a settling chamber.
14. The system shall use a floating absorbent blanket or pillow to enhance the removal of petroleum-based organics floating on the water, and a hydrophobic petrochemical absorbent with a minimum capacity of 100 ounces per chamber shall be provided.
15. During site development, 1 dry well per basin shall be tested to demonstrate that the assumed percolation rate is valid. All dry wells shall be securely covered with filter cloth or other material to prevent silt infiltration during construction. Prior to Release of Assurances or Certificate of Occupancy, dry wells shall be re-tested if a dry well has been compromised during construction. If the re-test indicates reduced dry well performance, the dry well shall be restored to design specifications prior to Release of Assurances or Certificate of Occupancy.
16. Landscaping shall be installed a minimum of 4 feet from the perimeter of the bolted ring and grate.
17. Dry well grates shall be 24 inch cast iron stamped with the raised letters "Stormwater Only".
18. A separate covenant which specifies, or Conditions, Covenants and Restrictions (CCRs) which include, inspection and maintenance responsibilities shall be recorded when a dry well is used as a method of stormwater disposal. An example covenant can be found in Appendix G. The covenant or CCRs shall be reviewed and approved by the Floodplain Administrator prior to approval of the development plan or plat. For separate covenants, a properly executed covenant shall be provided to the Floodplain Administrator for recording prior to approval of the development plan. For CCRs, Floodplain Administrator approval is required prior to plat approval, and the CCRs will be recorded by the Development Services Department.
19. A typical dry well installation is shown in Figure 4.8. A photo of a commercial basin with a dry well installation is shown in Photo 4.5. Debris that has collected after a storm event is evident in Photo 4.5. Regular maintenance and providing clearance around the inlet are important management practices for dry wells.



**Figure 4.8 Typical Dry Well Installation**



**Photo 4.5 Detention Basin Dry Well Installation**

20. The project's drainage report shall provide the following information:
  - a. Plan for emergency stormwater disposal in the event the dry well(s) cease(s) to function; and
  - b. Maintenance Plan with at minimum the following:
    - i. Maintenance schedule,
    - ii. Type of maintenance activities,
    - iii. Exhibit showing the location(s) of the dry well(s), and
    - iv. Contact information of the driller or authorized maintenance professional.

#### **4.19.2 Dry Well Prohibitions**

1. Disposal methods using infiltration shall not be permitted for stormwater runoff which carries significant concentrations of sediment. This includes stormwater runoff flowing through sand bed channels, as well as stormwater runoff emanating from a predominantly natural watershed.
2. Dry wells are prohibited for industrial developments and other areas where hazardous waterborne pollutants may enter a dry well.
3. In multi-use basins, dry well inlets shall not pose a hazard to pedestrian safety.
4. Landscaping shall not impair dry well function.

## **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 and convey stormwater runoff through the distributed stormwater management infrastructure.

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 except as follows:
  - a. For residential subdivisions where density is less than 2 units per acre and where natural drainage patterns are preserved, on-lot retention volume may be counted toward first-flush retention when:
    - i. The residences are subject to requirements of the Green Building Program or other equivalent standard,
    - ii. Stormwater harvesting areas are located and sized to accept and retain, at a minimum, the 0.5 inch of rainfall from impervious and disturbed areas on each lot,
    - iii. Easements or other encumbrances are provided to alert owners of the purpose of and responsibility for the stormwater harvesting areas,
    - iv. The remaining first-flush retention requirement associated with the rest of the development is provided in roadside or other stormwater harvesting basins located in common area or right-of-way, and
    - v. Prior approval from the Floodplain Administrator is obtained.
  - b. For mass-graded developments, on-lot retention volume may be counted toward first flush retention when:
    - i. The stormwater harvesting areas are located in the front yard adjacent to the right-of-way in order to support shade and landscaping adjacent to pedestrian areas, and
    - ii. Easements or other encumbrances are provided to alert owners of the purpose of and responsibility for the stormwater harvesting areas.

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.
3. Providing first flush retention underground is prohibited.

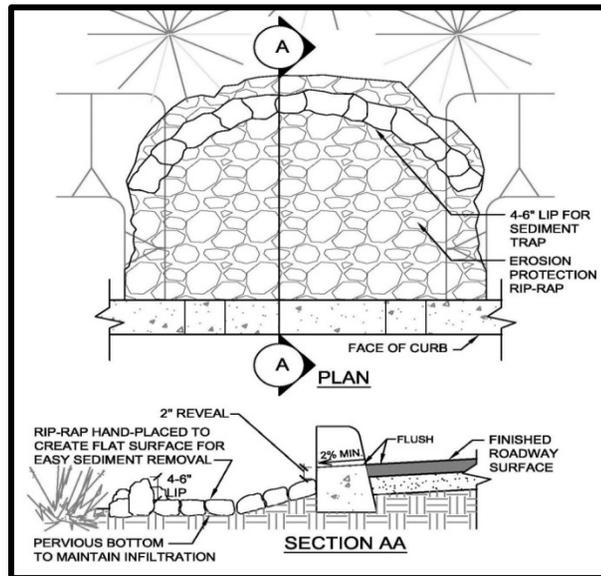
### **5.3 Stormwater Harvesting Basins**

#### **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  $\frac{1}{2}$  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  $\frac{1}{2}$  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 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.

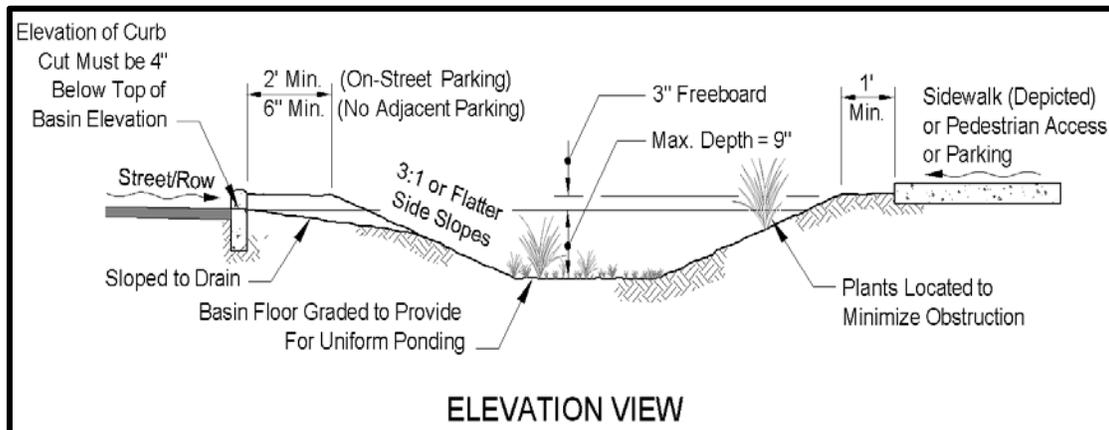
When a roadside stormwater harvesting basin is proposed to be located adjacent to a private street, the basin should be located within Common Area or within a drainage easement.

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**

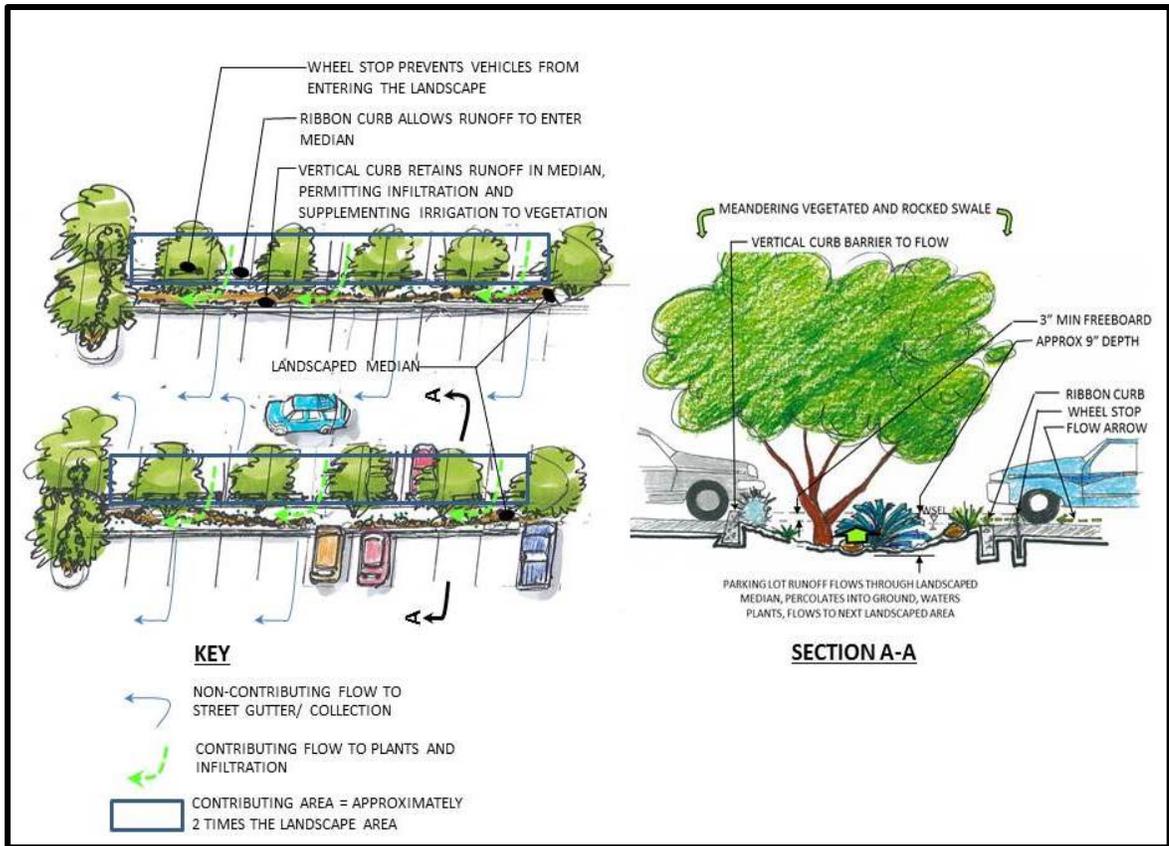
When stormwater harvesting basins are proposed adjacent to parking areas, the top of the basins shall be separated horizontally from edge of the parking area by a minimum of 1 foot.

### **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.



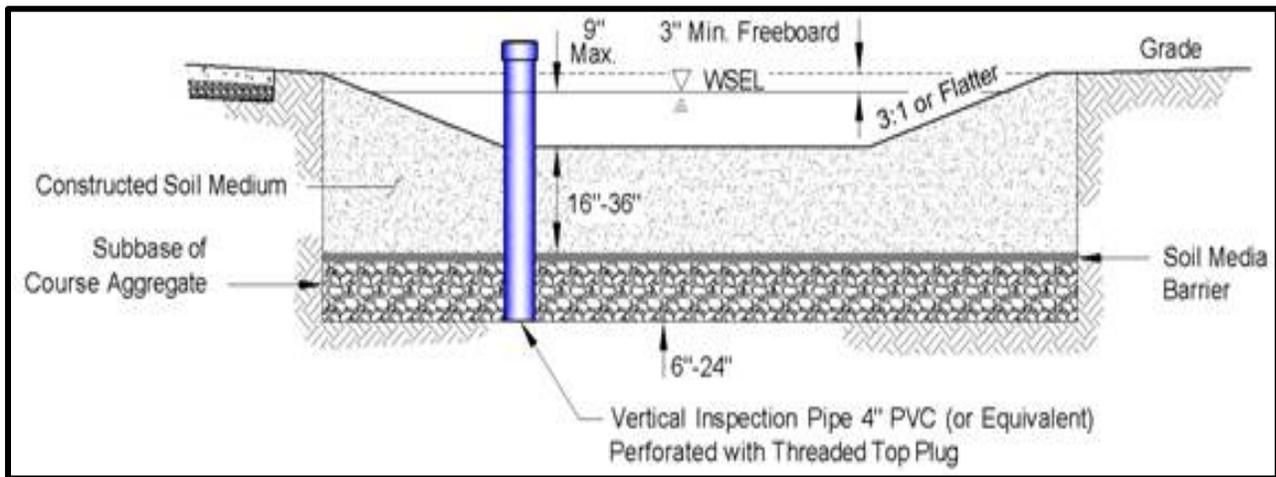
**Figure 5.3 Expanded Area Non-contributing Basin in a Parking Lot Median**

## 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 (ASTM C-33 sand) and organic material such as peat, top soil, mulch, or compost. The mixture should be approximately 85% sand, by volume, and 15% organic material. 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 apply:

1. 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.
  
2. 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.
  
3. A maximum of 9 inches of retention is allowed, unless designed as describe below. The depth is measured from the lowest elevation on the basin floor to the lowest outlet invert elevation.
  - a. The retention depth of up to 18 inches may be allowed if the following conditions are met. See Figure 5.5
    - i. Percolation testing is performed with results that suggest that the retention volume can infiltrate within the storage time required pursuant to Section 4.5.
    - ii. In order to enhance evapotranspiration, a minimum of 30% of the basin area shall consist of vegetated terrace. Native vegetation shall be used, and may be considered mitigation areas.
    - iii. In order to enhance infiltration and provide additional retention volume, a minimum of 20% of the basin area shall be constructed as a bio-retention basin that meets the standards of Section 5.7. The maximum ponding depth above the bio-retention area shall not exceed 9 inches. This area may be planted with native shrubs and grasses.
    - iv. The remaining 50% of the basin area may be constructed so that the maximum retention depth is 18 inches. This area shall meet the construction requirements of part 1 of this Section.

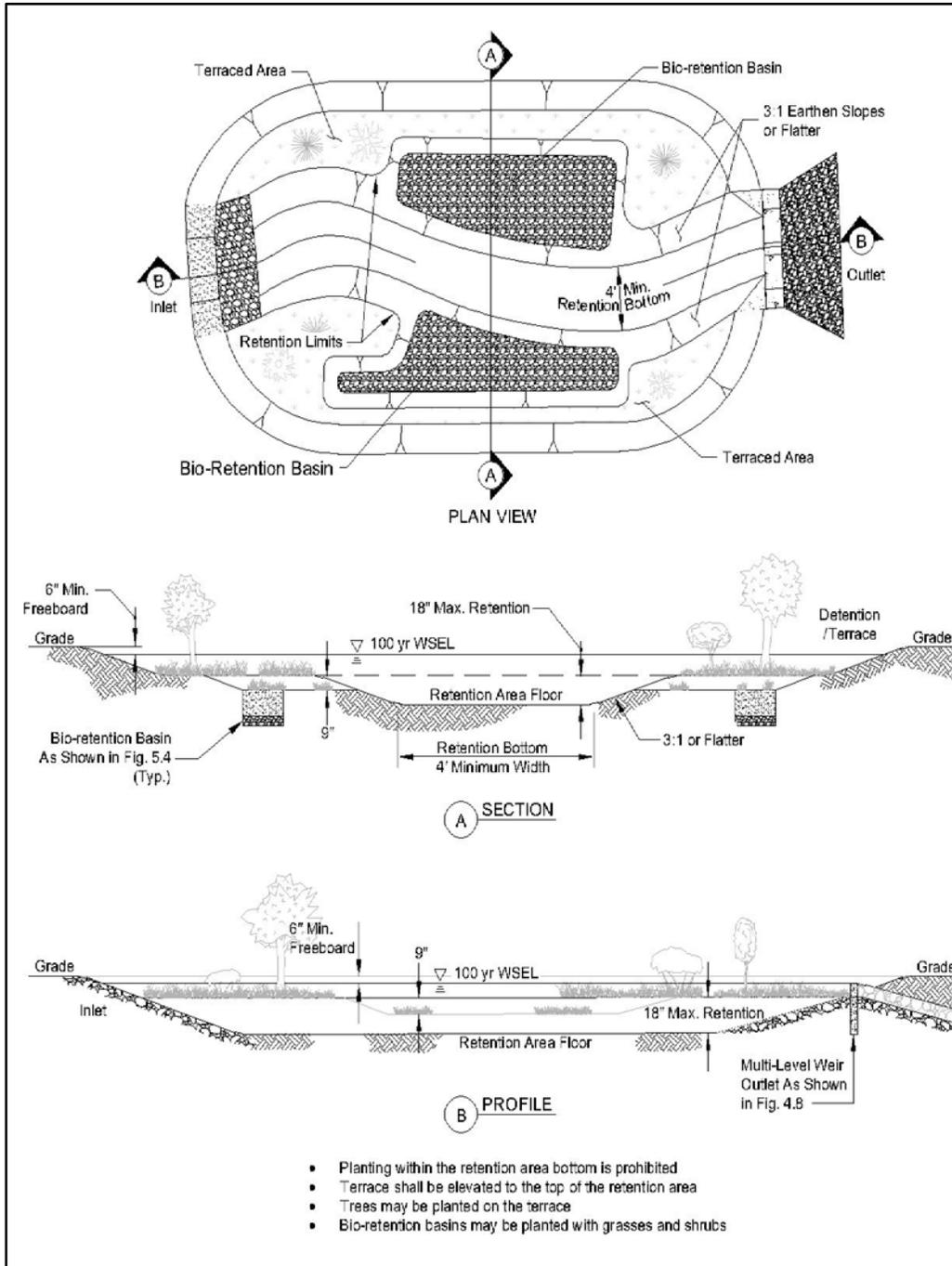


Figure 5.5 Terraced Detention Basin with Retention

## **5.9 Pervious Pavements**

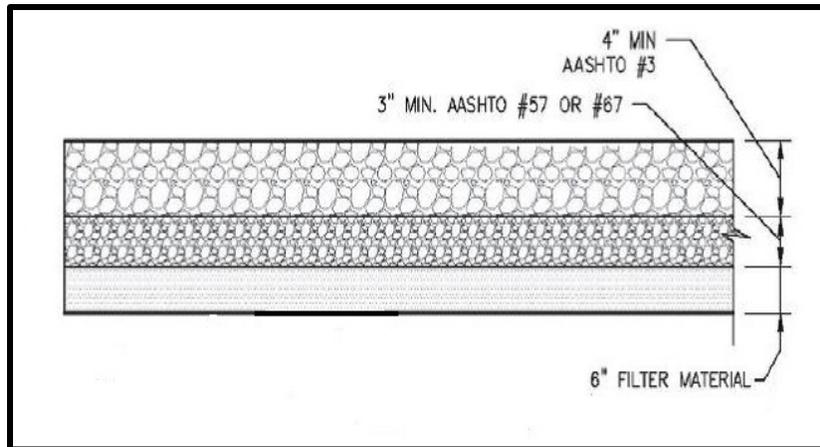
Pervious pavements can infiltrate or store water, reducing peak runoff and volume. When determining the first flush retention volume required, the runoff volume reduction due to the use of pervious pavements can be quantified by considering the pervious pavement a disturbed surface rather than an impervious surface. 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**



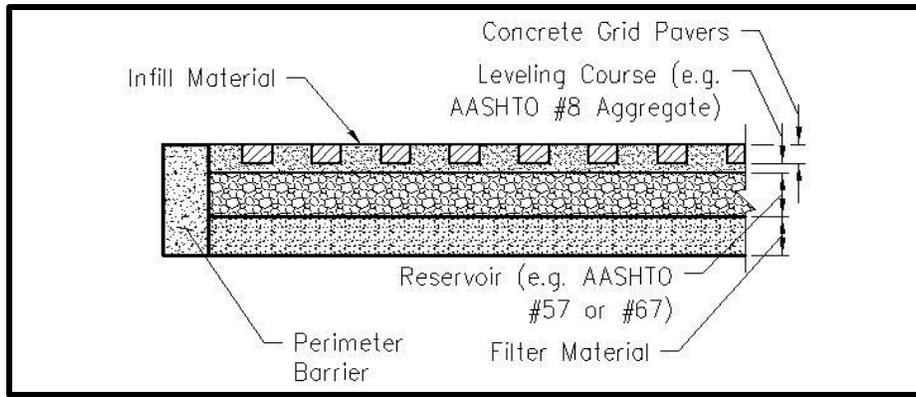
**Figure 5.6 Porous Gravel Cross Section**

### **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.



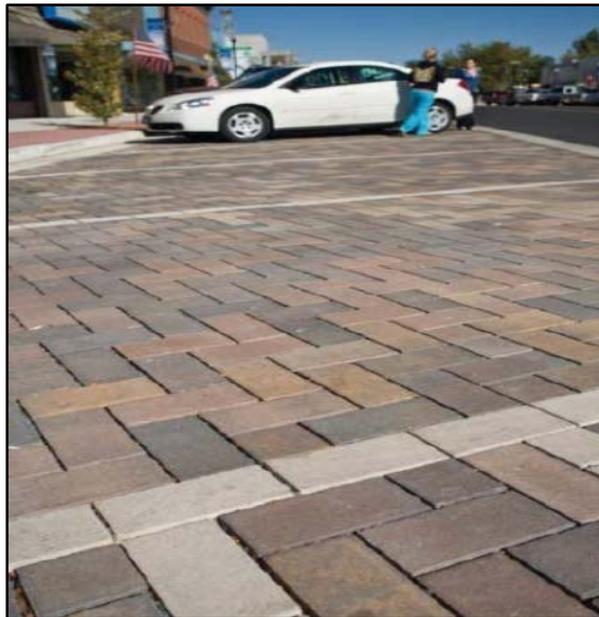
**Photo 5.2 Concrete Grid Pavement Installation**



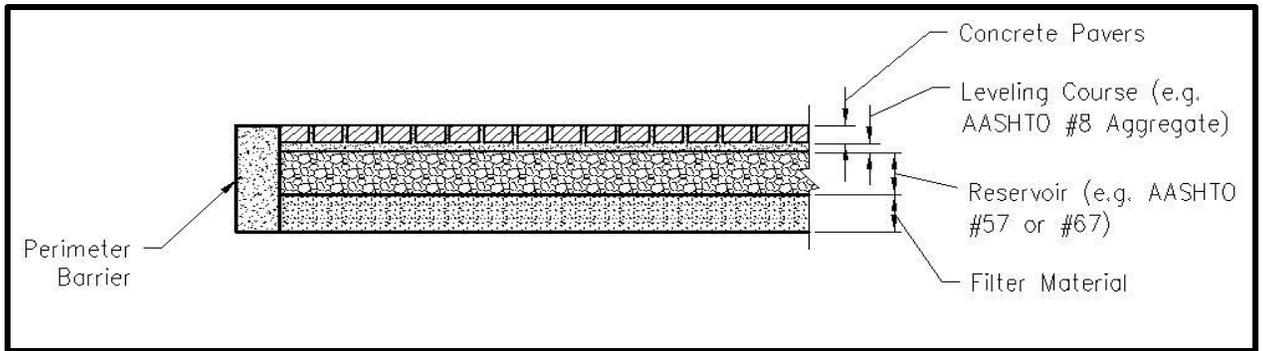
**Figure 5.7 Concrete Grid Cross Section**

### **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**



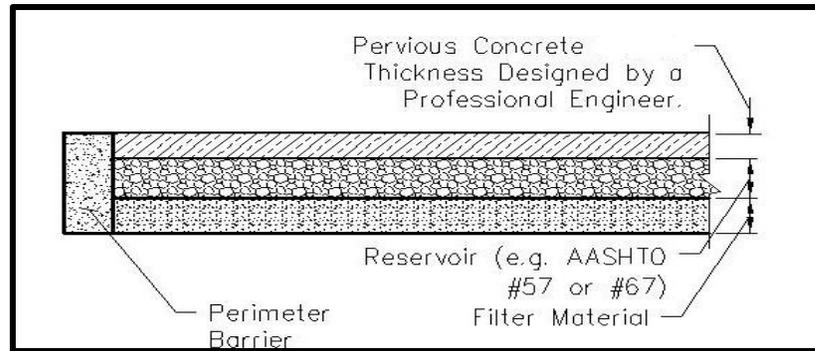
**Figure 5.8 PICP Cross Section**

#### **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.

## **6. MULTIPLE-USE CONCEPTS**

With appropriate site planning, detention basins and stormwater harvesting basins can serve other practical purposes in addition to being a vegetated amenity. Other acceptable uses and/or benefits include passive and active recreation, habitat enhancement and landscaped bufferyards. These are more fully described below.

### **6.1 Multiple Benefit Concepts**

#### **6.1.1 Resource Benefits of Shaded Basins**

1. **Energy Reduction:** Shade-producing vegetation planted in stormwater harvesting basins on the east, west and north sides of a building can be used to capture runoff from the building and adjacent impervious areas to irrigate vegetation that can shade the building and reduce the cooling costs.
2. **Potable Water Reduction:** Watering of vegetation accounts for a substantial portion of the potable water used in our region. The use of water harvesting can reduce amount of the potable water used for irrigation. When new landscaping is required, or if augmentation of the urban canopy is desired, these new plantings require irrigation. After an initial establishment period, the use of water harvesting basins can result in viable plants that do not need additional irrigation from potable water.

#### **6.1.2 Public Health Benefits of Shaded Basins**

1. **Heat Reduction:** Vegetation planted in basins produces shade that can reduce overall ambient air temperature which has a health benefit to the community. This benefit is particularly important if an impervious unshaded area can be replaced with a pervious shaded area. The overall reduction in temperature can also reduce energy demand for cooling.
2. **Air Quality Improvements:** Air quality improvements come in the form of reduction in dust from wind breaks provided by vegetation in basins, and mitigation of harmful gasses.
3. **Water Quality Improvements:** Basins can capture water that contains contaminants that might impact water quality. In addition, soil and plant processes can break down organic constituents like oil. Utilizing organic mulch such as wood chips in stormwater collection basins enhances the ability of soil and microbes to break down pollutants while maintain and improving soil infiltration capacity.

### **6.1.3 Transportation Benefits of Shaded Basins**

1. **Traffic Safety:** Stormwater harvesting basins in curb-extensions and street intersections can slow traffic and increase safety in residential areas. Known areas of problematic speeding may be made safer with these traffic-calming features.
2. **Extended Pavement Life:** Shaded pavement has been shown to have a longer life in desert environments which can reduce the long-term expenditure for pavement maintenance.
3. **Improved Pedestrian Accessibility:** Shaded walking areas are more conducive to pedestrians and bicyclists and are an element of the Complete Street design. The placement of detention and stormwater harvesting basins adjacent to roadways and parking lots or within medians and islands can be used to capture runoff from the street or parking lot to irrigate vegetation that can shade streets or parking lots.
4. **Reduced Street Noise:** Vegetation planted in stormwater harvesting basins next to roadways reduces street noise.

### **6.1.4 Benefits of Basins to Habitat**

1. **Enhance Wildlife Corridors:** The placement of basins adjacent to watercourses, riparian habitat or other existing vegetated areas creates a larger corridor for wildlife, and a bigger buffer from adjacent improvements. Utilization of native, multi-story canopies (e.g. a combination of ground covers, shrubs, and trees) further enhances structural habitat for wildlife.

### **6.1.5 Property Value Benefits**

1. **Increased Property Value:** Creating a landscaped amenity of the stormwater features for the benefit of the site and/or public rights-of-way is encouraged. Greater abundance of trees and other vegetation has been shown to be associated with increased property values. This is the result of aesthetic improvements as well as some of the other benefits described above (e.g. reduced energy and water costs) which have a direct economic benefit.
2. **Property Screening:** Frequently, new development is required to provide bufferyards so that the intensity of development is not too severe, and that appropriate screening of the new

development occurs. By placing stormwater harvesting basins within the bufferyard, landscaping will receive increased amounts of runoff which can be removed from supplemental irrigation more quickly. In addition, due to the expected density of this vegetation, additional requirements for screening with walls or fences may be waived.

## **6.2 Multiple Use Concepts**

### **6.2.1 Human Activity Zones**

If the detention basin also is intended for human activity, the following additional design standards apply:

1. A basin designed with human activity zones shall contain a minimum of 1 pedestrian access slope of 8:1 or flatter and a maximum of 100 feet either to the base of an access slope or to a 4:1 or flatter basin side slope.
2. All facilities and furnishings placed below the elevation of the 100-year water surface shall be waterproof and not floatable.

### **6.2.2 Basins Containing Landscape Bufferyards**

If the detention basin or stormwater harvesting basin is also intended to support bufferyard landscaping, the following additional design standards apply:

1. The drainage report must demonstrate that the multiple uses of the bufferyard for both landscaping and detention are compatible.
2. The project landscape plan must be submitted to the Floodplain Administrator for review prior to final approval of the development plan or plat.
3. The Floodplain Administrator will review for requirements of the applicable floodplain ordinances and policies. Landscape requirements shall be reviewed by the Development Services Department.

## **7. INSPECTION AND MAINTENANCE REQUIREMENTS**

### **7.1 Inspection and Maintenance General Requirements**

1. Inspection and maintenance are required for all basins. An inspection and maintenance protocol including frequency of inspection, a checklist of items to be inspected and recommended maintenance when an inspection identifies a maintenance requirement shall be prepared by an Arizona registrant. The protocol may be included in the project drainage report or prepared as a separate document. The protocol shall be reviewed and approved by the Floodplain Administrator prior to approval of the tentative plat or development plan. The protocol shall be delivered to the entity responsible for inspection and maintenance. An example of a detention basin inspection and maintenance checklist is provided in Appendix F.
2. Upon completion of construction of all basins, an As-built Certification shall be prepared by an Arizona registrant and submitted to the Floodplain Administrator and entity responsible for basin maintenance. The plan associated with the As-built Certification shall be used by the responsible party when performing periodic inspections and when restoring the basin to design specifications, if required. The Floodplain Administrator may utilize the certification during enforcement actions.
3. The periodic maintenance described in this chapter does not require a Floodplain Use Permit.
4. Periodic inspections shall occur a minimum of once per year. If significant storm events occur between annual inspections, additional inspections are required following each of the significant events.
5. Inspections shall include examination of the design components described in Chapters 4 and 5 which are incorporated in the project site being inspected. During an inspection, conditions shall be checked for proper functioning and compared to design specifications. If function impairment or deviation from design specifications is observed, maintenance shall be performed as described below or as directed by the inspector.

### **7.2 Inspection and Maintenance Requirements for All Basins**

#### **7.2.1 Basin Location and Collection**

1. Basins shall be maintained to perform as designed for the life of the project. Flow paths and structures delivering flow to basins shall not be altered. Obstruction of flow paths or structures, alteration of basin location or modification of flow direction shall be remedied, and the basin functioning shall be restored to design specifications.

2. Conveyances to the basins shall be maintained free of leaves, debris, or other obstructions.
3. Inlet and outlet locations shall be maintained free of obstructions.

#### **7.2.2 Basin Depth and Freeboard**

1. The depth of the basin shall be inspected to ensure the design volume, depth and freeboard are maintained.
2. For detention basins, the design depth shall be restored when the depth of sediment exceeds 6 inches above the lowest bottom floor elevation shown on the basin as-built plans. For stormwater harvesting basins, the design depth shall be restored when the design depth of the basin is reduced by more than 1 inch.
3. Slopes shall be maintained to the original design configuration.
4. Trash and debris shall be removed.

#### **7.2.3 Basin Storage Time**

1. Basin bottoms shall be inspected for evidence of ponding lasting longer than the limits in Section 4.5.1 for Detention Basins and longer than 24 hours for stormwater harvesting basins.
2. If an inspection identifies evidence of ponding exceeding these limits, the following maintenance shall be performed:
  - a. Areas of ponding shall be graded to drain to the outlet for basins with no retention;
  - b. Compacted soil shall be scarified to promote infiltration;
  - c. Basin outlets shall be maintained to function as designed; and
  - d. Obstructions at the outlet shall be removed.
  - e. Additional design remedies may be required, if problems persist.

#### **7.2.4 Basin Floor**

1. The basin floor shall be inspected to ensure that the design slope is maintained, that infiltration has not been significantly reduced and that vegetation or other obstructions do not alter slope, infiltration or basin volume.
2. Maintenance shall be performed when accumulated sediment and debris alter the design slope to the basin outlet or infiltration potential.
3. Invasive non-native plants shall be removed. A list of invasive non-native plants can be found in Appendix E of the Pima County Regulated Riparian Habitat Mitigation Standards

and Implementation Requirements available on the Rules and Procedures Page of the District's web page.

4. Soil with evidence of oil, grease or other chemicals shall be removed and disposed of properly.
5. Debris and trash shall be removed.

#### **7.2.5 Basin Side Slope**

1. Inspections shall occur to ensure that slope treatment has not been damaged by settling, vegetation, erosion, or other causes.
2. Should damage be observed, basin side slopes shall be restored to design specifications.
3. When slope treatment is dumped riprap, the treatment shall be repaired when foundation soil is lost or filter fabric is exposed.
4. Filter fabric that has migrated under a dumped rock riprap layer or has tears or holes shall be restored to design specifications.
5. Grouted riprap side slopes shall be restored to design specifications when foundation soil is lost or grout beds become damaged.
6. Retaining walls shall be restored to design specifications when signs of tipping, clogged weep holes or soil subsidence are observed.

#### **7.2.6 Basin Inlet Structure**

1. Inspections shall occur to ensure the inlet is free of obstructions and not damaged.
2. Should obstructions or damage be observed, inlets shall be restored to design specifications.
3. When an inlet includes a sediment trap, sediment shall be removed to the design elevation.

#### **7.2.7 Basin Outlet Structure**

1. Inspections shall occur to ensure the outlet and all components are free of obstructions and not damaged.
2. Should obstructions or damage be observed, outlets shall be restored to design specifications.

### **7.2.8 Basin Maintenance Access**

1. Inspections shall be conducted to ensure access to the basin is not compromised.
2. Conditions which compromise the design access shall be repaired.

### **7.2.9 Basin Landscaping**

1. Inspections shall occur to ensure that landscaping has not impacted basin function.
2. If damage is observed, the basin shall be restored to design specifications.
3. Invasive non-native plants shall be removed. 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 Requirements available on the Rules and Procedures Page of the District's web page.
4. Any vegetation or debris within the 20-foot radius described in Section 4.17.1 shall be removed.

## **7.3 Additional Inspection and Maintenance Requirements for Detention Basins**

### **7.3.1 Detention Basin Embankment**

1. Inspections shall be conducted to ensure the embankment is not damaged due to erosion, piping, sliding, settling or other causes.
2. If damage to an embankment is observed, the embankment shall be restored to design specifications.

### **7.3.2 Detention Basin Security Barrier**

1. Inspections shall be conducted to ensure the security barrier and surrounding grade are not damaged to the extent that the security of the basin is compromised.
2. If compromising damage is observed, the security barrier shall be restored to design specifications.

### **7.3.3 Detention Basin Perimeter Wall**

1. Inspections shall occur to ensure the perimeter wall and/or erosion at wall openings are not adversely impacting the basin.
2. If adverse impacts are identified, the basin and/or wall shall be restored to the design specifications.

### **7.3.4 Detention Basin Underground Storage System**

1. Inspections shall occur to ensure the underground storage system is not damaged and is functioning as designed.
2. Design specifications shall be restored when an inspection reveals any of the following:
  - a. Seepage, settlement, cracking, signs of improper joint alignment or displacement of joints;
  - b. Sediment accumulation; or
  - c. Damage to or malfunction of pumps, valves, sumps, piping, manifolds or appurtenances.

### **7.3.5 Detention Basin Equipment Elevation**

1. Electrical equipment shall be inspected to ensure that it is elevated a minimum of 1 foot above the 100-year water surface elevation.
2. Foundations shall be inspected for stability and material damage.
3. Conditions which compromise the design height of the equipment shall be repaired.

### **7.3.6 Detention Basin Pump**

1. Inspections shall be conducted after alarm system activation as well as annually and after significant storm events to ensure the pump is not damaged and is functioning as designed.
2. Prior to the summer and winter rainy seasons, the pump, back-up system and alarm system shall be operated to ensure the system is functioning as designed.
3. If damage/malfunction is observed, the system shall be restored to design specifications.
4. Trash and debris shall be removed from the pump system and properly disposed.

### **7.3.7 Detention Basin Dry Well(s)**

1. Inspections shall be conducted to ensure the dry well(s) and settling chamber(s) are functioning as designed.
2. If an inspection identifies that a dry well is not infiltrating within the storage limits outlined in Section 4.5.1, or other damage or maintenance requirements are identified, maintenance shall be performed to restore the dry well to design specifications.
3. Accumulated debris, weeds and trash shall be removed from the surface.
4. Sediment shall be removed from the settling chamber when approximately 15 to 20% of the original volume of the chamber is filled.
5. All sediment removed from a settling chamber shall be disposed of at an authorized sanitary landfill.

### **7.4 Additional Inspection and Maintenance Requirements for Bioretention Basins**

1. All other applicable stormwater harvesting basin inspection and maintenance requirements in this chapter shall be met.
2. Access to the vertical inspection pipe shall be maintained.
3. An inspection of the vertical inspection pipe shall occur to ensure infiltration is occurring. If standing water is observed in the inspection pipe, replacement of the medium or other method of retention is required.
4. Sediment shall be removed from the sediment trap.
5. The surface depression shall be inspected to ensure that the design depth is maintained. If reduced depression depth is observed, the design depth shall be restored.

### **7.5 Additional Inspection and Maintenance Requirements for Detention Basins with Retention**

1. Retention areas shall be inspected to ensure the retention areas are performing as designed. If ponding lasting longer than 24 hours is observed, the soil in the basin bottom shall be loosened to promote infiltration.
2. The retention area floor shall be maintained free of vegetation, debris and other obstructions.

3. The depth of the retention area shall be inspected to ensure the design volume is maintained. Sediment and other deposits shall be removed when the design depth of the retention area has been reduced by more than 1 inch.
4. Slopes shall be maintained to the original design configuration.
5. Soil with evidence of oil, grease or other chemicals shall be removed and disposed of properly and the basin returned to the original design specifications.

**7.6 Additional Inspection and Maintenance Requirements for Multi-Use Basins**

1. All other applicable inspection and maintenance requirements for detention basins in this chapter shall be met.
2. All equipment, hardscape, furnishings, and electrical equipment shall be maintained to the original design standards.

## **8. COVENANTS**

### **8.1 General Requirements**

1. For residential subdivisions, inspection and maintenance responsibilities shall be described in the recorded Conditions, Covenants and Restrictions when any of the following stormwater management practices are proposed:
  - a. Stormwater Harvesting Basins;
  - b. Embankments;
  - c. Underground storage;
  - d. Pumps; and
  - e. Dry wells.
  
2. For commercial projects, an inspection and maintenance covenant shall be recorded in the Public Records of Pima County when any of the following stormwater management practices are proposed:
  - a. Bioretention Basins;
  - b. Embankments;
  - c. Underground storage;
  - d. Pumps; and
  - e. Dry wells.

Appendix G contains example covenants and exhibits for commercial projects. For residential subdivisions, covenants shall be recorded with the applicable Conditions, Covenants and Restrictions.

3. Covenants shall comply with the requirements of Chapter 16.38 of the Floodplain and Erosion Hazard Management Ordinance, or other applicable sections of the Ordinances.
  
4. For corporate covenants, the signer shall provide sufficient documentation to demonstrate authorization to sign for the corporation. Sufficient documents include:
  - a. Articles of Incorporation;
  - b. A corporate resolution demonstrating the individual's authority to represent the corporation; or
  - c. A notarized letter on corporate letterhead that indicates that the person is allowed to represent the corporation.
  
5. The covenants must specify inspection and maintenance responsibilities of the property owner(s). It shall be the responsibility of the property owner(s) to perform maintenance as necessary to ensure the integrity of the stormwater detention and retention facilities.

## **9. DETENTION WAIVER REQUEST AND PAYMENT OF IN-LIEU FEE**

Collection of a fee in lieu of a detention system may be allowed when certain structural flood control measures are provided or it can be demonstrated that detention at the site does not provide offsite flood relief due to parcel size, location within the drainage basin, or other factors.

### **9.1 Waiver Request Requirements**

1. At least one of the following shall be demonstrated when a detention waiver is requested:
  - a. Structural flood control measures are proposed in place of detention systems.
  - b. The project site is 1 acre or less.
  - c. The project is located adjacent to a major watercourse. For the purpose of this manual a major watercourse has a 100-year peak discharge of 10,000 cfs or greater. Approval to classify another watercourse as a major watercourse may be granted by the Floodplain Administrator if engineering justification demonstrates adequate downstream capacity within the watercourse to convey the 100-year flood peak to a logical downstream conclusion under conditions of ultimate watershed urbanization.
  - d. The project is located on a secondary tributary of a primary tributary, draining a watershed of no more than ten square miles, of a major watercourse and the relationship between the travel time of the discharge from the project and the rise times of the hydrographs of the project flows and the primary tributary satisfy Equation 9.1; it can be demonstrated that the natural watercourses and drainage infrastructure within the secondary tributary watershed have adequate capacity to convey the future 100-year flood peak emanating from the watershed under conditions of ultimate watershed urbanization; and it can be demonstrated that the primary tributary peak discharge is not affected by the future 100-year flood peak from the secondary tributary or, if it is affected, the primary tributary and all drainage infrastructure downstream of the confluence of the secondary and primary tributaries have adequate capacity to convey the future 100-year flood peak under conditions of ultimate watershed urbanization.
  - e. The development has a density that is less than 2 units to the acre and preserves natural drainage patterns. The development shall not rely on constructed drainage facilities, such as constructed channels and storm drains to convey stormwater runoff.
  - f. The project site is eligible for a waiver due to other engineering justification acceptable to the Floodplain Administrator.
2. Demonstration of the criteria in this section does not guarantee approval of a detention waiver request.

### 9.1.1 Tributary Location

1. If the project site is located on a secondary tributary of the major watercourse (e. g., Channel 2 of Figure 9.1) then it must be demonstrated that the secondary tributary and all drainage infrastructure within the sub-watershed have adequate capacity to convey the future 100-year flood peak emanating, under conditions of ultimate urbanization, from that portion of the sub-watershed which contains not only the proposed development, but also all areas upstream of the development. For instance, segment BC of Channel 2 in Figure 9.1 and any associated drainage infrastructure must have adequate capacity to convey the 100-year flood peak emanating from the areas draining into Channel 2 upstream of Point C, based upon conditions of ultimate watershed urbanization. In this example, if Equation 9.1 is met, it would not be required to demonstrate that segment AB of Channel 1 and associated drainage infrastructure have adequate capacity, since flood peaks would not be increased on this primary tributary as a result of the proposed development.
2. Peak discharges and times of concentration used in this analysis shall be calculated by the Pima County Hydrology method, or other method specified by the Floodplain Administrator. Hydrograph rise times shall be calculated by the methods presented in Appendix H.

Equation 9.1 
$$\frac{T + T_r'}{T_r''} \leq 0.40$$

Where:

$T$  = 100-year flow travel time between the downstream point of the project site and the confluence with a major watercourse, as defined in Section 9.1, paragraph 1.c.  $T$  shall be calculated by the incremental time of concentration illustrated in Example 9.1 below.

$T_r'$  = Rise time of the 100-year synthetic flood hydrograph for on-site drainage emanating from the project site under developed conditions.

$T_r''$  = Rise time of the 100-year synthetic flood hydrograph at its confluence with the major watercourse for drainage emanating from the entire watershed.  $T_r''$  shall be determined using the assumption that the entire watershed is fully developed with no stormwater detention facilities.

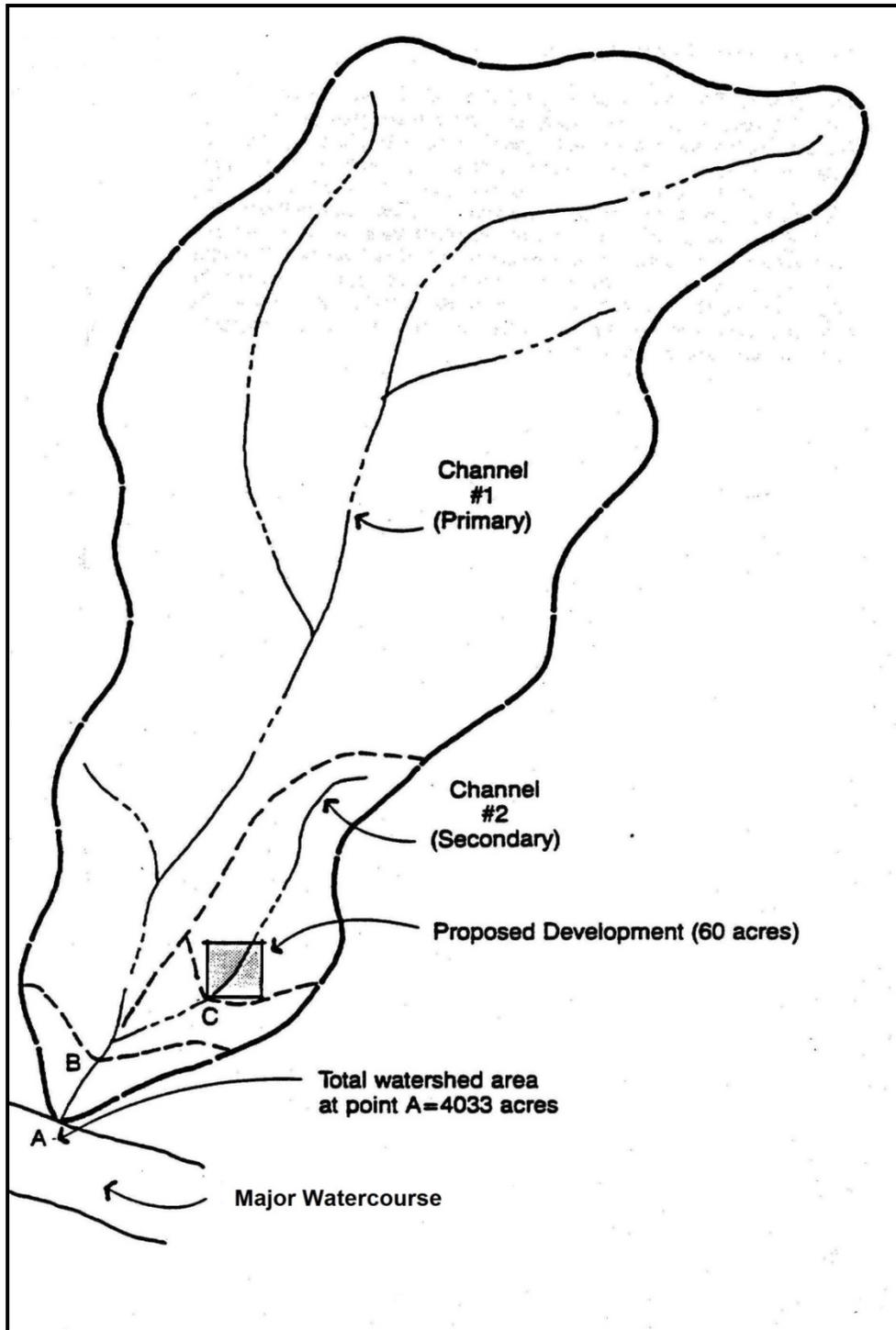


Figure 9.1. Sample Watershed for Example 9.1  
(Stormwater Detention/Retention Manual, Pima County Department of Transportation and  
Flood Control District, City of Tucson)

**Example 9.1**

A 60-acre parcel proposed for high-density urban development is located in the extreme lower portion of a 4033-acre sub-watershed of the Rillito Creek. The watershed locations are illustrated in Figure 9.1

The purpose of the example is to illustrate the method for determining if it can be demonstrated that the project is eligible for a detention waiver under the requirements of Section 9.1, paragraph 1.d.

Times of concentration, determined by PC-Hydro, for points along the channels of interest are:

Channel 1, Point A      $t_c = 61$  minutes

Channel 1, Point B      $t_c = 57$  minutes

Channel 2, Point B      $t_c = 25$  minutes

Channel 2, Point C      $t_c = 17$  minutes

The travel time through the reach of Channel 1 between Points A and B,

$$T_{AB} = 61 \text{ minutes} - 57 \text{ minutes} = 4 \text{ minutes}$$

The travel time through the reach of Channel 1 between Points B and C,

$$T_{BC} = 25 \text{ minutes} - 17 \text{ minutes} = 8 \text{ minutes}$$

$$\text{The total travel time } T = T_{AB} + T_{BC} = 4 \text{ minutes} + 8 \text{ minutes} = 12 \text{ minutes}$$

Incremental travel times are calculated for each channel segment located between the major watercourse and the project site. The total travel time,  $T$ , is the sum of the incremental travel times.

Determine  $T_r'$ :

The time of concentration for the on-site developed conditions runoff from the 60-acre parcel is obtained from PC-Hydro and is 6 minutes. The rise time,  $T_r'$ , obtained from the table in Appendix H is 14 minutes.

Determine  $T_r''$ :

For Channel 1, Point A, the time of concentration is 61 minutes.  $T_r'' = 53$  minutes is calculated by Equation H.1 in Appendix H.

From these values, Equation 9.1 is evaluated:

$$\frac{T + T_r'}{T_r''} = \frac{12 + 14}{53} = 0.49$$

The value of the solution is 0.49 which is greater than the limiting value of 0.40; therefore, it has not been demonstrated that the location of the project site relative to the primary tributary meets the criterion for a waiver stated in Section 9.1, 1.d. Furthermore, even if the solution is less than the limiting value, downstream channel and drainage infrastructure adequate capacity must also be demonstrated.

## **9.2 Waiver Application Requirements**

**For requirements, contact the Floodplain Administrator.**

### **9.2.1 Waiver Request Response and Approval**

1. The Floodplain Administrator will provide a response letter to the Applicant within 10 working days following the waiver request submittal.
2. If the request is approved, a fee calculation sheet with the required fee will be provided with the response letter.
3. If the request is approved, the applicant shall provide an electronic copy of the approved application and all attachments specified by applicable policies prior to approval of the development plan or plat.
4. A copy of the response letter granting approval of the waiver request shall be provided in the drainage report.
5. The fee shall be paid, according to the instructions in the response letter, prior to final approval of the development plan or plat.
6. If the waiver request is denied for incompleteness, the Applicant shall provide additional information as requested in the response letter and re-submit the waiver request for an additional review.

7. If the waiver request is denied because the project does not meet any of the criteria found in Section 9.1, detention must be provided.
  
8. Approval of a detention waiver request does not impact the requirement for first-flush retention.

## **10. DRAINAGE REPORT CONTENT**

The drainage report shall contain a separate section entitled Stormwater Detention and Retention. This section shall contain sufficient analyses and information to demonstrate that the applicable requirements of this manual will be met for the project.

### **10.1 Content for an Approved Detention Waiver**

1. If a waiver has been approved by the Floodplain Administrator, the Stormwater Detention and Retention Section shall contain the following:
  - a. A short discussion of the justification for the waiver; and
  - b. Copy of the Detention Waiver approval.

### **10.2 Content for LID Practices**

1. Provide a description of stormwater harvesting basins and the analysis of the first-flush retention requirement using the methodology found in Section 2.2.
2. Provide a discussion of use of additional LID practices, including:
  - a. Minimized disturbed and impervious surfaces;
  - b. Protection/enhancement of riparian habitat and regulatory floodplains and other higher permeability areas, such as natural areas;
  - c. Disconnected impervious surfaces;
  - d. Lengthened flow paths;
  - e. Use of conveyance systems which mimic natural conditions;
  - f. Decentralization of detention basins; and
  - g. Pervious pavements.
3. When stormwater harvesting basins are proposed, provide the analysis of the peak discharge rate reduction for each return period using the methodology presented in Section 3.3.
4. Provide a stormwater harvesting basin summary table which uses the same basin labels as shown on the proposed conditions drainage exhibit and the project plan with the following:
  - a. Total stormwater harvesting basin retention volume, cubic feet or acre feet;
  - b. First-flush retention volume, cubic feet or acre feet;
  - c. Bottom elevation, feet;
  - d. If applicable, invert elevations for inlet and overflow, feet;
  - e. If applicable, dimensions of inlets and overflow, feet;
  - f. The contributing area to each basin or group of basins, square feet or acres;

- g. The post-developed peak discharge directed to each basin or group of basins, cubic feet per second;
    - h. The reduced peak discharge rates attributable to stormwater harvesting for 2-, 10- and 100-year return periods, cubic feet per second; and
    - i. The pre-developed peak discharge rates, cubic feet per second, and indication if additional detention is required.
5. Provide a cross section of each stormwater harvesting basin showing and labeling the following information, as applicable:
  - a. Side slope with surface treatment and the horizontal-to-vertical ratio indicated;
  - b. 100-year water surface elevation, feet;
  - c. If applicable, inlet and overflow structures with dimensions, feet, material type and elevations, feet; and
  - d. Inlet and overflow protection, toe down, feet, rock riprap (length, feet, thickness, feet, or relative rock diameter, treatment, rock size, inches).
6. Provide a cross section of each bioretention basin, showing and labeling material layers and surface depression, inches, and side slopes.
7. On the proposed conditions drainage exhibit, show the location of all LID practices.

### **10.3 Content for Detention Basins**

1. A brief summary of the applicable detention requirements relevant to the development including a statement about the project's location within a Balanced or Critical Basin.
2. A description of the detention proposed to achieve the required post-development peak discharge or runoff volume reduction for the project.
3. A description of inlet and outlet structures, with supporting design calculations, including:
  - a. Hydraulic calculations for all inlet and outlet structures;
  - b. Calculations for erosion protection dimensions and rock sizing; and
  - c. Calculations demonstrating that flows exiting the project boundary approximate flow characteristics of pre-developed conditions.
4. Stage-storage-discharge table.
5. The analysis of the storage-indication method to determine amount of peak discharge rate reduction by a basin along with supporting documentation shall be provided.

The following storage-indication methods can be used to determine the peak discharge rate reduction:

- a. The PC-ROUTE spreadsheet with supporting documentation.
  - b. HEC-HMS Version 3.3, or higher, with supporting documentation, including:
    - i. HEC-HMS model summary output, and
    - ii. A CD of the modeling.
6. A basin summary table with the following basin design parameters:
- a. Detention volume, cubic feet or acre feet;
  - b. If applicable, retention depth, inches, and volume, cubic feet;
  - c. Top and bottom elevations, feet;
  - d. 100-year water surface elevations, feet;
  - e. Invert elevations for inlets and outlets, feet;
  - f. Dimensions of inlets and outlets, feet;
  - g. 2-, 10- and 100-year inflows, cubic feet per second; and
  - h. 2-, 10- and 100-year outflows, cubic feet per second.
7. A cross section of the basin showing and labeling the following information as applicable:
- a. Bottom slope (0.5% minimum unless retention is provided);
  - b. Side slope with surface treatment and the horizontal-to-vertical ratio indicated;
  - c. 100-year water surface elevation, feet;
  - d. Inlet and outlet structures with dimensions, feet, material type and elevations, feet;
  - e. Outlet protection, toe down, feet, rock riprap (length, feet, thickness, feet, or relative rock diameter, treatment, rock size, inches); and
  - f. If applicable, security barrier.
8. Cross sections perpendicular and parallel to the basin inlet and outlet structures, with dimensions, feet.
9. When a basin is located to accept flows from predominantly natural areas, supporting calculations for sediment basin design shall be provided by an engineer registered in the State of Arizona.
10. When a basin is proposed less than 15 feet away from a structure, the recommended minimum separation between a basin and a structure shall be provided by a geotechnical engineer registered in the State of Arizona.
11. When an embankment is proposed, the following shall be provided:
- a. Site conditions specified in Section 4.10.1.2;
  - b. For embankments designed to impound greater than 1 foot of water, the calculations for the emergency spillway design capacity as outlined in Section 4.10.1.9.; and

- c. Engineering analysis for erosion protection if the embankment is located within an erosion hazard setback or regulatory sheet flood area; and
12. When an underground storage system is proposed the following shall be provided:
- a. A storage volume analysis documenting 1.5 times the design volume of an above ground basin;
  - b. The drainage path to deliver flows in a reasonable and safe manner in the event the system cannot accept flow; and
  - c. A copy of the report specified in Section 4.13.1.8.
13. When a pump is proposed, the following shall be provided:
- a. The Floodplain Administrator's written acceptance to use the pump;
  - b. Analysis demonstrating that the pump can accommodate the entire volume of the 100-year post-developed hydrograph emanating from the contributing drainage area or a statement indicating that a back-up pump with an emergency power source will be utilized;
  - c. Demonstration that the pump's discharge rate does not exceed the pre-developed conditions 2-year peak discharge rate;
  - d. Trash rack/screen design calculations using a 2.0 clogging factor;
  - e. Emergency back-up plan;
  - f. Drainage exhibit showing drainage flow under clogged conditions; and
  - g. Inspection and maintenance protocol with, at minimum, the following:
    - i. Maintenance schedule;
    - ii. Type of maintenance activities; and
    - iii. Exhibit showing the location of the pump, alarm systems and other equipment.
  - h. A copy of the pump system analysis as outlined in Section 4.18.1.15.

#### **10.4 Content for Dry Wells**

1. When a dry well is used as a method of disposal, the following shall be provided:
- a. Justification for the use of a dry well;
  - b. The Floodplain Administrator's written approval of the dry well;
  - c. A copy of the percolation test that determines the stabilized infiltration rate;
  - d. Dry well system design by a licensed professional;
  - e. Calculations and supporting documentation for the dry well disposal rate;
  - f. Dry well specifications and cross section of a typical well;
  - g. Depth to groundwater information;
  - h. Documentation that the disposal rate meets the storage time standards found in Section 4.5; and
  - i. A plan for stormwater disposal in the event the dry well(s) cease(s) to function.
  - j. Inspection and maintenance protocol with at minimum the following:
    - i. Maintenance schedule;