



Drainage Policies and Standards

for Maricopa County, Arizona



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LIST OF ACRONYMS and ABBREVIATIONS

Term	Description
ACDC	Arizona Canal Diversion Channel, an USACE flood control project located in central Phoenix
ADEMA	Arizona Division of Emergency and Military Affairs
ADEQ	Arizona Department of Environmental Quality
ADMP	Area Drainage Master Plan
ADMS	Area Drainage Master Study
ADOT	Arizona Department of Transportation
ADOT Standards	ADOT Standard Specifications for Road & Bridge Construction, and ADOT Standard Drawings
ADWR	Arizona Department of Water Resources
ALTA	American Land Title Association
AZPDES	Arizona Pollutant Discharge Elimination System
BFE	Base Flood Elevation
BMP	Best Management Practice
CAFO	Concentrated Animal Feeding Operations
CAP	Central Arizona Project
CC&R's	Subdivision Protective Covenants, Conditions and Restrictions
CFR	Code of Federal Regulations
Cfs	cubic feet per second
CLOMA	Conditional Letter of Map Amendment
CLOMR	Conditional Letter of Map Revision
CLOMR-F	Conditional Letter of Map Revision Based on Fill
CMP	Corrugated Metal Pipe
CRS	Community Rating System
County/District	Maricopa County and the Flood Control District of Maricopa County
DDM	Drainage Design Manual for Maricopa County (3 volumes)
DFIRM	Digital Flood Insurance Rate Map
Du	dwelling units
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
FCDMC	Flood Control District of Maricopa County
FIRM	Flood Insurance Rate Map
FIS	Flood Insurance Study
Fps	feet per second
GI/LID	Green Infrastructure/Low Impact Development
LOMA	Letter of Map Amendment
LOMR	Letter of Map Revision
LOMR-F	Letter of Map Revision Based on Fill
MAG	Maricopa Association of Governments
MAG Standards	MAG Uniform Standard Specifications and Details for Public Works Construction

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MCDOT	Maricopa County Department of Transportation
MSGP	Multi-Sector General Permit
MCPRD	Maricopa County Parks and Recreation Department
NFIP	National Flood Insurance Program
NOI	Notice of Intent
NOT	Notice of Termination
NPDES	National Pollution Discharge Elimination System
NRCS	Natural Resources Conservation Service (formerly Soil Conservation Service, SCS)
PDSD	Planning and Development Services Department
PMR	Physical Map Revision
RFE	Regulatory Flood Elevation
RUSLE	Revised Universal Soil Loss Equation
SFHA	Special Flood Hazard Areas
SWPPP	Stormwater Pollution Prevention Plan
TMDL	Total Maximum Daily Load
USACE	United States Army Corps of Engineers
USBR	United States Bureau of Reclamation
USFS	United States Forest Service
WCMP	Watercourse Master Plan
WSEL	Water Surface Elevation

1 INTRODUCTION

1.1 PURPOSE

The purpose of this document is to provide guidance and detail on implementation of the Floodplain Regulations for Maricopa County and the Maricopa County Drainage Provisions (Section 1205 of the Maricopa County Zoning Ordinance). It is intended that drainage studies, plans, design reports, construction drawings and accompanying drainage/floodplain use permit applications prepared in accordance with the philosophies, policies and minimum standards contained herein will meet the minimum requirements of the governing regulations. This will expedite the review, approval and permitting processes and help meet the missions of both Maricopa County and the District. The term “County/Community/District” is hereinafter used to refer to Maricopa County, any community that has adopted this manual, and the Flood Control District of Maricopa County. The term Community is hereinafter used to refer to any community that has adopted this manual.

The document presents the County/Community/District philosophy on drainage and floodplain management, and planning for drainage facilities. It contains descriptions of federal, state, and county regulations pertaining to such facilities, including links to the various District and County regulations that can be found online. Most importantly, the policies and minimum standards for implementing the regulations are presented in this document. These policies and standards are based on flood and erosion hazard mitigation strategies that are intended to reduce or eliminate cumulative impacts resulting from development, reduce impacts to adjacent community character and our desert environment, and to enhance public safety. These policies and standards support the District’s Mission reduces risk from flooding so that property damage and loss of life is minimized, economic development is supported in a safe and responsible manner, stormwater is recognized as a resource for the long-term benefit of the community and environment.

This document is intended to be used in concert with the most current version of the Drainage Design Manual for Maricopa County (DDM), which consists of three volumes Hydrology, Hydraulics and Erosion Control. The objective of the DDM is to provide technical guidance for planning and design of storm drainage facilities in Maricopa County. The DDM provides a convenient source of analytical and design information that is specifically tailored to the unique hydrologic, environmental, and social character of Maricopa County. The Drainage Policies and Standards manual provides specific guidelines for application of this technical information for the purposes set forth in Section [1.3](#). If there are any conflicts between the DDM and this Drainage Policies and Standards Manual, the more stringent (most conservative) design requirements shall be used.

1.2 DISCLAIMER

The County/Community/District will review and approve flood hazard delineation studies, drainage reports and plans for construction projects for conformance with the Floodplain Regulations for Maricopa County, The Community’s drainage regulations, the Maricopa County/Community subdivision regulations and zoning ordinance, including the Drainage Provisions and these policies and standards, as appropriate under their separate authorities (refer

to Chapter 5). This notwithstanding the County/Community/District assumes no liability for insufficient design or improper construction. Review and approval does not absolve the owner, developer, design engineer, or contractor of liability for inadequate design or poor construction. The design engineer has the responsibility to design drainage facilities that meet standards of practice for the industry and promote public safety. Compliance with the regulatory elements, and meeting the policies and minimum design standards, does not guarantee that properties will be free from flooding or flood damage. The County/Community/District, and their officials or employees assume no liability for information, data, or conclusions prepared by private engineers or environmental professionals and make no warranty expressed or implied in their review/approval of drainage/floodplain projects or studies including stormwater quality submittals.

1.3 APPLICATION

Philosophies, policies and standards set forth in this document apply to private development projects within the unincorporated areas of Maricopa County, projects funded entirely by Maricopa County and/or the District, and projects funded in cooperation with Maricopa County and/or the District and/or other agencies, and for those communities where the District has floodplain management responsibilities. Only the floodplain portion of this manual applies to these communities unless this manual is adopted by the communities. These policies and standards also apply, in an advisory capacity, to federally-funded projects sponsored by Maricopa County and/or the District. It is understood that there may be exceptions to the policies and standards that may be granted by Maricopa County/Community and/or the District. The standards are minimum standards. There may be more stringent requirements in the event that public health, safety and welfare could be adversely affected by application of the minimum standard. The drainage portion of this manual will be administered by the County/Community. The drainage portion of this manual will be administered by the District for the District's projects. The Floodplain portion of this manual is the responsibility of the Flood Control District of Maricopa County.

1.4 BACKGROUND

It is the intent of the State of Arizona, Maricopa County, and the District to have a comprehensive floodplain and drainage management program that protects the health, safety, and welfare of its citizens, their property, and the environment. To accomplish this, the State of Arizona has mandated the establishment of County Flood Control Districts to identify and remediate flooding problems and administer the National Flood Insurance Program in Arizona. The Maricopa County/Community has regulatory authority for development drainage review, and managing stormwater quality issues.

In 1987, the Board of Directors of the District, and the Maricopa County Board of Supervisors, approved the Uniform Drainage Policies and Standards for Maricopa County, Arizona. The Uniform Drainage Policies and Standards for Maricopa County have since been superseded by the DDM. On April 15, 1991 the Board of Directors of the District adopted the Drainage Design Manual for Maricopa County, Volume I Hydrology, thereby requiring its use by jurisdictions cost-sharing with the District in flood control projects, by contractors working for the District, and beginning January 1, 1992, by all parties submitting drainage reports and studies to the District for review and approval. The Drainage Design Manual for Maricopa County, Volume II Hydraulics was published in November 1991. The most current editions of these two manuals are referred to herein as the Hydrology and Hydraulics volumes.

In 1998, the District started a collaborative effort with the City of Phoenix to meld their respective drainage design manuals. The purpose of this collaboration was three-fold. First, various technical aspects of both the City's and District's manuals required updating due to advances in the engineering science and further experience with applications unique to Maricopa County. Second, advances in computer technology provided the opportunity to develop a living document that would be posted on the internet that encompassed unique engineering software for the design/evaluation of drainage facilities. The user of the DDM is encouraged to routinely check the web-based version for updates since addenda will be issued by this means. Third, the "drainage policies and standards" identified in the 1996 and earlier versions of the Hydrology and Hydraulics volumes were removed to allow the City of Phoenix and all other municipalities within Maricopa County the opportunity to have their own stand-alone policies and standards that address the unique conditions in their respective communities.

The new Hydrology and Hydraulics volumes now only provide comprehensive technical methodologies for definition of flood and erosion hazards and for design of drainage facilities within both the unincorporated and incorporated areas of Maricopa County. The intent is that the DDM be adopted as a part of each separate Drainage Policies and Standards manual prepared and adopted by individual municipalities.

In January 1993, a third document, Volume III, Erosion Control was published. This document was prepared with the help and assistance of the Erosion Control Task Force Technical Committee. Similar to the Hydrology and Hydraulics volumes, The Erosion Control volume is a technical manual to provide guidance to agencies, developers, engineers, and contractors in complying with the new AZPDES permitting process for construction activities as well as other AZPDES permit requirements. This volume provides information and potential strategies for the AZPDES permitting process. The main focus of this volume is on the construction site component to stormwater management but includes a broader discussion on other permitting issues associated with the Arizona Department of Environmental Quality (ADEQ) and the stormwater permitting program responsibilities of the Environmental Protection Agency (EPA).

This document provides drainage policies and standards specific to the unincorporated areas of Maricopa County, and those communities for which the District conducts reviews. The latest edition of the DDM is incorporated into this document by this reference.

1.5 SCOPE

The Maricopa County Drainage Policies and Standards manual is divided into nine chapters that address the major administrative areas of drainage and stormwater management. The intent of this manual is to provide implementation guidelines for meeting the intent of the drainage and floodplain regulations for the design of drainage and stormwater facilities. Chapter 2 (Drainage Planning) stresses the County/Community/District vision for drainage and stormwater management while providing guidance for the planning process. The drainage and stormwater management's policies provided in Chapter 3 (Policies) build upon this vision and are supported by the District's floodplain and Maricopa County's Section 1205 Drainage Provisions of the Zoning Ordinance/Community's drainage regulations. A Floodplain Regulation for Maricopa County has been in force since February 25, 1974. Revised District floodplain regulations (Floodplain Regulations for Maricopa County) were adopted January 17, 2018. Federal and state regulatory requirements are outlined in Chapter 4 (Regulations) for the convenience of the user. District and Maricopa County/Community specific regulations are listed in Chapter 5 (Regulations), and hyperlinks to online copies presented. The minimum standards, provided in Chapter 6

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(Standards), identify specific criteria for the definition of flood hazards and the design of drainage and stormwater facilities in conformance with the more general policies. These standards are also supported by the District's floodplain and Maricopa County's Section 1205 Drainage Provisions of the Zoning Ordinance/Community's drainage regulations. Chapter 7 is a compilation of the requirements from chapter 2 through 6 and additional information specific to individual lots located outside of subdivisions. Finally, Chapter 8 (Revision Process) identifies the procedures for modifying policies and standards.

2 DRAINAGE PLANNING

2.1 PURPOSE

The District's Vision is for the residents of Maricopa County and future generations to have the maximum level of protection from the effects of flooding through fiscally responsible flood control actions and multi-use facilities that complement and enhance the beauty of our desert environment. The purpose of this chapter is to encourage thoughtful and careful consideration of drainage issues when preparing to impose change on a natural system, whether that change is a new subdivision, transportation facility, or flood control project to benefit upstream, downstream, and adjacent properties. To accomplish this goal, discussions are provided on drainage planning philosophy, types of drainage plans and their purposes, information that should be gathered and used as a part of the planning process, components of the drainage planning process, the preferred approach to drainage planning, and final design considerations. The purpose for applying proper drainage planning is to minimize or eliminate adverse impacts and to achieve the many benefits, including the following:

1. Maintain good standing in the National Flood Insurance Program (NFIP).
2. Increased public safety.
3. Reduced costs, including the cost to repair homes and property damaged by flooding, erosion and deposition of sediment, and the cost of drainage infrastructure, street construction, and maintenance.
4. Avoidance of flood damage claims and resultant litigation.
5. Continuity of stormwater flow through the site to meet legal requirements for not impacting adjacent, upstream, and downstream properties.
6. Improved stormwater quality.
7. Reduce the loss of groundwater recharge resulting from development and use of impervious conveyance channels.
8. Compatibility with existing and proposed regional drainage plans.
9. Improved movement of traffic, and all weather access to homes and businesses.
10. Combining improved opportunities for open space and park areas with more recreation and multiple purpose potential within necessary drainage facilities while meeting the open space requirements and in coordination with existing and proposed preservation/conservation plans and habitat studies.
11. Development of otherwise un-developable land.
12. Opportunities for lower building construction cost.

13. Avoidance of fines and fees levied for non-compliance with Federal (NPDES) and State (AZPDES) stormwater regulations.
14. Preservation of natural desert washes and riparian areas which provide natural stormwater conveyance, stormwater infiltration, wildlife habitat and travel corridors, and passive recreation opportunities.
15. Reductions in potable water use through increased stormwater capture and reuse on natural and built landscape environments in streetscapes, residential and commercial developments, and parks and designated open spaces.

2.2 WHAT CONSTITUTES DRAINAGE PLANNING

Good drainage planning is a complex process. Application of drainage planning applies to the complete range of projects from preparation of regional plans for large watersheds, down to planning site drainage for the corner commercial complex or a single family residence. Drainage planning consists of the following considerations:

1. A drainage plan, in addition to providing a unified drainage plan, should be coordinated with planning for open space and recreation facilities, planning for transportation, and other urban considerations including water conservation and water harvesting opportunities that include green infrastructure/low impact development (GI/LID) techniques. Drainage planning should not be done after all the other decisions are already made as to the layout of a new subdivision, commercial or industrial area. It is this latter approach that creates drainage problems, and often requires costly corrective action. The design should be approached as an integrated system that includes considerations for multiple purpose use, landscaping, water conservation, and rainwater harvesting/reuse opportunities.
2. Drainage and stormwater runoff facilities are an integral part of public infrastructure systems, are a key to the continued function of adjacent natural ecological systems, and should be planned as such.
3. Basic planning considerations that should be taken up early include: planning for the drainage system, developing an appropriate grading concept, and minimizing impacts to the environment and enhancing functional benefits --including improving water quality and increasing rainwater harvesting opportunities. An integrated, holistic design approach that addresses environmental issues up front will result in less cost over the long term of the project, may eliminate a future requirement to possibly retrofit due to more stringent environmental regulations and is a key concept for developing drainage infrastructure in concert with community and environmental needs and desires.
4. When planning a new subdivision for residential purposes, various drainage concepts should be evaluated before decisions are made as to street location and block layout. It is at this point of the development process where the greatest impact can be made on the cost of drainage and transportation facilities, reducing environmental impacts, and maximizing benefits to the community.

5. When flood or erosion hazards are involved, the planner should take these hazards into consideration in land planning to avoid unnecessary complications when designing the infrastructure.
6. The drainage engineer must be included in the formulation of both site-specific and regional drainage plans and all urban planning should be coordinated from the beginning with the drainage engineer.
7. Incorporation of the natural drainage ways with the design of the street drainage patterns should be coordinated to achieve integrated, multiple-purpose, multiple-benefit stormwater management strategies as expressed in the policies and design criteria presented in this manual.
8. The quality of the planning significantly impacts the costs to the developer and the citizens of Maricopa County. Construction and/or long term maintenance costs for drainage and flood control measures are high without this planning. Furthermore, inadequate planning potentially affects residents, our natural desert environment, and other infrastructure systems in terms of flood damages and long term impacts.
9. Supplemental and complementary benefits and uses or multiple uses from drainage facilities should be considered. Both passive and active recreational uses are examples. Water conservation, rainwater capture, aquifer recharge, and stormwater reuse are potential examples Landscape designs (using low-water, drought-tolerant plant species) that provide shade opportunities, have myriad health benefits, and reduce heat island impacts are also encouraged to be integrated as part of the system. Any effort made towards increasing local and community-wide benefits is appropriate and is encouraged.

2.3 DRAINAGE PLANNING PHILOSOPHY

Planning of drainage facilities should be based upon incorporating natural waterways, artificial channels, storm drains, and other drainage works into the development of a desirable and aesthetic community, rather than attempting to superimpose drainage works on a development after it is laid out. Preserving natural channel systems and floodplains, in their natural state, is the preferred alternative and should be the focus of the planning effort. Defining the need for constructed storage basins, channels and storm drains should be based on minimizing the impact to the preserved natural system while meeting the safety, stormwater quality, natural resources, and aesthetic criteria that govern the need for such facilities. The drainage facilities that are identified as necessary components should then, where practical, be designed as a focal point of the community for multiple purpose objectives, thereby minimizing misuse (e.g. dumping) and encouraging proper care and maintenance as a community resource.

Drainage should be considered on the basis of two design phases. The first is the preliminary phase where conceptual drainage plans are developed. The second is the final design phase, which encompasses detailed engineering using the first phase as the basis for the final design. The first phase is a more global view, and results in the conceptualization of an overall drainage solution. The second phase is an extension of the first where the engineering details for the localized issues are worked out.

A well-planned drainage system that preserves as much of the natural waterways as possible, can reduce or mitigate the cost of expensive capital improvement infrastructure and the long term

maintenance of such facilities. It can also protect the development area from extensive property damage and loss of life from flooding and reduce costs to the public. Including considerations for multiple-use opportunities, passive/active recreation areas, open space credits, and water conservation and rainwater harvesting/reuse could enhance and increase development returns for lots located next to such waterways and provide for additional community benefits in addition to effective drainage solutions. A drainage system exists in a community whether or not it is planned and designed, and whether or not development is situated wisely with respect to it. Water will obey the law of gravity and flow downhill regardless of whether people and development are in its path.

2.4 TYPES OF DRAINAGE PLANS

Drainage plans can be divided into two types: regional and local. Regional plans are those prepared by a governmental agency for continuity on a regional basis. Local drainage plans for private land development or public projects that must conform to the regional plan, or stand on their own merits if a regional plan has not been developed. Both of these types typically have two component phases consisting of a conceptual drainage plan and a final drainage plan, as mentioned above. Conceptual drainage plans deal with the broad assessment of existing drainage conditions and development of conceptual alternatives to accommodate drainage. Final drainage plans provide detailed analysis of preferred conceptual solutions, and/or documentation of preferred solutions and details to support the final design of a project. This section describes the two types of plans and their respective component phases.

2.4.1 Regional Drainage Planning

The District, as directed by ARS Title 48 Chapter 21, provides regionally-coordinated planning functions that identify drainage hazards and problems on a watershed basis. Technically sound and cost-effective solutions are then developed and implemented through either non-structural or structural approaches, which include regulations, the District's 5-year Capital Improvement Program (CIP), and coordination and construction by the development community and other communities and agencies. The following are elements the District considers when determining if a structural approach proposed as a part of a District plan is eligible for funding under the CIP. Such projects can affect proposed developments and projects planned by other agencies or communities.

1. The watershed contributing to the project is located in or the downstream impacts affect more than one municipality, at least one municipality and the unincorporated county, or only the unincorporated county or counties.
2. A project is identified as a primary element of a drainage master plan that affects more than one municipality, at least one municipality and the unincorporated county, or only the unincorporated county, or that manages stormwater from a watershed at least ten (10) square miles in area or provides benefits to or impacts in an area of at least ten (10) square miles.
3. The project is required as mitigation, protects the integrity or improves the performance of an existing District flood control or stormwater management project, or enhances the resale value of property owned by the District.

4. New facilities or modifications to existing facilities needed for flood hazard mitigation that will be operated and maintained by the District. These facilities may include channels, dams, detention basins, flood warning infrastructure, or components of the Arizona Pollutant Discharge Elimination System.

Developers should check with the District to determine if new floodplains, regulations, or projects have been identified or developed as part of the regional drainage plans detailed in this section. Regional drainage plans, on a watershed basis, are typically called Area Drainage Master Studies & Plans (ADMS & ADMP). Another type of regional drainage plan is a Watercourse Master Plan (WCMP). Construction projects that are defined as a part of a regional drainage plan typically have a Final Drainage Design Report for documenting the basis for the design. Regional drainage planning now also typically includes stormwater quality plans or plan components and should be encouraged to include water conservation strategies and rainwater harvesting implementation guidance. These plan phases are discussed in more detail as follows:

ADMS. The ADMS constitutes the conceptual/preliminary drainage plan hydrology and hydraulics component. An ADMS is prepared to identify areas prone to flooding and related hazards, and present possible management alternatives. Alternatives typically include an array of stormwater conveyance and storage structural components for hazard management, and non-structural hazard management methods. Water conservation, land planning and natural resource considerations should be included at this stage in order to be holistic in its approach. The ADMS typically includes mapping, detailed hydrologic and hydraulic analyses, and identification of flooding and erosion hazards within a major watershed area. Management alternatives are identified, evaluated, and classified. These plans are an excellent source for hydrology as sub-basin hydrographs are typically provided for the 6- and 24-hour storms.

ADMP. An ADMP constitutes a final drainage plan component. The ADMP is typically a more detailed study, providing analysis of selected alternatives recommended in the ADMS, and a thorough evaluation of a final recommended alternative. The challenge is once an alternative is selected, inserting community and multiple use opportunities afterward is a challenge. Water conservation, landscape enhancements, stormwater management and GI/LID options should be considered as part of the initial presentation of possible management alternatives. The ADMP can also provide guidelines for development within the study area, which have a focus on watershed management to implement a public safety strategy. The ADMP may also include watershed components of any WCMP completed in the study area.

WCMP. A WCMP is similar to an ADMP, except that a WCMP has a focus on the management of a particular major watercourse and associated flood and erosion hazard zones. It provides the technical background for planning new development. For more information on lateral erosion hazard zones, refer to FCDMC (2018) Hydraulics. Watercourse management alternatives are typically focused on methods of minimizing cumulative impacts resulting from encroachments within the floodplain. The WCMP are required to consider water conservation strategies in their planning efforts per ARS 48-3609.01.C. Recommendations for watershed management techniques are provided to support the recommended watercourse management alternative.

Final Drainage Design Report. A Final Drainage Design Report constitutes a final drainage plan component. It is the final documentation of the detailed drainage design shown on contract construction drawings for a project defined in an ADMP, WCMP, or a capital improvement project created through a process other than an ADMP or WCMP. Refer to Section [2.4.3](#) for a description of a Final Drainage Design Report, which is common to both the government agency and private land development types of drainage plans.

Regional Stormwater Quality Planning. Regional drainage issues in the past were focused mainly on the water quantity issues and water quality issues were not addressed. Regional drainage planning should consider water quality and other community/environmental concerns, such as water conservation and water harvesting opportunities. With new and more stringent environmental regulations and the focus on context sensitive approaches to development, water quality and conservation considerations should be taken into account.

2.4.2 Local Drainage Planning

Drainage plans are also prepared for land development and public projects. Here, the focus is to identify existing flooding conditions and to develop approaches to prevent the proposed development from exacerbating existing flooding conditions while protecting the proposed development. Drainage plans are typically required as described below. Drainage plans for developments or drainage improvements should consider water quality components to their site development to prevent stormwater runoff concerns and promote water conservation, rainwater harvesting, low impact development technologies, and multiple use opportunities. Adjacent subdivision or developments are encouraged to work together to promote local drainage and multiple use opportunities.

2.4.2.1 Large Developments

Any significant development divided into units or phases may be considered as a large development. Stormwater quality concerns should be met on a unit/phased basis. It would not be appropriate to address stormwater quality, water conservation, and multiple use strategies at the final phase of development. By phasing or implementing stormwater and water harvesting BMPs upfront water quality concerns will be met. The drainage plans required for large developments are:

1. **Drainage Master Plan.** A Drainage Master Plan is a conceptual plan that establishes the drainage approach and system to be used for the entire development. It also establishes how and when the various drainage system components will be constructed. This in turn has a significant impact on the size and orientation of lot and street layouts. Preparation of a Drainage Master Plan and the overall development plan is an iterative process between the developer, land planner and the drainage engineer/planner. The Drainage Master Plan will often significantly impact the definition of development units and phases.

The first step in preparing a Drainage Master Plan is studying the hydrology of the watersheds that contribute stormwater runoff to the master plan study area, and the hydrology of the onsite area.

The second step is definition of existing 100-year floodplains and base flood elevations for watercourses within the development where Federal Emergency Management Agency (FEMA) regulatory base flood elevations have not been established. This is to be done in accordance with Section [3.7.2](#). The definition of erosion hazards and an assessment of the drainage system sediment balance are to be done where necessary in conformance with Section [3.8](#).

The third step is definition and evaluation of drainage system alternatives, and recommendation of a drainage scheme. The key to preparing Drainage Master Plans for land developments is developing an approach to intercept offsite flow and identifying a workable means of conveying the flow through the project. The method for discharging to the downstream drainage network (whether natural or man-made) is established in a manner that returns the flow to its historical flow path without changing the pre-development flow characteristics. Drainage Master Plans for land developments also identify locations for stormwater storage facilities to accommodate on-site runoff, and identify a stormwater quality plan for the development. Offsite flows are not allowed to drain through the onsite conveyance or storage facilities. The above principles remain valid for conceptual drainage plans for all parcels regardless of size.

Drainage Master Plans are to be prepared in conformance with the report outline presented in Section [6.14](#) for the technical (Hydrology and Hydraulics) portions of the report document.

2. Preliminary Drainage Design Report. A Preliminary Drainage Design Report is a conceptual drainage plan for an individual unit or phase of the master planned development. It implements the drainage system recommended in the Drainage Master Plan to the specific unit in question. Adjustments are made to the Drainage Master Plan hydrology and hydraulics, if necessary, and alternatives for drainage facilities specific to the unit/phase are defined that meet the guidelines defined in the Drainage Master Plan. The alternatives are analyzed and a recommended drainage system, including parameters for use during final design, is presented. These parameters include:

- Design discharges and design storage volumes.
- Definition of stormwater conveyance methods, including: channel locations, geometry, lining types and recommended slope ranges; storm drain locations, including preliminary sizes and material types; natural floodplains to be left undisturbed; and guidelines for use of street sections for stormwater conveyance.
- Definition of the methods that will be used for the erosion and scour protection.
- Location, size, and recommended grading and layout of proposed stormwater storage basins.

Recommended stormwater quality design parameters.

- Proof that the Drainage Master Plan recommendations for handling stormwater along the master-planned area boundaries are being met. This must include any needed addendum to the Drainage Master Plan for revised recommendations for future unit/phases.
- Stormwater quality concerns must be addressed on a unit or phase basis as construction of the development occurs.

- Considerations for water conservation and water-harvesting strategies, integrated landscape design, and co-locating multiple-use opportunities are encouraged.
 - Preliminary Drainage Design Reports are to be prepared using the report outline presented in Section [6.14](#).
3. Final Drainage Design Report. A Final Drainage Design Report constitutes a final drainage plan component. It is the final documentation of the detailed drainage design shown on contract construction drawings for the development project. Refer to Section [2.4.3](#) for a description of a Final Drainage Design Report, which is common to both the government agency and private land development types of drainage plans.

2.4.2.2 Local Developments

Local developments are typically considered to be less than 640 acres in size. The drainage plans required for local developments are:

1. Preliminary Drainage Design Report. A Preliminary Drainage Design Report is a conceptual drainage plan for a private or agency project. For simple projects with minimal drainage considerations, the detail and length of the report is intended to be minimal. For larger projects with significant drainage considerations, the submittal requirements and level of detail may be a combination of the Drainage Master Plan and Preliminary Drainage Design Report for Large Developments as described above.
2. Final Drainage Design Report. A Final Drainage Design Report for Local Developments is the same as for Large Developments. The level of detail required is commensurate with the complexity of the drainage design.

2.4.3 Final Drainage design Report

As stated above, a Final Drainage Design Report constitutes a final drainage plan component. Final drainage construction drawings provide engineered solutions and details to implement the final drainage design of a project. The Final Drainage Design Report documents the supporting calculations and design assumptions the construction drawings are based on. The hydrology and hydraulics of the selected approach from the Drainage Master Plan and Preliminary Drainage Design Report is further refined and documented to apply to the specifics of the chosen drainage solution. The project may be a regional capital improvement project to alleviate existing flooding conditions or improvements resulting from land development. The design report documentation is to be prepared in accordance with Section [6.14](#).

2.5 INFORMATION FOR DRAINAGE PLANNING

There is a significant amount of existing information available to the hydrologist or drainage engineer that should be considered when undertaking a drainage plan. The following table highlights some of these.

Table 2.1 Types of Available Drainage Information

Item	Source	Description
Flood Insurance Studies	FEMA, District	Watershed peak discharges, floodwater levels, flood risk.
Area Drainage Master Plans & Studies (ADMP & ADMS)	District & Municipalities	Watershed hydrographs and peak discharges, conceptual storage and conveyance solutions.
Watercourse Master Plans (WCMP)	District & Municipalities	Management of a particular watercourse and its associated flood and erosion hazards.
Studies & plans from existing flood control projects	District, USACE, USBR, NRCS	Examples: ACDC, Cave Buttes Dam, CAP dikes, Indian Bend Wash.
Transportation Plans & Studies	ADOT, MCDOT, Municipalities	Corridor studies address existing and proposed drainage conditions. Plans depict drainage improvements.
Land Use Zoning Maps	Municipality, County, MAG	Provides insight to future runoff characteristics. Zoning may limit type of drainage solution.
Soil Maps	NRCS & USFS	Identifies runoff characteristics and engineering limitations.
Aerial Photography	public & private	Identifies watershed and existing land use characteristics.
Topographic Mapping	public & private	Used to determine watershed boundaries, slopes, and water-course hydraulic characteristics.
ALTA Surveys	Maricopa County Recorder's Office	Land ownership, boundary & utility easements (if available).
Drainage plans from adjacent developments	Municipalities/County/Land Developer/Home Owners Assoc.	Depicts existing or proposed conditions for adjacent properties that may affect the site under study.
Utility Plans	Utility companies	Depicts the location of underground and above ground utilities that may affect the location of drainage facilities and the routing of stormwater.

2.6 DRAINAGE PLANNING PROCESS

2.6.1 Plan Development

The drainage planning process requires the collection and assimilation of information from most of the sources identified above. Consideration must be given to regulations, environmental impacts, ordinances, open space, zoning, regional hydrology, flood hazards, safety, compatibility with adjoining projects, and cost. As part of the initial layout design, the designer must consider and accommodate the future need of vehicular access for maintenance purposes. Preliminary design should minimize long-term maintenance requirements.

2.6.2 Waters of the United States (Section 404)

Waters of the United States, for the purposes of the Section 404 program (refer to Section [4.5](#)), are drainage ways meeting certain criteria that define them by federal law as being under the jurisdiction of the U.S. Army Corps of Engineers (USACE). Waters of the United States are often referred to as jurisdictional waters. Construction activities that impact jurisdictional waters require a permit issued through the USACE. For most areas under study, jurisdictional waters exist. Therefore, drainage plans must consider the nuances of jurisdictional waters (See Chapter 4 (Regulations), and Policy 3.3.3). The professional undertaking a drainage plan must have knowledge of 404 requirements to apply to the planning objective or have the jurisdictional waters delineated prior to delving too far into the drainage planning process. It is likely that the jurisdictional waters will have a significant impact on the overall drainage plan, remediation, and on-going maintenance activities.

2.6.3 Waters of the United States (EPA)

Waters of the United States as defined by the Environmental Protection Agency (EPA) has a different context from that defined under Section 404. When dealing with stormwater quality issues refer to Policy 3.6.5.

2.6.4 Regulations, Policies, and Standards

All drainage plans and construction drawings shall meet District and Maricopa County/Community regulations. The policies (Chapter 3) and standards (Chapter 6) are intended to be an implementation guide for preparing drainage plans and drainage designs that are in conformance with the regulations. The time required for the review process is normally less, and review comments minimized, if the drainage plans are prepared in conformance with the policies and standards. Sometimes additional documentation may be required for submittal and review by the County/Community/District to prove conformance with the regulations. These policies and standards also establish the minimum guidelines for capital improvement projects, both public and private.

2.6.5 Watercourse Open Space

Maricopa County Drainage Policies and Standards

The concept of integrated design in flood control, environmental considerations, and recreational uses are encouraged to be applied to drainage corridors (watercourses). Natural or semi-natural drainage and/or greenbelt corridors can be developed with desirable landscaping, stormwater quality improvements, water conservation and rainwater reuse concepts, and multiple-use trails incorporated into the drainage design to provide for recreation opportunities and community benefits. This concept can be applied to new drainage facilities during design and to existing facilities that currently do not provide passive/active recreation and wildlife opportunities. The multi-use trails should be located and designed in a manner to: avoid significant impacts to Waters of the United States (Section 404), minimize the effects of erosion, minimize excessive interaction with nuisance flows, and minimize trail maintenance requirements. For public safety, design of such features must include appropriate warning signs and barriers to discourage travel through low-flow channels during runoff events, refer to section 6.2. Reasons for utilizing natural drainage and/or greenbelt corridor design concepts to accommodate stormwater include:

1. Watercourses make excellent natural, open spaces of high scenic value and quality due to their associated unique vegetation, potential wildlife habitat, heat island impact mitigation effects, undulating landforms, etc.
2. Natural features (such as topography) and natural processes (such as erosion), have defined the landscape character along natural watercourses as a drainage and stormwater runoff corridor that merits considerations to minimize impacts
3. Riparian vegetation is dependent on natural watercourses for water supply and seed disbursement and germination.
4. Many desert wildlife species actively seek natural watercourses and associated vegetative communities for habitat and travel corridors.
5. Negative impacts to watercourses have long term environmental consequences such as habitat loss, reduced potential for flood conveyance, loss of a valuable vegetation and wildlife habitat, reduced ground water recharge potential, and impaired stormwater quality.
6. Negative impacts to watercourses have public safety consequences adjacent, upstream, and downstream of the impact area, including the potential for higher rates of runoff downstream.
7. Negative impacts to watercourses often have decreased property value implications as negative environmental impacts may diminish abutting land value.
8. Designating open space along watercourses is often more cost effective for the developer due to the high risk of flooding in these corridors and can provide additional community benefits such as increased recreational spaces, natural desert and riparian visual aesthetics, and preservation of natural, pervious landscapes to reduce heat island impacts. These provide economic benefit through higher home values and reduced up-front infrastructure costs.
9. Structural solutions that negatively impact natural watercourses often have increased maintenance and associated costs over the long term.

2.6.6 Stormwater Storage

In the planning process, it is a County/Community/District goal that stormwater storage basins be combined in an integrated manner (where feasible) with open space, parks, water conservation efforts, and multi-use trails to create focal points and amenities for the community instead of isolated, single function facilities. These integrated uses should be planned and designed to augment local community and County's park, trails, open space, and water conservation/reuse goals. Benefits include an enhanced sense of community, increased open space and a better quality of life for citizens. The County/Community/District encourages integrated use of drainage and recreation facilities on both public and private lands, whenever possible. Drainage facilities should be designed to meet multiple community goals and coordinated with the County/Community/District to assure compliance with stormwater quality requirements. The use of surge basins that receive floodwater storage only during heavy runoff events when the adjacent storm drain system capacity is exceeded may need to have multi-use limited during seasons when storms can occur frequently. Refer to the ADWR, 1999.

2.6.6.1 Public Stormwater Storage Basins

Given the demand for organized sports fields such as soccer and ball fields, basins may serve multi-use purposes. However, it is recommended to avoid siting of regularly-used recreational facilities at the very bottom of stormwater storage basins. The District recommends that multiple-use basins be designed with tiers, terraces, and gentle slopes to allow for the collection and conveyance of nuisance water around play areas to allow for dry field conditions as much as possible.

Locating stormwater storage basins adjacent to existing parks is encouraged to increase the amount of contiguous open space. Integrating curvilinear, naturalistic basins into park design is encouraged for both active and passive recreation purposes. While being subject to meeting Maricopa County/Community aesthetic, safety standards and programmatic goals.

2.6.6.2 Private Stormwater Storage Basins

The County/Community/District recommends curvilinear designs for stormwater basins in private development projects as well. In these developments, the use of open space in combination with stormwater storage basins is also encouraged in order to provide a more natural and aesthetically pleasing method of addressing runoff, stormwater storage, water harvesting and stormwater quality. This practice can provide measurable benefits to the residents of the development when sufficient passive or active recreation amenities are provided. These open space areas should be made focal points of the community instead of isolated tracts, which helps create a sense of community. Other design considerations, that are encouraged, include: community access, multi-use trails, water conservation and rainwater harvesting, increased infiltration potential, and habitat connectivity as layered complimentary and integrated benefits.

2.6.7 Zoning

Zoning often dictates watercourse development and open space requirements for land development projects. Rezoning land to address flooding or erosion hazards, either through the

use of an overlay or replacement zoning district or through conditions of zoning approval that limit the use of such land (such as having a tract dedicated to open space on the final plat), can, provide a natural or limited structural design approach to watercourse management. Generally, this results in a more ideally-situated open space. Even small washes lend themselves to non-structural solutions in the same manner as larger watercourses if the identification of the flood hazards and erosion impacts are initiated early enough. Where ADMPs and WCMPs have been completed, implementation plans may recommend land use and drainage design options. In other areas, individual rezoning applications or zoning overlay districts may warrant stipulations or design guidelines that address watercourse treatment and the degree to which the watercourse may be altered or disturbed.

2.6.8 Design Hydrology and Hydraulics

The drainage engineer should determine if there is existing hydrologic and hydraulic information available for the upstream watershed and project site that is suitable for use in design of the project improvements. This includes researching the information sources listed in [Table 2.1](#). In particular, review of the District ADMS or ADMP that encompasses the project area provides the design team with valuable information pertaining to the magnitude of stormwater discharges and volumes affecting the project. The design engineer must either concur with the ADMS, ADMP and/or WCMP by statement, or submit additional documentation addressing and substantiating any differences. The FEMA Flood Insurance Rate Maps (FIRM) should also be reviewed to establish if regulated floodplains cross the project. Where existing studies are not available, the drainage engineer should contact the District, as it has an aggressive schedule to undertake the study of new areas. “In-progress” information is often available, and if not, staff experience regarding these issues is extensive. **Study and FIRM information may be available on the District’s website.**

In the event there is insufficient hydrology or hydraulic information available, then the drainage engineer will have to generate new information using the Hydrology and Hydraulics volumes and the policies and standards herein. At the drainage plan level, the drainage engineer should concentrate on quantifying off-site flows that may impact the project, and determine the means for conveying that flow through the project site. A reasonable estimate of the design peak discharge is necessary to approximate the channel or drainage structure type and capacity, with a goal to maintain historic conditions. Again, the improvements presented in a drainage plan shall not adversely impact adjacent property owners.

2.6.9 Other Hazard Considerations

Drainage plans need to focus on more than flood levels derived from open channel hydraulic analyses. Aggradation of channel beds and overbanks via sedimentation and degradation of channels from erosive processes should be considered. In addition, the lateral migration of watercourses may threaten public safety, health and welfare, unless proper erosion hazard zones are identified, prohibiting development in these areas unless remediation of the hazard is accomplished. FCDMC (2018) Hydraulics and ADWR (1996) publications regarding study methodologies for this type of hazard should be considered during the planning process. The determination of flood levels on alluvial piedmonts is particularly challenging because of active geomorphic processes. The plan should consider the FEMA’s latest alluvial fan flooding analysis guidelines (FEMA, 2003), the District’s Piedmont Flood Hazard Assessment for Flood Plain Management for Maricopa County, Arizona (Hjalmarson, 2003) or most current version, and the

National Research Council (1996), when drainage planning on alluvial piedmonts. Application examples of FEMA 2003 guidelines and engineering analysis details can be found in FCDMC (2014). Finally, ponding areas up gradient of elevated roads, railroads, and irrigation canals must be considered during the development of the drainage plan to assess finished floor elevations, outfall hydraulics, and compensation for volume displacement.

2.6.10 Safety

A basic tenet of any capital improvement project is the promotion of public safety. Public safety must be a consideration taken throughout the development of a drainage plan. Excessive stormwater depth, high velocities, unwanted erosion, high sedimentation levels, and/or poor stormwater quality pose a threat to safety and public health.

2.6.11 Cost

During the development of a drainage plan, initial capital costs, long term maintenance costs, and stormwater treatment costs should be considered.

2.7 APPROACH TO DRAINAGE PLANNING

2.7.1 Open Channel Conveyance

The alignment of a planned drainage system is often set by following the original natural watercourse flow line or low flow channel. In these cases, the alignment need only be defined on available topographic mapping or aerial photographs. In many areas about to be urbanized, the runoff has been so minimal that well-defined natural channels do not exist. However, low flow channels nearly always exist which provide an excellent basis for location of improved channels. Use of these channels to convey stormwater is likely to reduce development costs and minimize drainage problems. In some cases, the wise utilization of natural watercourses in the development of a drainage system will eliminate the need for an underground storm drain system. Where WCMP's have been completed, setbacks for erosion hazard zones may have been identified. If setbacks have not been defined as part of the WCMP, then erosion hazard areas should be approximated following the methodologies identified in ADWR (1996) and the District's Hydraulics volume (FCDMC 2018) Hydraulics. Detailed lateral migration and long-term erosion analyses would be performed as part of final design in those circumstances.

The drainage plan is where major decisions are made as to design velocities, location of structures, means of accommodating conflicting utilities, and the potential alternate uses in the case of an open channel. The choices of channel types available to the design team are finite, with possible solutions dependent upon good hydraulic practice, basic project requirements, environmental design considerations (including stormwater quality control and treatment options), alignment with community desires/needs, and other associated project goals -- such as multiple use opportunities and water conservation potential. However, from a practical standpoint, the basic choice to be made is whether or not the channel is to be lined to protect the effects of higher flow velocities, or, if the natural channel and floodplain that already exists can be effectively utilized with considerations to erosion setbacks and the 100-year flooding limits can be used. An

evaluation of alternatives based on desired outcomes should be made to determine the most beneficial course of action.

A more natural approach is preferred, especially in native desert environs. The more desirable setting for the channel and overbank floodplain areas is an undisturbed, natural one. The benefits of such include:

- Velocities are usually lower, resulting in longer concentration times and lower downstream peak flows. This provides for increased infiltration/aquifer recharge opportunities of storm flows in a more natural manner and may reduce sizes and costs of needed infrastructure downstream lower velocities are safer in the event of accidental public trespass.
- Natural channel and overbank floodplain storage tends to decrease peak flows.
- Maintenance needs are usually less than artificial channels.
- The natural channel and overbank floodplain provides desirable open space and recreational areas adding significant social benefits. The more closely the character of an artificial channel can be made to emulate that of a natural channel with overbank floodplain, the higher the quality of the artificial channel.

For a drainage plan, the level of analysis necessary to establish artificial channel widths may vary. If the artificial channel is for a watercourse with a 100-year peak discharge of 50 cfs or greater, a detailed floodplain analysis may be required (see [Table 6.7](#)). The level of analysis is also dependent upon the existing or proposed land use and whether encroachments, such as road culvert embankments, affect the flow regime. Otherwise, simple “normal depth flow” calculations may suffice. Where channel slopes exceed 0.5% to 1.0%, supercritical flow analysis may be warranted.

Another key component of planning for a channel at the drainage plan level is the transitioning of flow into and out of a proposed channel. County/Community/District policy (Policy 3.4.2) requires that proposed facilities do not exacerbate flooding conditions for adjoining properties. Thus, any drainage improvement must not increase water levels or result in erosive velocities greater than pre-development conditions. Interceptor channels (and other low impact development techniques, such as: bioswales, microbasins) may be required/needed to collect offsite flow into an onsite channel. Similarly, spreading basins or 4:1 channel expansions may be necessary to transition from an artificial channel to the existing downstream floodplain.

2.7.2 Storage

The preliminary drainage plan design is where decisions need to be made regarding the use and location of stormwater storage facilities. Locating storage facilities where topography is favorable to the construction of excavation of basins will provide significant benefits including the reduction of peak flows and the settling-out of sediment and debris. The latter can help to improve the quality of water downstream.

For conceptual sizing of stormwater storage facilities, a storage per unit area relationship along with a safety factor can be utilized to derive an approximate stormwater volume for storage and stormwater quality treatment. The storage per unit area is primarily dependent upon the land use

of the proposed project within the proposed project area only and upon the design rainfall depth for the area in question. Offsite flows are not allowed to mix with onsite flows and therefore should be handled separately from onsite storage facilities.

For land development projects involving large acreage, overlaying the proposed site plan with existing topography allows for the development of a conceptual or preliminary grading plan. Establishing proposed grade breaks for mass grading consistent with existing drainage divides is the preferred method. Taking this approach wherever possible during the drainage planning effort provides an additional benefit in that it minimizes earthwork and storm sewer expenditures pursuant to final design. Preliminary plans should address the issue of maintenance for all drainage structures by both integrating maintenance features in the design and by specifying the designated maintenance authority. Undertaking such an approach supports the basis for preliminary stormwater storage design and will tend to minimize the necessity for dramatic design revisions resulting from unforeseen drainage requirements during final design.

2.7.3 Environmental Protection

There are numerous federal, state, and local regulations that must be adhered to during plan development and implementation. At the federal and state level, Section 404 of the Clean Water Act (Waters of the U.S.) and Section 401 (water quality) permitting are typically required during the project approval process and may be required for maintenance or other activities proposed in conjunction with the drainage facilities. For the District, the plan must comply with the Federal NPDES (40 CFR 122), the state AZPDES stormwater quality programs, and also any action or restriction they consider reasonably necessary to meet their obligations, if any, to comply with local, state or federal water quality laws. Taking the requirements of these regulations into account during the development of the drainage plan will streamline the design and implementation process. For example, recognition of the “trigger points” in 404 permitting will provide guidance in developing mitigation plans (see Chapter 4, Federal and State Regulations). **The County/Community/District strongly endorses minimizing disturbances to natural watercourses in order to lessen the impacts on the environment, including: native vegetation, riparian habitat, natural conveyance features, natural recharge potential, and other ecological processes.**

2.7.4 Pervious Concrete

The Maricopa Association of Governments’ Uniform Standard Specifications and Details for Public Works Construction, Section 323 allows for the use of pervious concrete. Per Section 323 pervious concrete “is usually part of a water management system used to reduce runoff rates and volumes from on-grade surfaces such as patios, walkways, driveways, fire lanes, and parking spaces...intended for light traffic areas”. Refer to Table [6.3](#) & [6.5](#) for runoff C coefficients and developed condition parameters.

2.8 FINAL DESIGN CONSIDERATIONS

The drainage plan serves as the framework for final design. A thorough drainage plan streamlines the final design process. Changes may occur during final design. However, changes due to drainage issues should be minor.

It is during final design that street drainage is analyzed and catch basins/storm drains are designed. The specifics and supporting analysis for open channels including culverts and bridges, and the influences of sedimentation and scour, are developed during final design. It is here that stormwater storage facility details, including pump stations (for public project only) if appropriate, are enumerated to permit review by the County/Community/District and subsequent construction. During final design, the design engineer applies the policies and standards of the County/Community/District to finalize long term maintenance of the drainage improvements while accommodating safety and health concerns. Additional considerations include: provisions for water-harvesting, low impact design techniques, pedestrian amenities, streetscape design, water conservation strategies, and other multiple-use opportunities that should be designed in concert (integrative) with the overall drainage improvements.

2.9 REFERENCES

ADWR, 1996, *State Standard for Watercourse System Sediment Balance*, State Standard 5-96, Flood Warning and Dam Safety Section.

ADWR, 1999, *State Standard for Stormwater Detention/Retention*, State Standard 8-99, Flood Warning and Dam Safety Section.

Federal Emergency Management Agency (FEMA), 2003, *Guidelines and Specifications for Flood Hazard Mapping Partners*, Appendix G: Guidance for Alluvial Fan Flooding Analysis and Mapping.

FCDMC, 2018, *Drainage Design Manual for Maricopa County, Hydrology*.

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Flood Control District of Maricopa County (FCDMC), Arizona (2014), *Re-analysis of Alluvial Fans No.5 and No.6 in Scottsdale and Phoenix, Maricopa County, Arizona based on 2003 FEMA Alluvial Fan Guidelines*.

Hjalmarson, H. W., 2003 (Draft), *Piedmont Flood Hazard Assessment for Flood Plain Management for Maricopa County, Arizona*: for Flood Control District of Maricopa County, Phoenix.

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National Research Council, 1996, *Alluvial Fan flooding: National Academy Press*.

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3. DRAINAGE POLICIES

3.1 PURPOSE

The policies contained in this chapter are the general principles by which the County/Community/District implements the District and Maricopa County/Community regulations and ordinances governing stormwater management. Application of these policies assist the County/Community/District in their mission to provide regional flood hazard identification, regulation, remediation, and education to Maricopa County residents so that they can reduce their risks of injury, death, and property damage from flooding, while still enjoying the natural and beneficial values served by floodplains. The policies in Chapter 3 are intended to meet this purpose and are for internal and external application. The County/Community/District regulations and ordinances that these policies help implement include the following:

- Floodplain Regulations for Maricopa County, latest revision with text amendments.
- Maricopa County Zoning Ordinance, latest revision with text amendments.
- Maricopa County Subdivision Regulations, latest revision with text amendments.
- Maricopa County Quality Management and Discharge Control Regulation, May 2009.
- Additional District policies and standards include:
 - Drainage Design Manual - Hydrology, (2018) or most current edition.
 - Drainage Design Manual - Hydraulics, (2018) or most current edition.
 - Drainage Design Manual – Erosion Control, (2013) or most current edition.
 - Erosion Hazard Guidelines, (ADWR, 1996).
 - Policy for the Aesthetic Treatment and Landscaping of Flood Control Projects, (FCDMC, 1992, updated 2009).
 - Piedmont Flood Hazard Assessment for Flood Plain Management for Maricopa County, 2003 draft (Hjalmarson, 2003).
 - The directory of documents can be found at the District website.
 - The County/Community/District has adopted floodplain management and stormwater drainage policies with this document that set forth guiding principles for stormwater management. These drainage policies fall under the following categories:
 - General

Maricopa County Drainage Policies and Standards

- Planning
- Drainage Patterns
- Hydrology
- Stormwater Quality
- Floodplain Management
- Erosion Hazard Management
- Street Drainage
- Conveyance Facilities
- Stormwater Storage Facilities
- Floodplain Use Permits for Sand and Gravel Mining
- Ownership and Maintenance
- Erosion Control During Construction

These policies, together with the stormwater management documents listed above, define the criteria and procedures to be used for stormwater management and drainage design and construction in Maricopa County.

3.2 GENERAL

The policies listed in Chapter 3 are intended for both internal uses by County/Community/District employees and external use by the public. The following policies are intended to clarify general issues related to public versus private projects, and new development versus retrofit and rehabilitation projects.

Policy 3.2.1 Design Standards for New Construction. The standards listed in Chapter 6 apply as the minimum requirements for new public and private development projects on previously undeveloped land or on land where existing improvements are completely removed.

Policy 3.2.2 Design Standards for Rehabilitation Projects. For the purposes of this policy, a rehabilitation project is any project that will repair (other than routine, ongoing maintenance) and/or improve existing facilities. Rehabilitation projects are to be constructed to the standards listed in Chapter 6, but they may be built to a lesser standard under the following conditions:

1. Adjacent, upstream and downstream properties and/or drainage facilities would be adversely affected by constructing the proposed improvements to current standards and the cost to mitigate the adverse effects is determined by the County/Community/District to be impractical. Such properties must not be adversely affected by the proposed improvements, when compared to existing conditions.

2. If the project is funded with public funds and the proposed improvements will increase public safety, health and welfare, even though it is designed to a lesser standard.

Policy 3.2.3 Subsidence and Fissures. The designer should consider the effects of subsidence and/or fissures when planning, designing, and constructing drainage facilities.

3.3 PLANNING

Proper planning and design of drainage facilities are equally important to meet the needs of a growing community as are water, wastewater, streets and other infrastructure. The following are County/Community/District policies related to drainage planning for private developments.

Policy 3.3.1 Compatibility with Studies of Record. Developments shall acknowledge and assess their project for compatibility with any ADMSs, ADMPs, WCMPs, or flood insurance studies.

Policy 3.3.2 Watercourse Master Plan Requirements. Where a WCMP has been completed, the approved plan for erosion setbacks, structural and non-structural measures, existing and/or future condition floodplain and floodway requirements should be followed.

Policy 3.3.3 Permits. There are numerous federal, state, county, and community permits that may be required prior to the start of construction of a project (see Chapter 4 and Chapter 5). It is not the County's/Community's/District's responsibility to ensure that the plans for a proposed project satisfy state and federal permit requirements. It is the County's/Community's/District's policy that all such permits must be obtained, but it is the owner's responsibility to determine which permits are required and to obtain them as appropriate for the timing of the project. County/Community/District-issued permits may be withheld pending written proof that required State and/or Federal permits have been obtained.

3.4 DRAINAGE PATTERNS

The provision for facilities to convey stormwater runoff is a necessary part of land development activity. In the natural environment, stormwater runoff will determine its own course. Land development may result in alteration of the natural alignment of a drainage system. This may result in realigned flow paths, larger peak discharges, greater volume of runoff, higher water surface elevations, increased flow velocities and other drainage modifications that can adversely impact other properties and natural areas, which must be mitigated. As a result, the following are County/Community/District policies:

Policy 3.4.1 Disturbances to Natural Watercourses. Disturbances to natural watercourses should be minimized in order to preserve the watercourses' natural and beneficial functions (As defined by FEMA 480).

Policy 3.4.2 Historic Drainage Patterns. Historic drainage patterns, where runoff enters and exits a property, shall be maintained.

Policy 3.4.3 Alteration of On-Site Drainage Patterns. Activities on a property that affect drainage shall not result in adverse impacts on adjacent properties. At a minimum, such drainage

activities, including wash relocations and the concentration of sheet flows or braided washes, shall not adversely change water surface elevations and flow characteristics. Such drainage activities shall require an engineered report that substantiates there are no adverse impacts.

Policy 3.4.4 Drainage Facilities and Structures. Any drainage facility or structure that will be located within a watercourse, drainage way, or other means of conveying or storing stormwater shall be designed and constructed to the standards listed in Chapter 6.

3.5 HYDROLOGY

Hydrology addresses surface water and the estimation of peak discharges, volumes and time distributions, which result from precipitation events. Hydrologic data is fundamental in the design of drainage facilities. The purpose in the application of hydrology is ultimately for the delineation of the limits of flood prone areas, for the design of drainage structures and facilities; and to define what constitutes natural and/or historical conditions at property boundaries. There are a number of methods for obtaining the necessary hydrologic information to accomplish this purpose, as described in the following policy.

Policy 3.5.1 Source of Peak Discharge and Runoff Volume Information. The following is the preferred order of hierarchy for obtaining peak discharges and runoff volumes for various floodplain and drainage purposes:

1. The first choice is to obtain accepted peak discharges and runoff volumes of record from ADMSs, ADMPs, WCMPs or flood insurance studies. The results from these studies must be evaluated to determine if the assumptions made are still valid and appropriate for the intended purpose. Such studies may only provide information for the 100-year storm. Information for other storm frequencies may be obtained by appropriate revision of the existing computer models using the procedures defined in the Hydrology and Hydraulics volumes.
2. The second choice is the drainage plans and design reports from adjacent properties. This information may be used where available and if approved by the reviewing agency for use on the project. If this is used, the user assumes all liability for the information used since the original design was for a different purpose. It is recommended that the designer coordinate with all nearby jurisdictions to ensure a comprehensive search for applicable study data is made, and that they are aware of proposed changes that may affect their drainage systems.
3. If choices 1 and 2 above are not available options, or are deemed inappropriate, then peak discharges and runoff volumes should be estimated in accordance with the procedures in the Hydrology and Hydraulics volumes.

3.6 STORMWATER QUALITY

In March 2003, Arizona municipalities within the urbanized area were brought into the municipal stormwater permitting program through Phase II of the Federal stormwater program called the National Pollutant Discharge Elimination System (NPDES). In Arizona, this program is called the Arizona Pollutant Discharge Elimination System (AZPDES), except for tribal lands, which are administered by the EPA. Maricopa County has been designated as a permittee under this

program. Maricopa County meets the minimum federal requirements for designation by the United States Environmental Protection Agency (EPA) as a small Municipal Separate Storm Sewer System operator or MS4. As a small MS4, the County is required by the Federal Water Pollution Control Act of 1972, commonly known as the Clean Water Act (as amended), to implement and enforce a program to improve to the maximum extent practicable the quality of stormwater in the County's stormwater conveyance system within the unincorporated urbanized areas of the County. Maricopa County has adopted a regulation to implement and enforce its stormwater quality program (Maricopa County Quality Management and Discharge Control Regulation, May 2009). The following are County's/Community's/District's policies as they relate to stormwater quality:

Maricopa County policies related to stormwater quality are:

Policy 3.6.1 Discharge of Pollutants. No person or entity may cause the discharge of pollutants⁽¹⁾ into a natural drainage system or a public storm sewer system or facility.

Policy 3.6.2 Pollutants on the Land Surface. Pollutants released to the land surface that subsequently become a constituent of stormwater runoff are considered a discharge of pollutants⁽²⁾.

Policy 3.6.3 Soil as a Pollutant. Soil is considered a pollutant when it is entrained in stormwater runoff from construction sites in quantities greater than natural conditions.

Policy 3.6.4 Erosion Control. Erosion control measures for new developments should be in conformance with Best Management Practices (BMPs) identified in the DDM - Erosion or other EPA, ADEQ, or locally approved method.

Policy 3.6.5 Stormwater Pollution Prevention. Stormwater Pollution Prevention is to be addressed through the use of BMPs to the maximum extent practicable to comply with federal, state, county or local regulations or ordinances. Refer to the Erosion Control volume.

Policy 3.6.6 First Flush. The District has established a minimum level of control for new development at which stormwater pollution prevention practices must be put in place. This minimum standard is "First Flush", and consists of retaining or treating the first 0.5 inches of direct runoff from a storm event. Normally, this minimum level of control is met by following the County/Community/District retention requirement (Section [5.2](#), Policy 3.11.1, Standard 6.10.5). In the event that normal County/Community retention standards are waived (100 year, 2 hour storm), or a surface based bleed off for the retention basin is proposed, the first flush provisions for storage shall still apply. Refer to Standard 6.4.1 for technical details and an example application.

This first flush policy is the result of ARS 48-3622 where the District may require any action or impose any restriction that the District considers reasonably necessary to meet the District's obligations, if any, to comply with local, state or federal water quality laws. The full text of this statute is included in Section [5.6](#).

The County/Community/District encourages the use of green infrastructure and low impact development techniques in concert with these stormwater policies to improve water-harvesting potential, improve water quality, and reduce the impacts of increased run-off downstream. These green infrastructure techniques may be use to meet the first flush volume requirements if equivalent volume and performances are achieved.

- (1) Pollutant shall have the same meaning as defined in ARS 49-201 (28).
- (2) As of 11/30/01, excludes certain activities such as not-for-profit washing of vehicles, non-agricultural irrigation water discharges, fire hydrant/potable water system flushing, dust control watering, and discharge of residential evaporative cooler/air conditioning condensate. Since the federal regulations pertaining to this matter change periodically, the practitioner should review the Federal Register for revision.

3.7 FLOODPLAIN MANAGEMENT

Maricopa County/Community participates in the NFIP, which provides flood insurance to its citizens and flood mitigation assistance and emergency assistance to flood victims. The Department of Homeland Security, Federal Emergency Management Agency (FEMA) oversees the NFIP. FEMA has regulations pertaining to floodplain management that must be followed in order for the County/Community to continue as a member of the NFIP. The State of Arizona, in turn, requires each County to form a flood control district and to adopt and enforce floodplain regulations for the county. The District has adopted floodplain regulations for Maricopa County that meet or exceed the FEMA and State regulations.

The District has local policies to manage floodplains in a uniform and consistent manner to meet the intent of the floodplain regulations. These policies are categorized as being FEMA related and non-FEMA related in nature. Erosion and sedimentation hazards management are an integral part of floodplain management. Policies are also established to manage erosion and sedimentation hazard areas in a uniform and consistent manner.

3.7.1 FEMA

Refer to the Floodplain Regulations for Maricopa County (Section [5.3](#)). FEMA has identified floodplains and established floodways that are shown on the FIRMs. Refer to Section 4.3 for a description of the NFIP under which these maps were prepared. The District policies related to implementation of the Floodplain Regulations are as follows:

Policy 3.7.1 Best Available Technical Information. New or updated information for FEMA defined floodplains and floodways is constantly being prepared, both by the District and by others. It is the District's policy, in conformance with FEMA Guidelines, to use this information for regulatory purposes and to provide it to the public as the "Best Available Technical Information". However, until the effective FIRM is revised, the requirements from the effective FIRM will also be used. Examples of "Best Available Technical Information" follow:

1. New studies that have not yet been submitted to FEMA. This information is usually from studies that are in progress but could also be completed studies that are being held pending further investigations such as completion of an ADMS, ADMP or WCMP. This information may be shared with the public if appropriate and approved for release by the Chief Engineer and General Manager of the District. It will be stamped preliminary, and the recipient will be notified that the information is subject to change and is used only at-risk. This information may be used for regulatory purposes, particularly if the floodplain and/or floodway widths or 100-year water surface elevations exceed those of the effective FEMA Flood Insurance Study (FIS).

2. New studies that have been submitted to FEMA but not yet approved. The same conditions from item 1 apply here. The effective FEMA FIS will be used for regulatory purposes for all other cases.
3. Floodway delineation in a new study prior to submittal to FEMA.

Policy 3.7.2 CLOMR Requirement Prior to Issuance of a Grading Permit. Subdivisions and other proposed developments greater than 50 lots or 5 acres, and planning to submit a CLOMR for modification of a FEMA-designated floodplain and/or floodway, must receive District approval and submit the CLOMR request to FEMA before a grading and drainage permit will be issued by Maricopa County/Community for the development.

Policy 3.7.3 LOMR Requirement Prior to Final Development Approval. Subdivisions and other proposed developments greater than 50 lots or 5 acres that have submitted a CLOMR to FEMA for modification of a FEMA-designated floodplain and/or floodway, must receive District approval, Community approval, and must receive an FEMA-approved LOMR (the effective date contained on the LOMR) before final approval by Maricopa County/Community is granted for building occupancy for the development. LOMRs are to be submitted within six months following completion of the development (44 C.F.R. § 65.3).

Policy 3.7.4 Location of Structures. The developer should locate proposed structures outside of a FEMA-designated floodplain if at all possible. District staff will attempt to work with the developer on building placement and issue a Floodplain Clearance if the proposed structure(s) is successfully placed outside the floodplain.

Policy 3.7.5 Public and Private Roads Affecting FEMA Floodplains. A CLOMR and LOMR must be submitted to the District and FEMA for approval if a proposed roadway affects a FEMA-designated floodplain and/or floodway. This applies to all development including those done by MCDOT, ADOT, the District and all District-regulated communities within Maricopa County.

Policy 3.7.6 Development in the floodway. Any development within the floodway that results in any increase in the effective flood elevation or extent either vertically or horizontally will require a CLOMR (44 C.F.R. § 60.3.d(4)). The increase is measured from the effective study. This also applies to floodways shown on the Flood Management Maps for Maricopa County.

If there are no increases, then a no rise certification and analysis per Sections 405 & 602 of the Floodplain Regulations for Maricopa County is required. A CLOMR is not required (C.F.R. § 6.3.d(3)).

Policy 3.7.7 Scour Protection for Utilities. Underground transmission lines (example: electrical, Natural Gas, Gasoline, Oil, fiber optic, cable, water, sewer) should be protected against scour within the Special Flood Hazard Area or those area shown on the District's Flood Management Maps. The scour depth is to be calculated as set forth in chapter 11 of FCDMC (2018) Hydraulics.

The scour depth for Individual lot utility service connections should be protected against scour within the Special Flood Hazard Area or those area shown on the District's Flood Management Maps. The scour depth is to be calculated as set forth in chapter 11 of FCDMC (2018) Hydraulics. In addition, the scour depth may be calculated as set forth in ADWR (1996) except for gas and electric lines.

The scour depth is to be designed by a Professional Civil Engineer.

3.7.2 Non FEMA

There are many flood prone areas in Maricopa County/Community that do not have floodplains or floodways identified by FEMA. The District's mission is clear: To provide regional flood hazard identification, regulation, remediation, and education for Maricopa County/Community residents so that they can reduce their risks of injury, death and property damage from flooding, while still enjoying the natural and beneficial values served by floodplains. Flood prone areas, meeting the definition set forth in the District's Floodplain Regulations (Section 5.3), are subject to regulation.

County/Community/District policies pertaining to non-FEMA flood or erosion prone areas follow:

Policy 3.7.8 Requirement to Delineate 100-year Flood Hazard Area and Establish Minimum Finished Floor Elevation. In locations where development is proposed and a FEMA regulatory floodplain does not exist, delineation of the 100-year flood hazard area may be required by the County/Community/District. The minimum finished floor elevation requirements always apply. Refer to [Table 6.7](#) for more specific criteria and requirements. Required delineations are to be prepared using the technical guidance in the Hydrology and Hydraulics volumes and require approval by the County/Community/District.

Policy 3.7.9 Erosion Protection. The need for erosion protection must be determined. One form of erosion protection is setting the building outside of the calculated erosion zone. Building pads and foundations may be required to have an additional setback or be protected from erosion and scour in conformance with the procedures in the Hydraulics volume. As an alternative to structural protection, building setbacks from washes may be required for protection from erosion hazards, as set forth in ADWR (1996) and FCDMC (2018) Hydraulics. Erosion protection is regulated by the District for areas within the designated floodplain. Areas outside of the floodplain are regulated by the County/Community.

Policy 3.7.10 Lot Grading. Lots are to be graded to drain so as not to adversely affect adjacent property owners. Runoff redirected from its natural flow location may drain onto or through an adjacent property if a drainage easement(s) or tract(s) is provided. Such easements or tract(s) must be recorded against the deed(s) of the affected properties. A legal description and exhibit drawing of every easement, sealed by an Arizona registered land surveyor, must be included as a part of the recorded documents.

3.8 EROSION HAZARD MANAGEMENT

3.8.1 Riverine Areas

Policy 3.8.1 Riverine Erosion Hazard Zones. Erosion hazard guidelines (ADWR, 1996), as a minimum, apply to:

- Structures that could fail or incur significant damage as a result of erosion or deposition.
- Proposed structures that, if built, could result in adverse impacts to adjacent properties.
- Watercourses that do not have erosion hazard zones approved by the District.

- Watercourses within existing or proposed subdivisions, including residential and non-residential.
- Watercourses identified by the District as having significant potential flood hazards.
- Watercourses with drainage areas equal to, greater than 30 acres, or a 100-year peak discharge estimate of more than 50 cfs, as estimated using the procedures in the Hydrology and Hydraulics volumes.

Erosion zones consistent with ADWR (1996) may be required for all properties developed in which the watercourses are to be left in an undisturbed state. Depending on the geomorphic conditions of the area, if the erosion limits are suspected by the District/County/Community to exceed those estimated using a Level I analysis, as defined in ADWR (1996), a Level II or Level III analysis may be required. A detail methodology for lateral erosion setback can be found in the FCDMC (2018) Hydraulics.

3.8.2 Distributary Flow Areas

Policy 3.8.2 Watercourse Stability Analysis. Stability of the watercourse divergence point(s) and divergent wash(es) should be determined prior to the approval of a proposed structure.

Policy 3.8.3 Proposed Watercourse Alterations. Proposed modifications should not disturb the natural divergence location(s), especially if upstream, downstream or adjacent parcels may be adversely impacted.

Policy 3.8.4 Erosion Hazard Zones. Erosion hazard guidelines (FCDMC, 2018) should be applied to all divergent watercourses adjacent to the proposed structure.

3.8.3 Sheet Flow/Unconfined Flow Areas

Policy 3.8.5 Vegetation Removal and Flow Concentration. Erosion potential directly relates to vegetation removal and concentration of flows. Proposed development should limit vegetation removal and concentration of flow to a minimum, especially in undisturbed natural desert conditions.

Policy 3.8.6 Single-lots. Flows will not be concentrated beyond the typical shallow swale around the structure. These swales should daylight and broaden to the original sheet flow conditions on the downstream side of proposed structures. Erosion protection may be required.

Policy 3.8.7 Subdivisions. The subdivision drainage design should focus on limiting the concentration of flows to the absolute minimum condition. Where flows are concentrated, appropriate scour protection should be applied to the channelized reach. Concentrated flows shall be returned to the natural sheet flow condition prior to exiting the property.

3.8.4 Alluvial Fan/Piedmont Areas

Policy 3.8.8 Active Alluvial Fan Identification. FEMA’s 2003 guidelines on alluvial fan shall be followed to identify the active alluvial fan areas. FEMA guideline document is entitled “Guidelines and Specifications for Flood Hazard mapping partners, Appendix G: Guidance for Alluvial Fan Flooding Analyses and Mapping.” Application examples of the FEMA 2003 guidelines and engineering analysis details can be found in FCDMC (2014).

Policy 3.8.9 Erosion Hazards Zone Identification. The identified active alluvial fan areas are erosion hazards zones. For the inactive alluvial fan areas, the lateral-erosion hazard zone procedures in Maricopa County’s Hydraulics Manual (2018 or the latest) shall be followed to identify the erosion hazard zones.

Policy 3.8.10 Deposition Hazards Zone Identification. The identified active alluvial fan areas are also deposition hazards zones. The active alluvial fans are subject to both erosion and deposition hazards due to the great uncertainty of flow paths.

Policy 3.8.11 Active Alluvial Fan Hazard Mitigation. The possible mitigation methods for active alluvial fan hazard zones are detention basins at the fan apex, open channels as floodway corridors, diversion channels, etc.

3.9 STREET DRAINAGE

The primary purpose of streets is to serve transportation needs. Accommodation of street drainage is provided so that motorists, emergency vehicles, pedestrians and cyclists have a reasonable level of access and safety during storm events. For new public street construction or improvements to existing public streets, stormwater flowing within or across a street is to be managed in accordance with the following County/District policies.

The County/Community/District encourages the use of green infrastructure and low impact development techniques in concert with these street drainage policies to improve water-harvesting potential, improve water quality, and reduce the impacts of increased run-off downstream. Streetscape and drainage designs should be developed as an integrative solution with multiple community benefits included.

Policy 3.9.1 No Adverse Impacts. Street design should identify any increase in peak discharge and flow velocities and account for them in the roadway design so there are no adverse impacts to other properties, pedestrians and cyclists.

Policy 3.9.2 Safety. Streets should be designed to convey stormwater runoff so as to provide motorists, pedestrians, cyclists and emergency vehicles access and safety during a storm event. Design for major roads may need to address all-weather access for emergency vehicles.

Policy 3.9.3 Standards. Streets shall be designed to accommodate stormwater in conformance with Drainage Standards in Chapter 6.

Policy 3.9.4 Velocity. Street flow velocities in excess of those established in the Drainage Standards in Chapter 6 require County/Community/District administrative approval.

Policy 3.9.5 Inverted Crowns. Inverted crown streets are not permitted (See standard 6.5.5).

Policy 3.9.6 Local Streets. Local streets shall not be designed to collect or direct runoff from expressway, arterial, and collector roads. Expressway, arterial and collector roads shall not direct drainage onto local streets.

Policy 3.9.7 Culverts and Bridges. Culverts or bridges should be provided for all expressway, arterial, and collector roads that cross open channels or drainage ways. Exceptions may be approved by the County/Community/District. Engineering justification must be provided and approved administratively by the County/Community/District.

3.10 CONVEYANCE FACILITIES

Stormwater conveyance facilities are defined to include open channels, undisturbed watercourses (such as rivers and washes), ditches and swales, streets, culverts, or storm drains. The following are County/Community/District policies related to drainage conveyance facilities:

Policy 3.10.1 Review. Watercourses may be reviewed for conveyance capacity and erosion/sedimentation considerations in accordance with the Drainage Standards in Chapter 6 and the Hydrology and Hydraulics volumes.

Policy 3.10.2 Hydraulic Structures. All hydraulic structures are to be designed and constructed, as a minimum, in conformance with the *Uniform Standard Specifications and Details for Public Works Construction* (MAG Standards) by the Maricopa Association of Governments, latest edition, including any County/Community/District amendments. Use of the ADOT *Standard Specifications for Road & Bridge Construction and Standard Drawings* (ADOT Standards), latest edition of both including any County/Community/District amendments, is also permissible. Additional details and specifications may be necessary or required, and in all cases, the final approved construction documents, compliant with current design standards, shall control.

Policy 3.10.3 Acceptance of Existing Structures/Facilities. Prior to the acceptance by Maricopa County/Community and/or the District, to incorporate existing structures and/or facilities for maintenance, such structures and/or facilities shall be refurbished for the intended life cycle and constructed or reconstructed as a minimum, in conformance with the MAG Standards, latest edition, including any County/Community/District amendments. Use of the ADOT Standards, latest edition including any County/Community/District amendments, is also permissible. Additional details and specifications may be necessary or required, and in all cases, the final approved construction documents, compliant with current design standards, shall control.

Policy 3.10.4 Erosion/Sedimentation Analyses. The designer of drainage facilities should undertake the appropriate level of erosion/sedimentation analysis commensurate with the risk of undesirable consequences expected to the health, safety, and welfare of the general public. Design water surface elevations for excavated channels are to be below adjacent natural ground, including design freeboard.

Policy 3.10.5 Levees and Berms. Levees or berms should not obstruct side or interior drainage to a channel. These are only allowed as public projects, with maintenance oversight of a governmental agency.

Policy 3.10.6 Irrigation Canals. Irrigation canals may not be used as an outfall for stormwater runoff without written approval by the agency that owns the facility.

Policy 3.10.7 Siphons. The use of siphons for stormwater conveyance is strongly discouraged. A siphon may be allowed provided it is demonstrated there is no other feasible option and adequate provisions for on-going maintenance are in place.

Policy 3.10.8 Trash Racks and Access Barriers. Trash racks at entrances and access barriers at outlets are to be provided for stormwater conduits as specified in Drainage Standard in Chapter 6.

Policy 3.10.9 Landscape Character. All channels should be designed to blend into the surrounding landscape to the greatest reasonable extent possible. This can be accomplished through integrated drainage design, utilizing natural drainages and structural and landscape aesthetics with an understanding of the community and landscape context where the project is being proposed.

Policy 3.10.10 Stormwater Conveyance During Construction. Stormwater conveyance is to be provided at all times during construction in such a manner as to not increase flood depths, sedimentation, or erosive velocities above pre-construction levels for the areas adjacent to, and downstream of, construction projects.

3.11 STORMWATER STORAGE FACILITIES

Land development can convert natural pervious areas into impervious or otherwise altered surfaces. These activities may cause an increase in runoff volume and/or peak discharge. The temporary storage of stormwater runoff can decrease downstream peak discharges and associated impacts to drainage infrastructure. The following are County/Community/District policies related to stormwater storage:

Policy 3.11.1 Stormwater Retention for Developments. All development (residential and non-residential subdivisions, and single non-residential parcels) shall make provisions to retain stormwater runoff falling within its boundaries in accordance with the Drainage Provisions (Section 1205 of the Maricopa County Zoning Ordinance) (Section [5.2](#)) or the Community's Drainage Regulations, the procedures provided in the Hydrology and Hydraulics volumes, and the Drainage Standards in Chapter 6. Stormwater retention is not required, but not prohibited, for single (un-subdivided) residential parcels equal to or greater than one (1) acre in area.

Policy 3.11.2 On-Lot Storage. On-lot storage is not allowed for residential subdivisions with a lot size less than one gross acre without a variance in accordance with Drainage Provisions (Section 1205 of the Maricopa County Zoning Ordinance), approved in writing by the Drainage Review Board in Maricopa County or with a variance from the Drainage Regulations of the Community as provided by the Drainage Regulations. Water harvesting by individual lot owner is allowed, this is not to be used as part of the required retention volume for the subdivision or development.

Policy 3.11.3 Multi-Use Features. The designers of stormwater storage areas in residential subdivisions are encouraged to incorporate multi-use features and to design the basin grading with varying side slopes, slope warping, and landscape architecturally derived land features that are aesthetically pleasing while accommodating required stormwater management and safety

needs. Aesthetics, multiple-use opportunities, and community needs as well as stormwater functionality are to be considered in the design of storage and conveyance facilities. While combining uses -- such as flood protection and stormwater management with passive/active open space -- is encouraged and considered beneficial to the community, siting constructed recreational facilities (particularly playgrounds for children) at the low point of stormwater storage basins should be avoided. If multiple use and recreation opportunities are part of the overall project goals, these basins should be designed with terraces, a defined low flow, and gentle side slopes to allow for the collection of nuisance water and conveyance around fields, while keeping designated play areas safe from inundation during higher frequency rainfall events, such as the one or two-year storm.

Policy 3.11.4 Landscape Character. All stormwater storage facilities should be designed to blend into the surrounding landscape to the greatest reasonable extent possible. This can be accomplished through integrated storage design, utilizing natural approaches and structural and landscape aesthetics and an understanding of the community and landscape context where the project is being proposed.

Policy 3.11.5 Public Health, Safety and Water Quality Enhancement. Stormwater storage facilities shall be designed with public health and safety in mind.

Policy 3.11.6 Drainage of Storage Facilities. Storage facilities shall be designed to drain in accordance with the procedures in the DDM, and the Drainage Provisions (Section 1205 of the Maricopa County Zoning Ordinance) or the Community's Drainage Regulations. All stormwater storage facilities shall be designed to drain to appropriate outfall facilities or percolate within 36 hours.

Policy 3.11.7 Underground Storage Facilities. Underground storage facilities are allowed but not encouraged. Such facilities must be designed in accordance with Section [6.10](#).

Policy 3.11.8 Basin Geometry. Depth and side slopes of stormwater storage facilities shall be in accordance with the procedures in the DDM and the Drainage Standards in Chapter 6. ADWR (1999) may also apply. The basin shall be designed with an emergency outflow.

Policy 3.11.9 Discharge to District-Owned or Maintained Facilities. The discharge from a stormwater storage facility into District-owned or maintained drainage facilities shall require a right-of-way use permit issued by the District for work in or on, and continued discharge to, District rights-of-way.

Policy 3.11.10 Offsite Flows. Off-site flows shall not be routed through a stormwater storage facility without County/Community/District approval. Offsite flows shall not be co-mingled with onsite flows.

Policy 3.11.11 FEMA Special Flood Hazard Area. Stormwater storage facilities shall not be sited within a FEMA Special Flood Hazard Area (Section 4.3.3) without Community/District approval.

Policy 3.11.12 Storage Requirement Waiver. The requirements for a Waiver of Policy 3.10.1 Stormwater Retention for Developments may be granted in cases where the developer demonstrates the meeting of the Storage Requirement Waiver. Waiver from stormwater Storage requirements may be granted in accordance with Section 1205-6 of the Zoning Ordinance -

Drainage Provisions or the Community's Drainage Regulations. The following items need to be addressed:

1. 100-year post-development peak discharges are less than pre-development and post-development times of concentrations do not exacerbate downstream conditions.
2. The downstream drainage system is adequate to safely accommodate existing and future build out conditions without adverse impacts to adjacent properties and the potential runoff has been included in a storage facility at another location.
3. The downstream drainage system is adequate for existing and future build out conditions, and the potential runoff can be directly carried to a regional drainage system without adverse impacts to adjacent properties.
4. A cost-share agreement is in-place, mutually acceptable to all concerned parties, for construction of regional drainage works that would obviate the need for on-site retention facilities.
5. Any discharge directly or indirectly into a District structure will require a Right-of-Way Use Permit from the District.
6. In any case, a variance will only be allowed after County/Community/District acceptance of any action or restriction they consider reasonably necessary to meet their obligations, if any, to comply with local, state or federal water quality laws as a result of their AZPDES permit.

3.12 FLOODPLAIN USE PERMITS FOR SAND AND GRAVEL MINING

Sand and gravel mining operations within jurisdictional watercourses in areas of Maricopa County for which the Flood Control District of Maricopa County performs floodplain management, must have an approved District Floodplain Use Permit prior to commencing operations.

3.13 OWNERSHIP AND MAINTENANCE OF DRAINAGE FACILITIES

It is essential that maintenance be considered during the planning, design and construction of drainage facilities. Maintenance is provided so that the facilities can function as they were originally designed and constructed, and so that the service life of the facility is maximized. Common maintenance problems associated with drainage facilities include growth of undesirable vegetation, debris accumulation, sedimentation, erosion, scour, soil piping, soil settlement and structural damage. Culverts and bridges are to be designed to avoid impacts to existing sediment transport conditions. The following are County/Community/District policies related to maintenance for stormwater and drainage facilities:

Policy 3.13.1 Ownership and Maintenance (Subdivisions). A privately-owned drainage tract should be provided for all new subdivision's common-use drainage conveyance and storage facilities. It must accommodate access for maintenance. A Homeowner's Association may be formed to own and maintain common stormwater conveyance and storage areas. Such common

stormwater conveyance and storage areas will be located within platted rights-of-way, drainage or open area tracts.

Policy 3.13.2 Ownership and Maintenance (Lot Splits). A privately-owned drainage tract should be provided for all new lot splits. Common-use stormwater conveyance and storage facilities must accommodate access for maintenance. Such developments shall dedicate common-use rights-of-way, and easements or tract(s); it needs to include a maintenance agreement and it must be recorded against the deed(s) of the affected properties.

Policy 3.13.3 Standard Drainage Easement. Drainage easements or tracts for Homeowner's Associations or privately-owned parcels should be prepared using the Standard Drainage Easement contained in Appendix [B.2](#), modified appropriately for the application. A legal description and exhibit drawing of every easement are to be included as a part of the recorded documents.

Policy 3.13.4 Permanent Accessibility. Provision for permanent drainage facility accessibility, including access for maintenance equipment into channels and culverts, is necessary for regularly scheduled maintenance activities. All drainage facilities shall be accessible for appropriate maintenance equipment, with special consideration given to access during flood emergencies.

Policy 3.13.5 Consideration of O&M Cost During Design. All drainage facilities should be designed and constructed with consideration to the cost of ongoing operation and maintenance, including maintenance related to stormwater quality.

Policy 3.13.6 Maintenance of Privately-Owned Drainage Facilities. The County/Community/District will not maintain privately-owned drainage facilities of any type.

Policy 3.13.7 Tracts for Privately-Maintained Facilities. Drainage facilities that are to be privately maintained should be encompassed within a drainage tract or easement with said tract or easement clearly identified as private property. All drainage facilities owned and/or operated by private entities, including Homeowner's Associations, shall be properly maintained to promote performance of the drainage facilities consistent with the original design intent, including stormwater quality.

Policy 3.13.8 CC&R Requirement. Homeowner's Associations that own and/or operate drainage facilities shall include statements in their CC&R's and on the recorded Final Plat clearly identifying that the Homeowner's Association is responsible for regular inspection, operation, maintenance and repair of the drainage facilities, including stormwater quality.

Policy 3.13.9 Final Plat Drainage Easement Maintenance Clause. Where the developer has chosen to not form a Homeowner's Association for the development, the language contained in Appendix [B.3](#) may be used on the Final Plat, modified appropriately for the application. The dedication on the Final Plat shall not dedicate drainage easements to the public, Maricopa County/Community or the Flood Control District of Maricopa County.

Policy 3.13.10 Alteration of Privately-Owned Facilities. Drainage features and facilities that are the responsibility of entities other than the County/Community/District (i.e. Homeowner's Associations, developers, management companies, private owners, or other entities) may not be altered in form or function without a proper permit.

Policy 3.13.11 Section 404 Permits. Where required, Section 404 permits shall be obtained prior to the start of maintenance activities that fall under Section 404 permit requirements.

3.14 EROSION CONTROL DURING CONSTRUCTION

The owner is responsible for obtaining permits necessary for performing maintenance activities, including, but not limited to, a Maricopa County Dust Control Permit and AZPDES permit. Construction activity disturbs the land surface thereby exposing native soils to increased rates of erosion by wind and rain. Airborne soil poses detrimental health risks and reduces visibility. Erosion of soil from construction sites by stormwater increases the rate of siltation of drainage ways, which can exacerbate flooding and increase the cost of on-going maintenance. The County/Community/District policies associated with erosion control during construction are as follows:

Policy 3.14.1 Requirement. Appropriate erosion control measures are required by ADEQ and EPA stormwater quality regulations (Section 4.5), and Maricopa County Air Pollution Control Regulations at construction sites.

Policy 3.14.2 Standards. Erosion control should be in accordance with the DDM Erosion Control, or as approved by the County/Community/District.

3.15 REFERENCES

Arizona Department of Transportation, latest edition, Standard Specifications for Road & Bridge Construction and Standard Drawings (ADOT Standards).

ADWR, 1996, *State Standard for Watercourse System Sediment Balance*, State Standard 5-96, Flood Warning and Dam Safety Section.

--- 1999, *State Standard for Stormwater Detention/Retention*, State Standard 8-99, Flood Warning and Dam Safety Section.

Federal Emergency Management Agency (FEMA), 2003, *Guidelines and Specifications for Flood Hazard Mapping Partners*, Appendix G: Guidance for Alluvial Fan Flooding Analysis and Mapping.

Federal Emergency Management Agency (FEMA), 2005, *National Flood Insurance Program (NFIP) floodplain Management Requirements, A Study Guide and Desk Reference for Local Officials*, FEMA 480

FCDMC, 1992, *Policy for the Aesthetic Treatment and Landscaping of Flood Control Projects*, Flood Control District of Maricopa County.

FCDMC, 2003, *Sand and Gravel Mining - Floodplain Use Permit Application Guidelines*, Flood Control District of Maricopa County.

FCDMC, 2018, *Drainage Design Manual for Maricopa County, Hydrology*.

FCDMC, 2018, *Drainage Design Manual for Maricopa County, Hydraulics*.

Maricopa County Drainage Policies and Standards

FCDMC, 2013, *Drainage Design Manual for Maricopa County, Erosion Control*.

Flood Control District of Maricopa County (FCDMC), Arizona (2014), Re-analysis of Alluvial Fans No.5 and No.6 in Scottsdale and Phoenix, Maricopa County, Arizona based on 2003 FEMA Alluvial Fan Guidelines.

Hjalmarson, H. W., 2003 (Draft), *Piedmont Flood Hazard Assessment for Flood Plain Management for Maricopa County, Arizona*: for Flood Control District of Maricopa County, Phoenix.

Maricopa Association of Governments, latest edition, Uniform Standard Specifications and Details for Public Works Construction.

Maricopa County Quality Management and Discharge Control Regulation, May 2009.

4 FEDERAL AND STATE REGULATIONS

4.1 INTRODUCTION

SPECIAL NOTE. This chapter is intended to provide an overview of pertinent federal and state regulations that address drainage and drainage related issues. County/District regulations, policies, and standards meet and often exceed these minimum requirements. Refer to Chapter 5 for the local regulations and a description of the permitting process pertinent to the unincorporated areas of Maricopa County or the community. The differences between the Federal and State regulations, and those for the unincorporated areas of Maricopa County, are not set forth in this chapter.

Engineers responsible for drainage design must conform to all regulations that may affect their project, including federal, state and local acts, codes, laws, regulations, ordinances, standards and policies. Although these regulations are constantly changing, the following discussion provides some guidance as to the areas where federal and state governmental agencies exercise control over drainage related activities.

4.2 WATER AND CULTURAL RESOURCE AGENCY CONTACT LIST

The list that follows identifies the various agencies one may need to contact to obtain information or file a permit for drainage projects. This list is provided as assistance and for information purposes only. This list may not include all agencies or environmental reviews or permits that are required for a given project. Telephone numbers and addresses are subject to change.

General Information

Environmental Protection Agency (EPA)

Public Information Center:

(415) 947-8000

(866) EPA-WEST

Web site: www.epa.gov/region9

Arizona Department of Environmental Quality (ADEQ)

(602) 771-2300, Main Number

(602) 771-4881, Ombudsman

(602) 771-2330, Emergency Response Line

Web site: <http://www.azdeq.gov/>

Arizona Department of Water Resources (ADWR)

(602) 771-8500

Web site: www.azwater.gov/dwr

Floodplain Information

Maricopa County Drainage Policies and Standards

Federal Emergency Management Agency

(510) 627-7100 (Oakland)

(202) 566-1600 (Washington D.C.)

(800) 621-FEMA

Web site: www.fema.gov

Clean Water Act Section 404 Permits

US Army Corps of Engineers

(602) 640-2015

Web site: <http://www.usace.army.mil>

National Pollutant Discharge Elimination System (NPDES) Permits

EPA (415) 972-3510

ADEQ (602) 771-2300

Aquifer Protection Permits

ADEQ

(602) 771-2300

Drywell Permits

ADEQ

(602) 771-2300

(877) 800-3207 – Hotline

Groundwater & other Water Permits

ADEQ (602) 771-2300

ADWR (602) 771-8500

Water Quality Certification 401 Permits

ADEQ

(602) 771-2300

State Species of Concern

Arizona Game & Fish Department

(602) 942-3000

<http://www.azgfd.gov>

Native Plant Law

Arizona Dept. of Agriculture

Plant Services Division

(602) 542-0994

Web site: <http://www.azda.gov>

Endangered Species Act

U.S. Fish & Wildlife Service

(602) 242-0210

Web site:

<http://www.fws.gov/southwest/es/arizona/>

Maricopa County Drainage Policies and Standards

Historic & Prehistoric Sites

State Historic Preservation Office

(602) 542-4009

Web site: <http://azstateparks.com/SHPO/index.html>

Native American Community Contacts, Maricopa County

Ak-Chin Indian Community

(520) 568-2227

Web site: <http://www.ak-chin.nsn.us/>

McDowell Yavapai Nation

(480) 837-5121

Web site: <http://www.ftmcdowell.org>

Gila River Indian Community

(520) 562-6000

Web site:

<http://www.gilariver.org>

Salt River Pima Maricopa Indian Community

(480) 850-8000

Web site: <http://www.srpmic-nsn.gov>

4.3 NATIONAL FLOOD INSURANCE PROGRAM

4.3.1 Introduction

The National Flood Insurance Act of 1968, as amended in 1973, provides for a federally subsidized National Flood Insurance Program (NFIP) conditioned on active management and regulation of development within floodplains by state and local governments. FEMA administers the NFIP as a part of its overall responsibilities in preventing and responding to natural events that damage private and public property, and any life-threatening natural event including floods. The NFIP provides flood insurance through Federal subsidy of the insurance offered by licensed insurance agents. This insurance is designed to provide an insurance alternative to disaster assistance, and intended to address the escalating costs of repairing damage to buildings and their contents caused by floods.

Participation in the NFIP is based on an agreement between local communities and the Federal Government. This agreement states if a community will adopt and enforce a floodplain management ordinance(s) to reduce future flood risks to new construction, the Federal Government will help make flood insurance available within the community as a financial protection against flood losses.

Availability of the subsidized flood insurance is contingent upon the development of a floodplain management system by the local municipality. Prevention of flood related property damage is achieved through the delineation of property subject to flood events and the establishment of specific rules concerning development within these identified areas. FEMA publishes FIRM's for certain flood prone areas that delineate different SFHA's.

Maricopa County and the Communities participate in the NFIP and has adopted floodplain regulations, through the District, and ordinances so that its citizens have access to the subsidized insurance. The role of the community is to enact and implement floodplain management ordinances required for participation in the NFIP.

4.3.2 Community Rating System

The NFIP Community Rating System (CRS) was implemented in 1990 as a program for recognizing and encouraging community floodplain management activities that exceed the minimum NFIP standards. The National Flood Insurance Reform Act of 1994 codified the Community Rating System in the NFIP. Under the CRS, flood insurance premium rates are adjusted to reflect the reduced flood risk resulting from community activities that meet the three goals of the CRS: (1) reduce flood losses; (2) facilitate accurate insurance rating; and (3) promote the awareness of flood insurance.

4.3.3 FEMA Special Flood Hazard Areas

Citizens within Maricopa County are required to ascertain whether or not their respective property is located in a FEMA SFHA before commencing with any building or land disturbance activity. FEMA Flood Insurance Rate Maps (FIRM's) are available for review at the District, Community, and the Arizona Department of Water Resources. The FIRM's are also available online. The FIRM's are used to determine if a property is located within a SFHA regulated by FEMA, and used by the insurance industry to determine flood insurance rates. Areas considered within the SFHA includes the boundary line as shown on the FIRMs. If part of the structure is located within the SFHA the whole structure is considered in the SFHA.

4.3.4 Flood Hazard Zones

The flood hazard maps are subdivided into zones that relate to flooding hazards. These are defined as follows:

1. **100-year Floodplain:** Floodplain resulting from the occurrence of the 100-year runoff event. FEMA sets its jurisdictional limits to the water surface elevation from the 100-year event, which is cited as the base flood elevation. The 100-year event is an event that has a one (1) percent chance of occurring in any given year. Jurisdictional limits are defined by horizontal flooding limits using the base flood elevation. The 100-year floodplain is divided by FEMA into the following hazard zones for flood insurance rating purposes:
 - a. Zone A: No base flood elevations determined.
 - b. Zone AE: Base flood elevations determined.
 - c. Zone AH: Flood depths of 1 to 3 feet (usually areas of ponding), base flood elevations determined.
 - d. Zone AO: Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain), average depths determined (and velocities determined for alluvial fan floodplains).

- e. Zone X (shaded): Areas of 500-year flood; areas of 100-year flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 100-year flood.
 - f. Zone X (unshaded): Areas determined to be outside 500-year floodplain.
2. **Floodway:** That portion of the 100-year floodplain that is required to convey the 100-year flood given a rise in water surface no greater than 1 foot. The allowable rise and the limits of the floodway are predetermined by the governing municipality.

4.3.5 Approval Actions Taken by FEMA

If a property is determined to be located within a FEMA SFHA after reviewing the appropriate FIRM, there are several approval options available that, if desired and applicable, the landowner must process through FEMA. The landowner must select the permit option that best fits the need of the property and satisfies FEMA requirements. Each permit option requires completion of specific application forms and may require that a registered land surveyor or professional engineer complete the forms. Each permit/application form is identified below by name followed by a brief description of the approval response to be expected from FEMA.

1. **Conditional Letter of Map Amendment (CLOMA)** - A letter from FEMA stating that a proposed structure that is not to be elevated by fill would not be inundated by the 100-year flood if built to the proposed finished floor elevation.
2. **Letter of Map Amendment (LOMA)** - A letter from FEMA stating that an existing structure or parcel of land that has not been elevated by fill would not be inundated by the 100-year flood.
3. **Conditional Letter of Map Revision Based on Fill (CLOMR-F)** - A letter from FEMA stating that a parcel of land or proposed structure that is to be elevated by fill would not be inundated by the 100-year flood if fill is placed on the parcel as proposed or the structure is built as proposed.
4. **Letter of Map Revision Based on Fill (LOMR-F)** - A letter from FEMA stating that an existing structure or parcel of land that has been elevated by fill would not be inundated by the 100-year flood.

Application forms for the four items listed above can be obtained from FEMA by reference MT-1 current FEMA form. FEMA's contact address is provided at the end of this section.

5. **Conditional Letter of Map Revision (CLOMR)** - A letter from FEMA commenting on whether a proposed project, if built as proposed, would justify a map revision.
6. **Letter of Map Revision (LOMR)** - A letter from FEMA officially revising the current FIRM to show changes to floodplains, floodways, or flood elevations over a relatively small area. Physical changes include watershed development, flood control structures, etc.
7. **Physical Map Revision (PMR)** - A reprinted FIRM incorporating changes to floodplains, floodways, or flood elevations over a relatively large area. Because of the time and cost involved to change, reprint, and redistribute a FIRM, a PMR is usually processed when a

revision reflects extensive changes in flood hazards or large-scope changes, and therefore typically takes a much longer time to process than a LOMR.

Application forms for the three items listed above can be obtained from FEMA by reference MT-2 current FEMA form. FEMA's contact address is provided at the end of this section.

Projects receiving a conditional letter must re-apply for a letter of amendment or revision upon completion of construction. The conditional letter allows financing and local approvals, of the structure to take place. To initiate FEMA review for a specific activity or location, a letter to FEMA requesting one of the "conditional" letters is sent to FEMA along with supporting data which includes a signed letter from the Chief Engineer and General Manager of the Flood Control District of Maricopa County and in a community that the Flood Control District of Maricopa County provides floodplain management, then a letter is also needed from that community indicating its concurrence with the request. Supporting data may be in the form of improved methodology or improved survey data. Improved methodology may be a different technique (model) or adjustments to models used in the effective FIS. Improved survey data include revised as well as new data. Floodway revisions involve any shift in the FEMA-designated floodway boundaries, regardless of whether the shift results in a change that is measurable at the scale of a DFIRM panel.

4.3.6 Construction in Special Flood Hazard Areas

The lowest floor of all residential structures constructed in the SFHA must be constructed to a minimum of the Regulatory Flood Elevation (RFE). Building structures located within the SFHA (but not within the Floodway) may be protected from floods up to and including the 100-year flood by placement of fill to elevate the structure to or above the RFE. See FEMA guidelines for further specifications. Basements of residential structures located in the SFHA must be elevated above the RFE.

The NFIP regulations allow nonresidential buildings (commercial structures, garages, warehouses, etc.) the option to flood-proof rather than elevate as a means of protection from the base flood. Non-residential structures can be flood-proofed to or above the RFE instead of being elevated. Detached garages, barns, and storage sheds are some examples of buildings that may not have to be elevated or dry flood-proofed if openings are installed to allow floodwaters to enter or exit a structure and meet all other wet flood-proofing requirements. Wet flood-proofing requires the use of flood-resistant materials below the RFE and elevating items subject to flood damage above the RFE. Flood-proofed structures must comply with appropriate sections of the NFIP regulation 60.3 and the Floodplain Regulations. A minimum of two (2) openings, on at least two (2) sides, having a total net area of not less than one (1) square inch for every square foot of enclosed area subject to flooding shall be provided. The bottom of all openings shall be no higher than one (1) foot above finished grade. Openings may be equipped with screens, louvers, valves, or other coverings or devices provided they allow the automatic entry and exit of floodwaters. See FEMA guidelines for further specifications.

Modular buildings must have the bottom of the structure (bottom of lowest beam and utilities) raised, as a minimum, to or above the Regulatory Flood Elevation (RFE) regardless of its use.

All new construction and substantial improvements shall be constructed with electrical, HVAC, plumbing, and other service facilities that are designed and/or located so as to prevent water from entering or accumulating within the components during conditions of flooding. Mechanical and

electrical equipment must be installed at or above the RFE as a minimum. Below ground tanks such as propane and water tanks must be anchored against flotation. Above ground tanks are considered structures for floodplain management purposes.

Under no circumstances can filling or other construction activity be allowed within a floodway that may cause any rise in the water surface elevation above the designated floodway elevation. Any development or changes in floodway elevation, width or location will require approval of FEMA by a Conditional Letter of Map Revision and a Letter of Map Revision.

An "Elevation Certificate" (FEMA Form 81-31) must be completed for each structure constructed in the SFHA prior to the electrical clearance and final acceptance for that structure. One copy of the "Elevation Certificate" is to be submitted to the Flood Control District of Maricopa County and one copy is to be submitted to the community Floodplain Administrator for incorporated communities. See Federal Code for a complete list of requirements.

4.3.7 Post Construction Review

After the proposed improvements have been constructed, the owner/developer is required to submit as-built/documents of record to FEMA and the community Floodplain Administrator along with a request for a letter of map revision or amendment as appropriate.

4.3.8 Fees

Fees will be assessed by FEMA for review of proposed and "as-built" projects as outlined in NFIP regulations 44 CFR Ch. 1, Part 72. In addition, the District levies a fee to help defray its cost for administering floodplain management in conformance with the NFIP.

4.3.9 Additional Information

FEMA publishes numerous documents to inform those within or adjacent to a SFHA. Those documents can be located using FEMA's contact address at the end of this section. The most recent version of the following documents are very useful to consult if a property is determined to be within a SFHA:

1. *"National Flood Insurance Program (Regulations for Floodplain Management and Flood Hazard Identification)", Federal Emergency Management Agency, 44 CFR, Part 1 most current revision.*
2. *"Guidelines and Specifications for Flood Hazard Mapping Partners, Federal Emergency Management Agency, February 2002.*
3. *"Technical Bulletin 2-93, Flood-Resistant Materials Requirements for Buildings Located in Special Flood Hazard Areas in accordance with National Flood Insurance Program", Federal Emergency Management Agency, April, 1993.*
4. *"Technical Bulletin 3-93, Non-Residential Flood Proofing Requirements and Certification for Buildings Located in Special Flood Hazard Areas in Accordance with the National Flood Insurance Program", Federal Emergency Management Agency, April, 1993.*

5. “*Technical Bulletin 10-01, Ensuring That Structures Built on Fill In or Near Special Flood Hazard Areas Are Reasonably Safe From Flooding in Accordance with the National Flood Insurance Program*”, Federal Emergency Management Agency, May, 2001.

Other publications about the NFIP can be found online at: www.fema.gov

4.4 State of Arizona

The State of Arizona has set minimum floodplain management requirements for both areas that are not studied and areas identified by FEMA as a SFHA. The Arizona Department of Water Resources (ADWR) is responsible for floodplain management statewide and for administering the NFIP at the state level. ADWR has developed a series of State Standards to aid in floodplain management for the FEMA and non-FEMA studied areas of the state. Each State Standard has a companion document called the State Standard Attachment (SSA). The SSA is the technical document that provides the methodology and examples of how to apply the standard.

The following is a list of State Standards (SS) currently available from ADWR. It is the responsibility of each person to ensure that they have the most current version or new State Standard available. ADWR does update existing State Standards periodically and is developing new State Standards where a need exists. These standards are available online at the Arizona Department of Water Resources website.

SS 1- State Standard for Technical Support Data Notebook

SS 2-96 - Requirement for Floodplain and Floodway Delineation in Riverine Environments

SS 3-94 - State Standard for Supercritical Flow

SS 4-95 - State Standard for Identification of and Development within Sheet Flow Areas

SS 5-96 - State Standard for Watercourse System Sediment Balance

SS 6-05 - State Standard for Development of Individual Residential Lots within Floodprone Areas

SS 7-98 - State Standard for Watercourse Bank Stabilization

SS 8-99 - State Standard for Retention/Detention

SS 9-02 - State Standard for Floodplain Hydraulic Modeling

SS 10-07 – State Standard for Hydrologic Modeling Guidelines

In addition, ADWR provides training documents in the appropriate use of the State Standards. The *Floodplain Issues in Transportation Design* training document is very appropriate for use in conjunction with this manual. It can be found on the same web page as the State Standards listed above.

4.4.1 Contact Information

Flood Control District of Maricopa County
2801 West Durango Street
Phoenix, AZ 85009
(602) 506-1501
web site: www.fcd.maricopa.gov

State of Arizona
Department of Water Resources
Flood Mitigation Section
3550 N. Central Avenue
Phoenix, AZ 85012
(602) 771-8500
web site: www.azwater.gov/dwr

Department of Homeland Security
Emergency Response and Recovery Directorate
Federal Emergency Management Agency
National Flood Insurance Program
Region IX
Federal Insurance and Mitigation Division
1111 Broadway, Suite 1200
Oakland, CA 94607-4052
(510) 627-7260
web site: www.fema.gov

4.5 SECTION 404 PERMIT FOR WATERS OF THE UNITED STATES

The U.S. Army Corps of Engineers (USACE) has been involved in regulating certain activities in the nation's waterways since the 1890's Section 10 of the River and Harbors Act of 1899. Up until 1960's, the primary thrust of the USACE's regulatory program was the protection of navigation. However, as a result of the environmental movement in the 1960's, several new laws and judicial decisions such as the Clean Water Act of 1968 and the Marine Protection, Research, and Sanctuaries Act of 1972 were introduced with emphasis on preserving the environment. Subsequently, after 1960, the program broadened into water resource protection in which under Section 404 of the Clean Water Act, focus was more on water quality, the cultural, biological and ecological aspects of both arid and aquatic environments.

Under this current program consideration is being made for public interest by balancing the environmental benefits to natural resources with the unfavorable ones. Therefore, Section 404 of the Clean Water Act insures that the physical, biological, and chemical integrity of our nation's water is protected from irresponsible and unregulated discharges of dredged or fill material that could permanently alter or destroy these valuable resources.

Section 404 of the Clean Water Act regulates the discharge of dredge or fill activities in waters of the US. Any person, firm, or agency (including federal, state, and local government agencies) planning to place dredged or fill material into waters of the United States, must first obtain a permit from the USACE. Areas that fall within the COE's jurisdiction area designated as "waters of the

United States” or “jurisdictional waters”. Waters of the United States includes essentially all surface waters such as navigable waters and their tributaries, all interstate waters and their tributaries, all wetlands adjacent to these waters, and all impoundments of these waters. In Maricopa County, for ephemeral washes in which there is only seasonal flow, a jurisdictional delineation is typically determined using the width of the wash, presence of recent scour and erosion marks (ordinary high water mark), hydraulic sorting, defined bank and the presence of riparian habitat. The regulations governing waters of the United States (including wetlands) apply to both public and private property.

A jurisdictional delineation should be conducted in the early stages of planning to determine and mitigate (avoidance, replacement) potential impacts to resources from project alignment. A jurisdictional delineation determines the presence or absence and extent of jurisdictional waters on a site. Subsequently, it is highly recommended that the inexperienced seek guidance from the USACE and other environmental professionals.

4.5.1 Permits

Any ground disturbance in a watercourse or wetland may require a Section 404 permit. The program provides for the consideration of all concerns of the public, such as environmental, social, and economic aspects, in the Section 404 permit decision-making process. As part of this responsibility, the Section 404 permit program extends its jurisdiction to areas that were not regulated prior to the Clean Water Act.

Capital improvement projects undertaken on behalf of and paid for by Maricopa County or the District must coordinate their efforts with their client department and/or the District prior to contacting the USACE. Joint ventures between the District or Maricopa County/Community and private entities must coordinate with the appropriate division prior to any inquiries or submittals to the USACE. Should a permit be required, determination of the types is dependent upon the nature of the land disturbance activity.

4.5.1.1 Individual Permits

Individual permits are required for activities that have more than minimal adverse effects on the aquatic environment and other public interest review factors. Due to the more significant impacts, a full public interest review is required as part of the application for an individual permit. The public notice is distributed primarily to adjacent property owners, regulatory agencies and all known interested persons. The COE’s district engineer will evaluate all comments and information prior to submittal for final approval of the permit.

The permit decision is generally based on the outcome of a public interest balancing process where the environmental benefits of the project are balanced against the detriments. A permit will be granted unless the project is not found to be the least environmental damaging and practicable alternative, exhibiting avoidance and minimization of impacts to the natural resources. Public interest, economics, engineering and other factors can also play a part in the final decision.

An individual permit also requires a 401 Water Quality Certification from ADEQ. Application forms for individual permits are available from all USACE regulatory offices and ADEQ.

4.5.1.2 Nationwide Permits

A nationwide permit (NWP) is a form of general permit that authorizes a category of specific activities that exhibit minimal adverse effects on the aquatic environment. These permits are valid only if it can be proven that the activity does not have more than minimal individual or cumulative adverse environmental effects or is contrary to public interest. If these conditions cannot be met, a regional or individual permit may be required. Please note that the NWP program was revised on March 19, 2017 (See FR Vol. 82, No. 4), and will expire in March 18, 2022. Nationwide permits listed below may be modified to accommodate regional conditions following review at a regional level. Contact the USACE office provided at the end of this section to obtain the most current information on the NWP program changes, including a complete listing, permit details, and regional limitations placed upon nationwide permits. Some activities under nationwide permits require preconstruction notification submittals to the USACE prior to the carrying out of those activities. Notification requirements are described in General Condition 13, in FR Vol. 77, No. 344, March 19, 2012. All nationwide permits must comply with the requirements of the particular nationwide permit, and meet the general conditions (27) required for each one, the 401 conditions (for water quality), and, if adopted, the Los Angeles District regional conditions and the 2015 new rule defining waters of the United States. A list of the more pertinent, presently available, nationwide permits follows.

NWP 3: Maintenance. The repair, rehabilitation, or replacement of any previously authorized, currently serviceable, structure or fill, or of any currently serviceable structure or fill authorized by 33 CFR 330.3. Discharges of dredged or fill material, including excavation, into all waters of the United States to remove accumulated sediments and debris in the vicinity of, and within, existing structures and the placement of new or additional rip rap to protect the structure.

NWP 6: Survey Activities. Survey activities including core sampling, seismic exploratory operations, plugging of seismic shot holes and other exploratory-type bore holes, soil survey and sampling and historic resources surveys.

NWP 7: Outfall Structures. Activities related to construction of outfall structures and associated intake structures where the effluent from the outfall is authorized, conditionally authorized, or specifically exempted, or are otherwise in compliance with regulations issued under the National Pollutant Discharge Elimination System program (NPDES) (Section 402 of the Clean Water Act).

NWP 12: Utility Lines. The construction, maintenance, or repair of utility lines, including outfall and intake structures and the associated excavation, backfill, or bedding for the utility lines, in all Waters of the United States, provided there is no change in preconstruction contours.

NWP 14: Linear Transportation Crossings. Activities required for the construction, expansion, modification, or improvement of linear transportation crossings (e.g., highways, railways, trail, and airport runways and taxiways) in waters of the United States subject to acreage limitations.

NWP 18: Minor Discharges. Minor discharges of dredged or fill material into all Waters of the United States subject to volume or acreage limitations.

NWP 20: Oil Spill Cleanup. Activities required for the containment and cleanup of oil and hazardous substances which are subject to the National Oil and Hazardous Substances Pollution Contingency Plan (40 CFR Part 300) in accordance with certain state and federal requirements.

NWP 25: Structural Discharges. Discharges of material such as concrete, sand, rock, etc. into tightly sealed forms or cells where the material will be used as a structural member for standard pile supported structures, such as bridges, transmission line footings, and walkways.

NWP 29: Single-Family Housing. Discharges of dredged or fill material into non-tidal Waters of the United States, including non-tidal wetlands for the construction or expansion of a single family home and attendant features (such as a garage, driveway, storage shed, and/or septic field) for an individual permittee.

NWP 31: Maintenance of Existing Flood Control Facilities. Discharges of dredged or fill material for the maintenance of existing flood control facilities, including debris basins, stormwater storage basins, and channels. The maintenance is limited to that approved in a maintenance baseline determination made by the District Engineer.

NWP 38: Cleanup of Hazardous and Toxic Waste. Specific activities required to effect the containment, stabilization, or removal of hazardous or toxic waste materials that are performed, ordered, or sponsored by a government agency.

NWP 39: Residential, Commercial, and Institutional Developments. Discharges of dredged or fill material into non-tidal Waters of the United States for the construction or expansion of residential, commercial, and institutional building foundations and building pads and attendant features that are necessary for the use and maintenance of the structures.

NWP 40: Agricultural Activities. Discharges of dredged or fill material into non-tidal Waters of the United States for the purpose of improving agricultural production and the construction of building pads for farm buildings. Authorized activities include the installation, placement, or construction of drainage tiles, ditches, or levees; mechanized land clearing; land leveling; the relocation of existing serviceable drainage ditches constructed in Waters of the United States; and similar activities.

NWP 41: Reshaping Existing Drainage Ditches. Discharges of dredged or fill material into non-tidal Waters of the United States to modify the cross-sectional configuration of currently serviceable drainage ditches constructed in these waters. The reshaping of the ditch cannot increase drainage capacity beyond the original design capacity or expand the area drained by the ditch as originally designed (i.e., the capacity of the ditch must be the same as originally designed and it cannot drain additional wetlands or other Waters of the United States).

NWP 42: Recreational Facilities. Discharges of dredged or fill material into non-tidal Waters of the United States, excluding non-tidal wetlands adjacent to tidal waters, for the construction or expansion of recreational facilities.

NWP 43: Stormwater Management. Discharges of dredged or fill material into non-tidal Waters of the United States for the construction and maintenance of stormwater management facilities, including activities for the excavation of stormwater ponds/facilities, detention basins, and retention basins; the installation and maintenance of water control structures, outfall structures and emergency spillways; and the maintenance dredging of existing stormwater management ponds/facilities and detention and retention basins.

NWP 44: Mining Activities. Discharges of dredged or fill material into: (i) Isolated waters, streams where the annual average flow is 1 cubic foot per second or less, and non-tidal wetlands

adjacent to headwater streams, for aggregate mining and other mining activities subject to certain limitations.

NWP 45: Repair of Uplands Damaged by Discrete Events.

NWP 46: Discharges in Ditches

NWP 47: [Reserved]

NWP 51: Land-Based Renewable Energy Generation Facilities

To apply for a nationwide permit, an application must be completed. USACE application forms for the permits are available from the local USACE regulatory offices (see contact information below).

4.5.1.3 Regional Permits

Regional permits are issued by the USACE District Engineer for a general category of activities when:

1. The activities similar in nature and cause minimal adverse environmental impact (both individually and cumulatively), and the regional permit reduces duplication of regulatory control by State and Federal agencies.
2. Can be issued to work with Special Area Management Plan, large-scale Habitat Conservation Plan. Can have different limits, conditions than Nationwide Permits.
3. Contact the USACE District Regulatory office in your area for information regarding regional permits.

4.5.2 Contact Information

U.S. Army Corps of Engineers
Los Angeles District, Regulatory Branch
3636 North Central Avenue, Suite 900
Phoenix, AZ 85012-1936 (602) 230-6949
Web site: <http://www.spl.usace.army.mil>

Arizona Department of Environmental Quality
Surface Water Permitting Unit
1110 W. Washington Street
Phoenix, AZ 85007 (602) 771-4665
Web site: <http://www.azdeq.gov/environ/water/permits/index.html>

Flood Control District of Maricopa County
Planning and Project Management Division
2801 W. Durango Street
Phoenix, AZ 85009 (602) 506-1501
Web site: <http://www.fcd.maricopa.gov>

4.6 STORMWATER NPDES/AZPDES

Stormwater systems are subject to the requirements and permitting process of the National Pollutant Discharge Elimination System (NPDES), which is a U.S. Environmental Protection Agency (EPA) program and is the administrative mechanism chosen for stormwater permitting. The EPA issued regulations in 1990 authorizing the creation of a NPDES permitting system for stormwater discharges from a large group of industrial activities (including construction activities) and for discharges from municipal separate storm sewer systems located in municipalities with a population of 100,000 or more. In 1999, Phase II of the stormwater program added small municipal separate storm sewer systems from any other municipalities located wholly or partially in urbanized areas if they were not already covered by Phase I of the stormwater program. In addition, construction sites that disturb one acre but less than five acres were also added. In Arizona, the NPDES program is called AZPDES, which stands for Arizona Pollutant Discharge Elimination System. An AZPDES permit is required for any point source discharge of pollutants to a water of the United States. Because stormwater runoff can transport pollutants either to municipal storm sewer systems or to Waters of the United States, permits are required for those discharges. In addition to stormwater permits, there are also NPDES/AZPDES permits required for the discharge of processed wastewater and the land application of sludge. The application process for both general permits is similar.

4.6.1 Permits

Most stormwater discharges are permitted under various general permits. However, an individual permit is required when the general permit requirements do not accurately represent the activity at a facility/municipality and a permit is customized to the site/for the permittee.

An individual permit may be necessary if the Limitations of Coverage section of a general permit does not allow the facility's discharge to be covered within the general permit. It is the responsibility of every applicant to determine if any of the Limitations of Coverage apply to the facility seeking a general permit.

4.6.1.1 Construction Activities

Stormwater discharges generated during construction activities can cause an array of physical, chemical and biological water quality impacts. Specifically, the biological, chemical and physical integrity of the waters may become severely compromised. Water quality impairment results, in part, because a number of pollutants are preferentially absorbed onto mineral or organic particles found in fine sediment. The interconnected process of erosion (detachment of the soil particles), sediment transport and delivery is the primary pathway for introducing key pollutants such as nutrients (particularly phosphorus), metals, and organic compounds into aquatic systems.

Stormwater runoff from construction sites can include pollutants other than sediment such as phosphorous and nitrogen, pesticides, petroleum derivatives, construction chemicals and solid wastes that may become mobilized when land surfaces are disturbed. Generally, properly implemented and enforced construction site ordinances effectively reduce these pollutants. In many areas, however, the effectiveness of ordinances in reducing pollutants is limited due to

inadequate enforcement or incomplete compliance with local ordinances by construction site operators.

Construction General Permit Coverage

This general permit authorizes discharges of stormwater associated with construction activity provided the operator complies with all the requirements of the general permit and submits a Notice of Intent (NOI) in accordance with the general permit.

Stormwater associated with large construction activity refers to the disturbance of five or more acres, as well as the disturbance of less than 5 acres of total land area that is a part of a larger common plan of development or sale if the larger common plan will ultimately disturb five acres or more (40 CFR 122.26(b)(14)(x)).

Stormwater associated with small construction activity, as defined in 40 CFR 122.26(b) (15), refers to the disturbance of equal to or greater than 1 and less than 5 acres of land for construction, or the disturbance of less than 1 acre of total land area that is part of a larger common plan of development or sale if the larger common plan will ultimately disturb equal to or greater than 1 and less than five acres.

Permit Waivers. There are two waivers available for small construction activities. The first is where the construction site operator has determined that the rainfall erosivity factor (R) in the revised universal soil loss equation (RUSLE) is less than 5. The second waiver is available where the operator certifies that stormwater controls are not needed based upon a total maximum daily load (TMDL). Currently Arizona TMDL's do not address this issue, but the permit includes the TMDL waiver as a potential future option.

How to Obtain Coverage. The operator of a construction site is responsible for obtaining coverage under an AZPDES permit. The operator could be the owner, the developer, the general contractor or individual contractor. When responsibility for operational control is shared, all operators must apply. Thus, a single construction site may have a number of operators who may operate under a common or separate Stormwater Pollution Prevention Plan (SWPPP).

Submit a NOI to the Stormwater Coordinator, Arizona Department of Environmental Quality, 1110 West Washington Street, Phoenix, Arizona 85007. This form must be complete and accurate and signed by the appropriate party in order for you to obtain coverage. The form also serves as a promise by the operator that there will be compliance with the permit conditions. ADEQ now offers a web-based service to assist individuals in applying for construction stormwater discharge permits. The operator must also develop and implement a SWPPP that satisfies the conditions of the permit. If your site is located within 1/4 mile of unique or impaired water, the SWPPP must be submitted with your NOI. In all other cases, do not submit the SWPPP to ADEQ; however the SWPPP must be available for ADEQ review. Once the SWPPP is prepared and a complete and accurate NOI is received by ADEQ, the operator must wait at least 2 business days before discharging. If ADEQ does not contact the operator within the waiting period, the operator may assume permit coverage has been granted. Whether or not ADEQ notifies the operator of a deficiency in the NOI, discharges are not authorized under this permit if the operator submits an incomplete or incorrect NOI. The SWPPP can be requested by any agency (including Maricopa County) and should remain available for review at the project site. For a more detailed description of unique or impaired waters, please see ADEQ's website at:

<http://www.adeq.state.az.us/environ/water/permits/stormwater.html>.

Notice of Termination. After the construction project is complete and the project's disturbed area is stabilized to at least 70 percent of natural background levels or responsibility for the project has been assumed by another operator, the permittee must submit a Notice of Termination (NOT) to end participation in the AZPDES stormwater program.

ADEQ's Construction General Permit

ADEQ's New General Permit for Construction (AZG2003-001) was issued on June 3, 2013. This permit replaces the previous construction general permit, which was issued for a five-year term by EPA Region 9 in February 1998 (63 FR 7858) and July 1998 (63 FR 36490). The AZPDES Construction General Permit expires on June 2, 2018.

The construction general permit authorizes stormwater discharges from large and small construction-related activities that result in a total land disturbance of equal to or greater than 1 acre, where those discharges enter surface waters of the United States or a storm drain. Note the AZPDES authorizing statute uses the term "navigable waters" which are defined as equivalent to the waters of the United States. However, because the term "navigable waters" can be confusing to the general public (i.e., the definition of "navigable waters" also includes ephemeral washes, intermittent streams, playas, and wetlands, that may not be able to be traveled by conventional vessels), this permit generally references discharges to Waters of the United States. This permit expands coverage from the 1998 construction general permit that provided coverage for large construction sites (i.e., those disturbing greater than 5 acres) to include both small and large construction activities (i.e., any project disturbing greater than 1 acre).

Permit Area. This general permit covers stormwater discharges from large and small construction activity in Arizona, except for those construction discharges in Indian Community Lands.

4.6.2 Industrial Activities

Activities that take place at industrial facilities, such as material handling and storage, are often exposed to stormwater. The runoff from these activities discharges industrial pollutants into nearby storm sewer systems and water bodies. This may adversely impact water quality. The initial focus of the NPDES permitting program was to regulate discharges of industrial process wastewater and municipal wastewater treatment plants. Most industrial facilities have permit coverage under a general permit because it is the most efficient permit option. General permits contain requirements for numerous types of industrial activities, allowing a facility operator to quickly obtain permit coverage. The Multi-Sector General Permit is the general permit currently available to facility operators.

Multi-Sector General Permit (MSGP)

The state currently recognizes the MSGP established by EPA, which became effective on October 30, 2000. This permit expired on October 30, 2005; however, it will remain in effect until a new one is issued by EPA.

The multi-sector general permit (MSGP) is designed for discharges of stormwater from certain industrial sites that are of a non-construction nature. The MSGP is one large permit divided into

numerous separate sectors. Each sector represents a different type of activity and is dependent upon its standard industrial classification (SIC) code or narrative description. Review the information on Facilities Required to Apply for a Stormwater Permit (40 CFR 122.26(b) (14)) for applicable SIC codes and descriptions. Once a SIC code or narrative description is determined, review the document "What's My Sector?" at the following web link to determine which sector of the MSGP contains the specific permit requirements for a facility. Once the necessity for a permit is determined, a facility will be subject to the requirements of more than one sector if it has operations that can be described by other sectors.

<http://www.azdeq.gov/environ/water/permits/msgp.html>

Application for this general permit is achieved by the completion of a simple one-page form called a notice of intent (NOI). The NOI is a promise by the applicant that there will be compliance with the permit conditions. However, before the NOI is submitted, a SWPPP must be prepared. The MSGP details the requirements EPA considers necessary for each sector to produce an acceptable SWPPP. There is no requirement to submit the SWPPP to ADEQ, but ADEQ, EPA or Maricopa County can request that the SWPPP be available for review. Once the SWPPP is prepared and the NOI submitted, there is a waiting period of two business days. If ADEQ does not contact the applicant within the waiting period, the applicant may assume permit coverage has been granted. After the two-day waiting period the permittee may implement the SWPPP and begin activities. ADEQ will confirm permit coverage with the permittee by a letter containing the discharge authorization number. If the NOI is submitted with missing, nonconforming or incorrect information, ADEQ will inform the applicant of the inadequacies and request additional information. Permit authorization to discharge stormwater is only possible after the submittal of a complete and accurate NOI. The permittee submits a notice of termination to end participation in the NPDES stormwater program. Failure to develop specific Best Management Practices (BMPs) or to implement these BMPs identified in the SWPPP may subject the Permittee(s) to fines of up to \$25,000 per day per violation.

Permit information and forms may be obtained from the agencies provided in Section 4.6.4.

4.6.3 Other Permits

For information on other permits available through ADEQ, check out ADEQ's website at: <http://www.azdeq.gov/environ/water/permits/azpdes.html>. The following is ADEQ's summary of the De Minimus Discharge Permit and the Concentrated Animal Feeding Operations program.

4.6.3.1 De Minimus Discharge Permit

ADEQ issued the first AZPDES De Minimus General Permit (DGP) No. AZG2004-001 on March 7, 2004. The permit allows for the discharge of pollutants associated with potable and reclaimed water systems, subterranean dewatering, well development, aquifer testing, hydrostatic testing of specific pipelines, residential cooling water, charitable car washes, building and street washing, and de-chlorinated swimming pool water. The permit also allows ADEQ to review and approve other case-by-case short-term and/or low volume discharges that are considered De Minimus. By definition (DGP, Part VII), De Minimus discharges contain relatively low levels of pollutants, are of limited flow and/or frequency, and shall not last for more than 30 days unless approved in advance by ADEQ.

The DGP authorizes discharges where they have potential to enter a water of the U.S. Note: the AZPDES authorizing statute uses the term "navigable waters," which is defined as equivalent to the waters of the U.S. However, because the term 'navigable waters' can be confusing to the general public (i.e., the definition of 'navigable waters' also includes ephemeral washes, intermittent streams, playas, and wetlands, that may not be able to be traveled by conventional vessels), this permit references discharges to waters of the U.S.

Authorization under this permit will require the owner or operator of the discharge facility to implement various BMPs and conduct discharge monitoring based on the type of discharge activity and the type of receiving water. For further information on this permitting program, visit ADEQ's website at:

<http://www.azdeq.gov/environ/water/permits/gen.html#demi>.

4.6.3.2 Concentrated Animal Feed Operations

ADEQ revised the AZPDES program rules (18 A.A.C. 9, Article 9) to conform to the updated federal regulations for Concentrated Animal Feeding Operations (CAFOs). The rule revisions became effective on Feb. 2, 2004. Under the new rule all CAFOs are required to apply for a permit, submit an annual report and develop and follow a plan for handling manure and wastewater. In addition, the rule moves efforts to protect the environment forward by placing controls on land application of manure and wastewater, covering all major animal agriculture sectors, and increasing public access to information through CAFO annual reports. The rule also eliminates current permitting exemptions and expands coverage over types of animals in three important ways: the rule eliminates the exemption that excuses CAFOs from applying for permits if they only discharge during large storms; second, the rule eliminates the exemption for operations that raise chickens with dry manure handling systems; and third, the rule extends coverage to immature swine and immature dairy cows. ADEQ issued the AZG2004-002 general permit on April 16, 2004. For further information on this permitting program, visit ADEQ's website at: <http://www.azdeq.gov/environ/water/permits/cafo.html>.

Application or approval of any permit from ADEQ does not grant approval for any other permits required by other federal, state, or local entities including the Flood Control District of Maricopa County (i.e. the granting of a De Minimus Discharge permit does not give anyone the right to discharge into a District structure without the District's prior approval/permit. A District right of way permit is still required).

4.6.4 Contact Information

Arizona Department of Environmental Quality
1110 W. Washington Street
Phoenix, AZ 85007
(602) 771-4449
Web site: <http://www.azdeq.gov>

Maricopa County Environmental Services Dept.
1001 N. Central Avenue, Suite 150
Phoenix, AZ 85004
(602) 506-6666

Web site: <http://www.maricopa.gov/envsvc/>

Flood Control District of Maricopa County
Engineering Division
Water Quality Branch
2801 W. Durango Street
Phoenix, AZ 85009
(602) 506-1501
Web site: <http://www.fcd.maricopa.gov>

4.7 DAMS

All dams in the state, except those owned or operated by an agency or instrumentality of the federal government, are under the jurisdiction of the Arizona Department of Water Resources (ADWR). A dam is any artificial barrier that impounds or diverts water above the natural ground surface. A detention basin or retention basin that impounds stormwater above the natural ground surface may be considered as being a dam under the authority of ADWR. The following do not fall under the authority of ADWR.

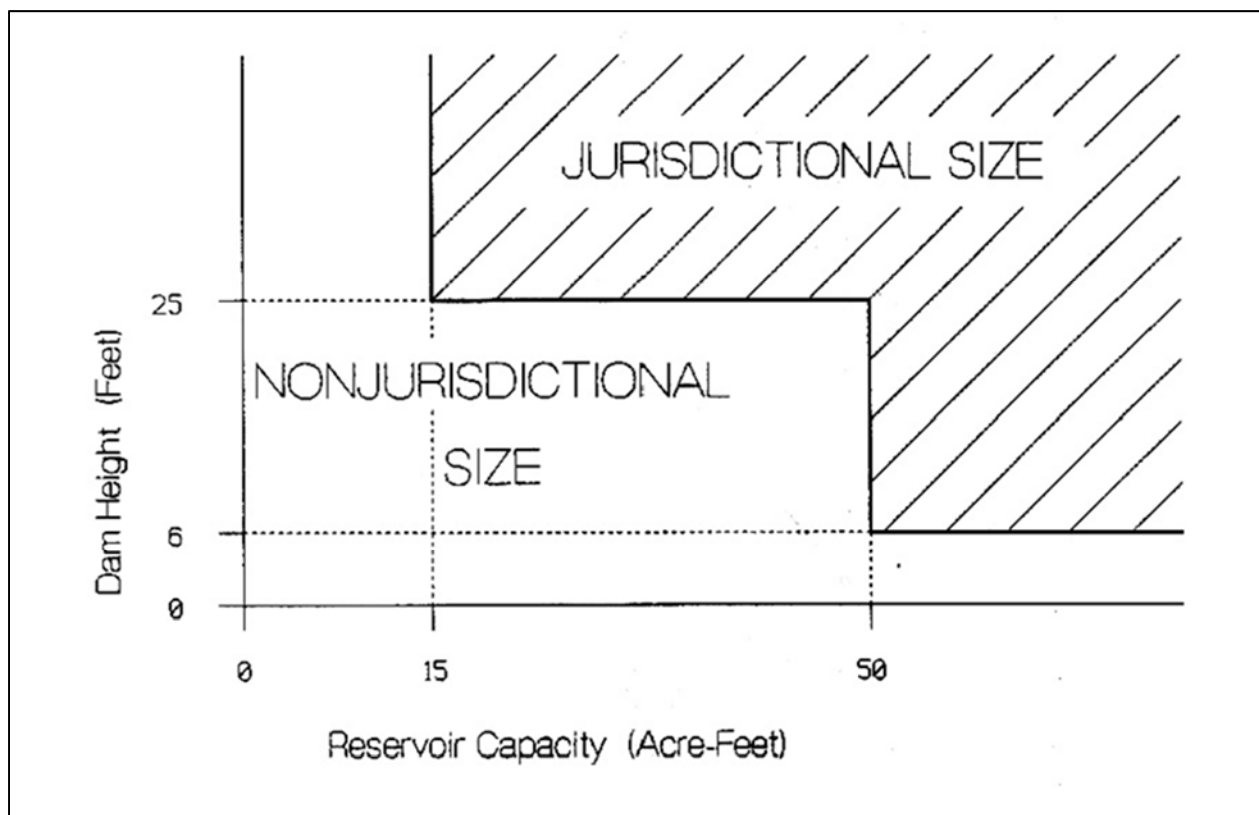
Any artificial barrier:

1. Less than 6 feet in height, regardless of storage capacity.
2. Fifteen acre-feet or less of storage capacity, regardless of height.
3. Between 6 and 25 feet in height, with a storage capacity less than 50 acre-feet.

Any impoundment or diversion structure that exceeds the criteria above will require a permit from ADWR. Individuals having questions should contact the Dam Safety Section of ADWR.

A JURISDICTIONAL DAM is either 25 or more feet in height or has capacity to store more than 50 acre-feet. HEIGHT is the vertical distance from the lowest point on the downstream toe (at natural ground) to the emergency spillway crest. CAPACITY is the maximum storage that can be impounded when there is no discharge of water.

Figure 4.1 ADWR Jurisdictional Dam Chart



4.7.1 Permits

A permit is required for all new dams or the repair, alteration or removal of an existing dam. Application forms are available from ADWR. An administrative review fee is required by ADWR.

4.7.2 Contact Information

State of Arizona
Department of Water Resources
Dam Safety Section
3550 N. Central Avenue
Phoenix, AZ 85004
(602) 771-8500
Web site: <http://www.azwater.gov/dwr>

4.8 DRYWELL REGISTRATION

A person who owns an existing drywell that is or has been used for stormwater disposal shall register the drywell with the Arizona Department of Environmental Quality (ADEQ). A drywell is a bored, drilled, or driven shaft or hole whose depth is greater than its width and is designed and

constructed specifically for the disposal of stormwater. Drywells must be registered by completing a form from ADEQ, and submitting a registration fee for each drywell.

4.8.1 Permits

Drywells are regulated by Arizona Revised Statute (A.R.S.) § 49-241 and § 49-331 through 336, and Aquifer Protection Permit statutes and rules. Drywells that drain areas where hazardous substances are used, stored, loaded, or treated are subject to the General Permit or full Aquifer Protection Permit. Specific rules regarding dry wells are found in R-18-9-102-A and R18-9-A301. Program guidance documents are available from ADEQ, and should be followed for dry well construction, maintenance, siting, investigation, decommissioning, and closure. Registration is generally not required for dry wells used in conjunction with golf course maintenance, and they are exempted from regulation under the dry well program. However, vadose zone injection wells (including dry wells) that receive stormwater mixed with reclaimed wastewater or groundwater from manmade bodies of water associated with golf courses, parks, and residential areas must be registered. In this situation, a general permit is issued by statute in lieu of an individual permit, provided that six criteria, including registration, are met (A.R.S. § 49 - 245.02).

Dry well registration and permit information and forms may be obtained from ADEQ at the location provided below.

4.8.2 Contact Information

Arizona Department of Environmental Quality
1110 W. Washington Street
Phoenix, AZ 85007
(602) 771-2300
Web site: <http://www.azdeq.gov>

4.9 AQUIFER PROTECTION PERMIT

An individual will need to obtain an Aquifer Protection Permit (APP) if they own or operate a dry well that discharges a pollutant either directly to an aquifer or to the land surface or the vadose zone in such a manner that there is a reasonable probability that a pollutant will reach an aquifer. ADEQ may provide an "APP Determination of Applicability Form" for dry wells in areas where hazardous substances are used, stored, loaded, or treated. Dry wells that are used solely for the disposal of stormwater runoff do not require an Aquifer Protection Permit; however, dry well registration is still a requirement.

4.9.1 Permits

The following APP Permits are available:

4.9.1.1 Individual Permits

Individual permits are issued for a term not to exceed the operational lifetime of the facility. Approval of individual permits can take, on average, from 6 months to 2 + years. Processing time is approximately 6 months; however, incomplete applications often result in delays.

4.9.1.2 Area Wide Permits

Area-wide permits may be issued in lieu of an individual permit to cover facilities under common ownership in a contiguous geographic area. Discharge reduction in the pollutant management area and the demonstration that aquifer water quality standards will not be violated or further degraded can be evaluated collectively for existing facilities. This type of permit is most applicable to large mining and industrial sites.

4.9.1.3 General Permits

There are currently 15 different types of general permits. These are issued by rule or statute, and the facility is automatically permitted, provided adherence to certain conditions. A separate permit document is not required to operate under these conditions and no fee is required.

Information regarding APP's is available from ADEQ at the location provided below.

4.9.2 Contact Information

Arizona Department of Environmental Quality
1110 W. Washington Street
Phoenix, AZ 85007
602) 771-2300
Web site: <http://www.azdeq.gov>

5 COUNTY REGULATIONS

5.1 INTRODUCTION

In addition to the Federal and state regulations discussed in Chapter 4, engineers responsible for drainage design must conform to Maricopa County and other local regulations that may affect their project including local acts, codes, laws, regulations, ordinances, standards and policies. Sections 5.2 through 5.5 list the County/District regulations that apply, and contain hyperlinks to the sites on the Internet where each document can be obtained. The following are the Maricopa County agencies that may be contacted to obtain assistance with application of these regulations.

General Information

Maricopa County Environmental Services Department
1001 N. Central Avenue, Suite 150
Phoenix, AZ 85004
(602) 506-6666
Website: <http://www.maricopa.gov/envsvc>

Floodplain Information

Flood Control District of Maricopa County
2801 W. Durango Street
Phoenix, AZ 85009
(602) 506-1501
Website: <http://www.fcd.maricopa.gov>

Maricopa County Department of Transportation

2901 W. Durango Street
Phoenix, AZ 85009
(602) 506-8600
Website: <http://www.mcdot.maricopa.gov>

Maricopa County Planning and Development

501 N. 44th Street, Suite 200
Phoenix, AZ 85008
(602) 506-3301
Website: <http://http://www.maricopa.gov/planning>

Historic & Prehistoric Sites

Historic Preservation Offices
(602) 542-4009 (for AZ SHPO)

5.2 DRAINAGE PROVISIONS

The Maricopa County drainage provisions are part of the Zoning regulations.

The drainage regulations for the communities can be found on their website.

5.3 FLOODPLAIN REGULATION FOR MARICOPA COUNTY

The District floodplain regulations can be found at the District website: <http://www.fcd.maricopa.gov>.

5.4 ZONING ORDINANCE AND SUBDIVISION REGULATIONS

The Maricopa County zoning ordinance and Subdivision Regulations can be found at Planning and Development website at: www.maricopa.gov/planning

The Zoning Ordinance and Subdivision Regulations for the communities can be found on their website.

5.5 MARICOPA COUNTY STORMWATER MANAGEMENT

It is the goal of Maricopa County to protect, maintain, and enhance the public health, safety and general welfare by establishing requirements and procedures to control the adverse effects of stormwater runoff and pollution associated with land development. This manual sets forth the policies and standards for management of urban drainage and floodplains. The Maricopa County Planning and Development Department administers the approval and permit processes established for grading and drainage. The District administers the approval and permit processes for floodplain management.

The Maricopa County Stormwater Management and Discharge Control Regulation can be found at: <http://www.maricopa.gov/EnvSvc/QC/StormWater/pdf/swregulation.pdf>

5.6 RELEASE OF STORMWATER TO DRAINAGE SYSTEMS

ARS 48-3622. Permission required to connect to stormwater drain; fee; violation; classification.

A person desiring to make a connection to any stormwater drain of a flood control district or to cause floodwaters or storm or other waters to be emptied into any ditch or drain of the district shall first apply to the district for permission to make the connection. The district may require the connection to be made in such manner as it directs and may impose reasonable conditions and such reasonable connection fee as it deems proper or, if reasonably justified by the circumstances, may refuse permission. In addition, the district may require any action or impose any restriction that the district considers reasonably necessary to meet the district's obligations, if any, to comply with local, state or federal water quality laws. A person making a connection which causes floodwaters to be so discharged without first having obtained permission is guilty of a class 2 misdemeanor.

5.7 PERMITS

Maricopa County has permit requirements for stormwater facilities. Individual permits are available for the following.

1. Drainage Facilities Permit
2. Grading and Drainage Permit
3. Floodplain Use Permit.

5.7.1.1 Drainage Facilities Permit

A Drainage Facilities Permit is required in order to connect and discharge stormwater into the County's drainage infrastructure. New storm drain segments or inlets, low-flow bleed-off lines from detention basins, or stormwater discharge pumps are examples of drainage facilities requiring a permit. This permit provides a procedure for Maricopa County to track additions to the county's storm drain system.

5.7.1.2 Building Permit

A Building Permit is required for development activities that include excavation, fill, drainage swales and channels, drainage structures and pipes, detention/retention areas, and dry wells.

5.7.1.3 Floodplain Use Permit

A floodplain use permit is required for all new or substantial improvements per the Floodplain Regulations for Maricopa County. This permit ensures that development will comply with NFIP criteria, State, and Federal law and provides proper documentation to assess flood insurance rates if needed.

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6 DRAINAGE STANDARDS

6.1 INTRODUCTION

The Hydrology and Hydraulics volumes provide technical guidance for definition and evaluation of flood and erosion hazards, and for design of drainage facilities. This chapter contains the minimum standards for applying the technical concepts contained in the DDM for design of drainage facilities in Maricopa County. These minimum standards apply in the unincorporated areas of Maricopa County and the municipalities for which the District may administer floodplain management and for any community that has adopted this manual. Unless otherwise specified, they apply to improvements within subdivisions created under the Maricopa County/Community Subdivision Regulations and to County/Community/District projects, including improvements that will be maintained by County/Community/District or subdivision improvements maintained by private entities such as Homeowner's Associations. These minimum standards may also apply to other situations, such as improvements made as a part of individual lot improvement. Since these minimum standards have their base in public safety, the prudent developer/engineer should consider their use where appropriate for similar applications.

It is not intended that these minimum standards be blindly applied in every application. There may be strong technical reasons why a particular standard is not appropriate for a given situation, or another method may also meet the intent of the Maricopa County Drainage Provisions (Section 1205 of the Maricopa County Zoning Ordinance) and Subdivision Regulations, Community Drainage and Subdivision Regulations, and/or the District's Floodplain Regulation. In many situations, in the interest of public safety, a higher technical standard may be more appropriate. The County/Community/District reserves the right to require a higher technical standard in the interest of public safety. In addition, the County/Community/District may review technical documentation submitted in support of using a different minimum standard for a specific application. Administrative approval may be granted by the County/Community/District, if found to be technically appropriate and to maintain an equal or higher level of public safety.

There are many computer programs available to help in the design of drainage systems. These programs may use different methods of analysis than those presented in the DDM. Therefore, the designer of the drainage system should check with the governing agency before using a particular software packages to apply the standards presented herein.

Drainage infrastructure should normally be designed for a minimum service life of 50-years. A longer service life is recommended wherever possible.

6.2 PUBLIC SAFETY

Designs for hydraulic structures must address the issue of safety. Since the County/Community/District has established the policy that disturbances to natural watercourses shall be minimized (Policy 3.4.1), the design of hydraulic structures must also address the protection of the natural environment while accommodating public safety. Emergency vehicle access is of particular importance. Minimum design standards for All Weather Access streets are intended to help keep such routes drivable during major flooding events, such as the 100-year

storm. The following minimum standards, and other standards in Chapter 6 and Policies in Chapter 3, address these issues:

Standard 6.2.1 Special Hazards. The designer should determine if the site is subject to special hazards including, but not limited to, subsidence or fissures, alluvial fans, or distributary flow. Subsidence and fissures can be researched starting with the Arizona Geological Survey at <http://www.azgs.az.gov/> and the Interferometric Synthetic Aperture Radar (InSAR) data – found the ADWR website. Additional geotechnical investigations may be required. Alluvial fans and distributary flow areas can be identified using guidance provided by Appendix G of FEMA (2003) and Hjalmarson (2003). Engineering analysis and design are required for development within special hazard areas.

Standard 6.2.2 Protection Related to Depth and Velocity. The designer shall carefully consider public safety where standing water depths, and water flow depths and velocities pose a hazard. This should be done for design of all drainage facilities, including stormwater storage facilities, channels, storm drains and street systems. [Figure 6.1](#) and [Figure 6.2](#), (USBR, 1988) shall be used in this regard to aid in defining the level of hazard, based on criteria such as the type and frequency of use of the facility by the public, access concerns for emergency response vehicles, the statistical frequency of hazardous storm events, and risks associated with public access combined with the frequency of the hazard. Engineering judgment shall be applied in assessing the risks and determining which areas require special attention. With the areas of concern defined, the designer shall include mitigation measures appropriate to the risk to discourage or prevent public access to these facilities during a flood event. The measures could include, but are not limited to:

1. Mitigating design criteria such as maximum flow rates and depths.
2. Signage to alert the public to the hazard.
3. Flood warning alarm or announcement systems.
4. Physical barriers, such as fencing or railings.
5. Higher minimum technical standards for design of drainage facilities.

Figure 6.1 Depth-velocity flood danger relationship for adults

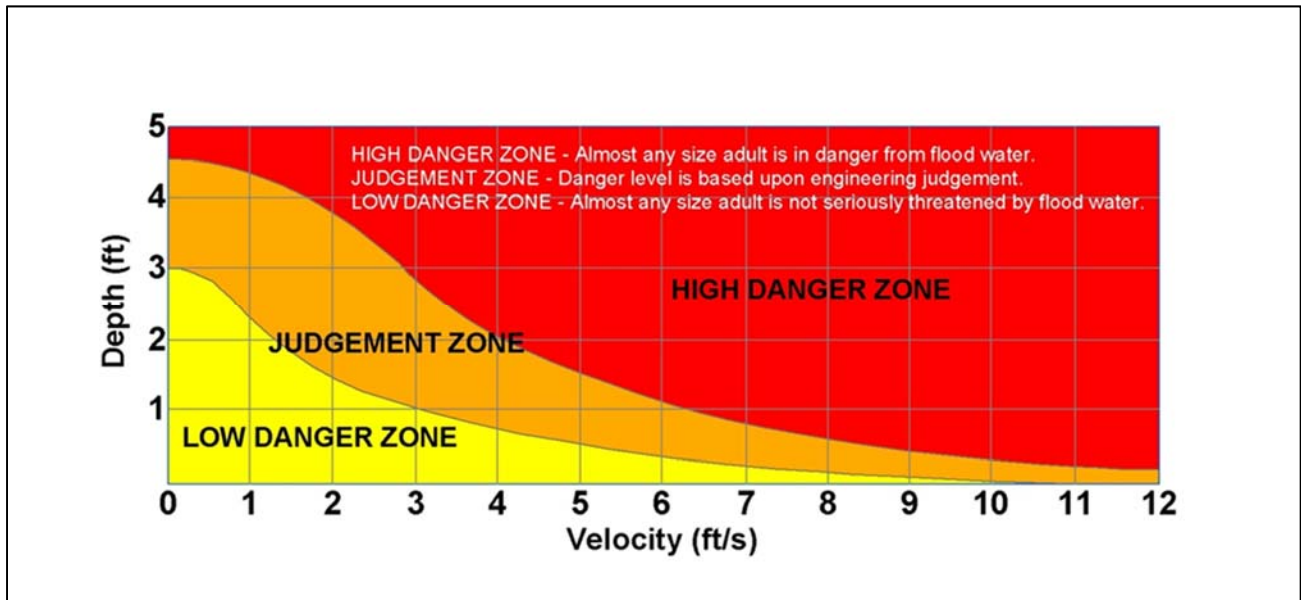
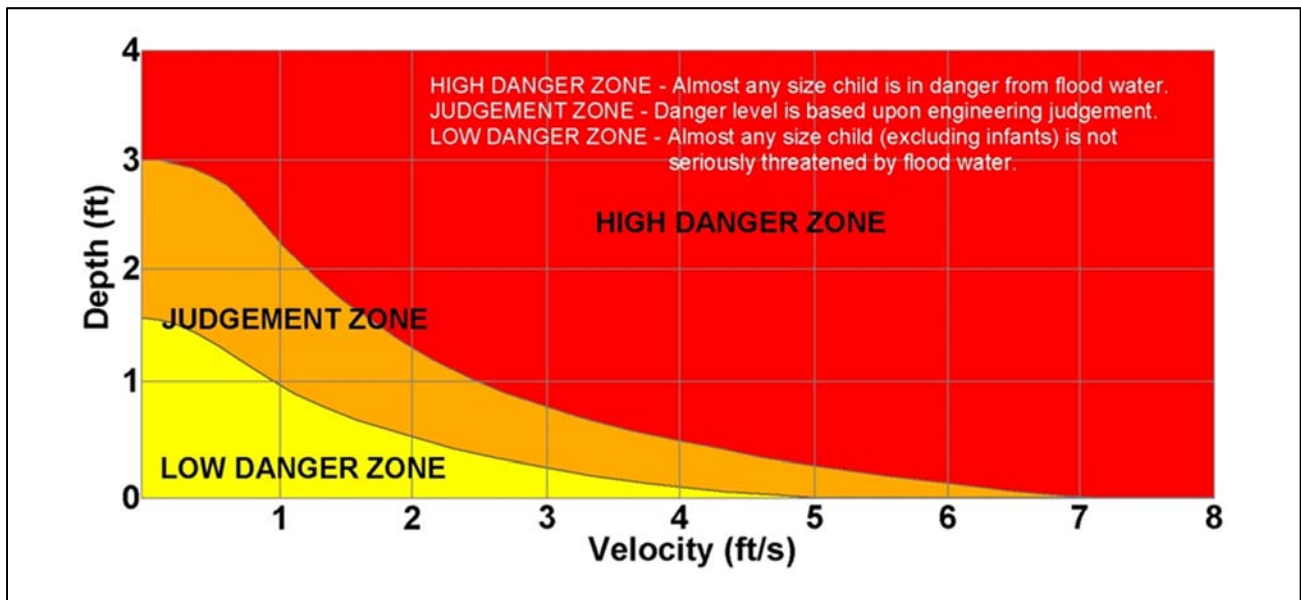


Figure 6.2 Depth-velocity flood danger relationship for children



Standard 6.2.3 Channel Drop Structure Height. For all channel drop structures, the maximum vertical height from invert crest to invert toe shall be 2.5 feet. Larger drops may be allowed if access and safety issues are addressed to the satisfaction of the County/Community/District. Protection for the effects of scour and erosion shall be provided. Drop structures constructed of concrete or pneumatically placed concrete shall have a roughened surface to discourage inappropriate recreational use, unless the specific design goal is to encourage recreational use.

Standard 6.2.4 Emergency Escape Requirements for Lined Channels. All concrete, pneumatically placed concrete, or smooth sided soil cement channels with a design flow depth greater than 3 feet shall have emergency escape stair-steps formed, alternating every 1,000 feet from one side of the channel to the other, or other approved alternative.

Standard 6.2.5 Stormwater Storage Ponds with Permanent Water Body. For stormwater storage ponds with a permanent water body in the bottom, the pond edge shall be designed to minimize safety hazards. A safety shelf shall be provided with water depth limited to 1.5 feet within 8 feet of the edge of the water feature, and gradually get deeper as needed.

Standard 6.2.6 Amenities within Stormwater Storage and Conveyance Facilities. Amenities placed within the inundation area of a stormwater storage facility, or the conveyance area of a channel, shall be adequately secured to prevent them from becoming waterborne debris.

Standard 6.2.7 Fencing Requirement. Fencing will be required for all constructed drainage basins and channels, located in developed areas, with side-slopes steeper than 4:1 or depths exceeding three (3) feet, unless provisions are made for safe exit from the facility during flooding conditions, appropriate warning signs are posted, and other deterrents to access during unsafe conditions are provided. Such provisions require the advance approval by the County/Community/District and they must be sealed by an Arizona registered Civil Engineer. Determining the type and height of such fencing shall be based on sound engineering judgment for the intended application. Fencing shall not be allowed to block the floodway of an open water course or channel.

Standard 6.2.8 Access Ramps and Access Roads. Drainage facilities must be readily accessible by emergency or maintenance vehicles. Access roads shall be required, including access to the bottom of channels. Access road ramps will be required for stormwater storage facilities and engineered channels with depths greater than 3 feet, or engineered channels with a bottom width of 10 feet or greater. A minimum of one (1) access ramp will be required for each reach of channel, defined by vertical drops or obstructions such as street culvert crossings. Ramped access roads are not necessary for stormwater storage facilities and engineered channels 3 feet deep or shallower with 6:1 side slopes or flatter along at least one side of the storage facility or channel that would allow maintenance and emergency vehicle access. Access for maintenance is required for all other engineered channels including swales, drainage ditches, etc. Access ramps shall be a minimum of 16 feet wide compacted with a longitudinal slope no steeper than 10%. Access vehicular travel lanes shall be at least 12 feet wide within a clear 16 foot wide tract (included as part of a right-of-way, or privately owned drainage tract) such that vehicles can freely maneuver. Hard surface paved access roads shall be at least 10 feet wide.

Standard 6.2.9 Trashracks and Access Barriers. Trashracks may be required on the entrances and access barriers on outlets to conduits or other hydraulic structures. Where such barriers are required, they shall be placed on both the inlet and outlet ends. They are required in areas where debris potential and/or public safety indicate they are necessary, such as in developed areas or where a person could likely be injured or trapped. Refer to [Table 6.1](#) for additional guidelines within such areas.

Table 6.1 Conduit and Hydraulic Structure Trashrack and Access Barriers

Facility Description	Diameter or Cross Sectional Area (per barrel)	Length	Inlet Trash Rack Required	Outlet Access Barrier Required
Culverts and Storm Drains	Dia < 24" Area < 3.14 sf	All	No	No
Outlets from multiple-use stormwater storage facilities.	Dia ≥ 24" Area ≥ 3.14 sf	All	Yes	Yes
Culverts and Storm Drains with sufficient bend that the opposite end cannot be clearly seen when looking into the structure.	Dia ≥ 24" Area ≥ 3.14 sf	All	Yes	Yes
Culverts and Storm Drains, other than noted above	Dia ≥ 24" 3.14 sf < Area ≤ 15 sf	L < 200 ft. L ≥ 200 ft.	No Yes	No Yes
Culverts and Storm Drains, other than noted above	Area > 15 sf	All	No	No

Flap gates may be substituted for access barriers on conduit or hydraulic structure outlets when it can be shown that sedimentation will not prevent the flap gate from opening or that the design of the outlet structure will reduce downstream sedimentation that would prevent the flap gate from opening.

Trashrack and access barrier assemblies shall be secured to prevent public access, but hinged or removable to allow access for maintenance. They shall be designed to withstand the hydrodynamic load resulting from the 100-year design event. The assemblies shall be suitable for exposure to sunlight, as well as submerged conditions. An anti-vortex device shall be included with the trash rack design if vortices are anticipated which could affect hydraulic efficiency and cause erosion of adjacent earth slopes. Anti-vortex devices may be applicable for drop-inlet type drainage structures with a vertical riser if weir control is not maintained in the riser through all design flow stages. Anti-vortex devices are not normally used for standard culvert installations. Refer to USACE (1980) and USDOT (2001).

Standard 6.2.10 Lot/Tract Grading – Cut and Fill.

The maximum grade on fill slopes shall be 3:1 (H:V). The maximum grade on cut slopes shall be 2:1 (H:V). Steeper slopes may be permitted based on a stability evaluation and certification by a licensed geotechnical engineer that the steeper slopes will be stable and safe.

6.3 HYDROLOGY

6.3.1 Design Storm Duration Criteria

The design storm duration specified for the type of structure under consideration in combination with the size of the contributing drainage area, varies depending on the risk to public safety. The following minimum standards shall be applied for the differing applications. Refer to [Table 6.7](#) for more specific minimum storm frequency-duration criteria.

Table 6.2 Design Storm Duration Criteria

Purpose/Method	Criteria
Retention basins	100-year, 2-hour rainfall as defined in the Hydrology volume for stormwater storage
Analysis for undisturbed drainage ways and design of engineered channels, bridges, and culverts:	
Drainage Area: 0 to 160 acres (Rational Method or Unit Hydrograph Method)	If only design peak charges are needed, then the Rational Method is acceptable. Refer to Section 5.3 of the Hydrology volume for limitations on use of the Unit Hydrograph Method.
Drainage area: 160 acres to 20 square miles (Unit Hydrograph Method)	6-hour local storm per Hydrology volume. Engineering judgment may dictate use of a 24-hour storm depending on soil conditions, or other hydrologic parameters or criteria. The County/District may require analysis of both the 6-hour and 24-hour storms, and require that the larger peak discharge be utilized.
Drainage area: 20 to 100 square miles (Unit Hydrograph Method)	Either a critically centered 6-hour local storm as defined in the Hydrology volume or a 24-hour general storm. The County/District requires analysis of both the 6-hour local storm and the 24-hour general storm, and requires that the larger peak discharge and runoff volume be utilized.
Drainage area.100 to 500 square miles (Unit Hydrograph Method)	24-hour general storm.

6.3.2 Rational Method Criteria

[Table 6.3](#) and [Table 6.4](#) contain C Coefficients for use with the Rational Method and are to be applied for most applications. **It is the engineers' responsibility to verify the applicability of these values for the intended application.** Higher values may be approved, within the ranges specified in Table 3.2 of the Hydrology volume, based on an analysis of planned and/or actual percent imperviousness and vegetation and soils conditions.

Table 6.3 Rational Method Developed Condition C Coefficients

Land Use ¹		Return Period				K _b Type ²
FCDMC Land Class	Maricopa Association of Governments/County Zoning Classifications	2-, 5-, & 10- Year	25- Year	50- Year	100- Year	
110	Rural Residential (<= 1/5 dwelling units (du) per acre Rural-190	0.42	0.46	0.50	0.53	A
120	Estate Residential (1/5 du per acre to 1 du per acre) Rural-70, Rural-43	0.42	0.46	0.50	0.53	A
130	Large Lot Residential - Single Family (1 du per acre to 2 du per acre) R1-35	0.48	0.53	0.58	0.60	A
140	Medium Lot Residential - Single Family (2-4 du per acre) R1-18, R1-10	0.65	0.72	0.78	0.80	A
150	Small Lot Residential - Single Family (4-6 du per acre) R1-8	0.68	0.75	0.80	0.84	A
160	Very Small Lot Residential - Single Family (>6 du per acre-includes mobile home) R1-7, R1-6	0.75	0.83	0.90	0.94	A
170	Medium Density Residential - Multi Family (5-10 du per acre) R-2	0.75	0.83	0.90	0.94	A
180	High Density Residential - Multi Family (10-15 du per acre) R-3	0.75	0.83	0.90	0.94	A
190	Very High Density Residential - Multi Family (> 15 du per acre) R-4, R-5	0.75	0.83	0.90	0.94	A
200	General Commercial (Commercial where no detail available) C-3	0.85	0.94	0.95	0.95	A
210	Specialty Commercial (<=50,000 sq. ft.) C-S, C-O, C-1, C-2, C-3	0.85	0.94	0.95	0.95	A

1 Originally from MAG 2000 Land Use Plan and Maricopa County Zoning Ordinance, the current MAG Existing Land Use Plan may be used. It is the users' responsibility to determine the appropriate Land Use types and parameter values.

2 Refer to the Hydrology Manual, Chapter 5, Table 5.3 for descriptions of each type.

Table 6.3 Rational Method Developed Condition C Coefficients

Land Use ¹		Return Period				K _b Type ²
FCDMC Land Class	Maricopa Association of Governments/County Zoning Classifications	2-, 5-, & 10- Year	25- Year	50- Year	100- Year	
220	Neighborhood Commercial (50,000 to 100,000 sq. ft.)	0.85	0.94	0.95	0.95	A
230	Community Commercial (100,000 to 500,000 sq. ft.)	0.85	0.94	0.95	0.95	A
240	Regional Commercial (500,000 to 1,000,000 sq. ft.)	0.85	0.94	0.95	0.95	A
250	Super-Regional Commercial (>= 1,000,000 sq. ft.)	0.85	0.94	0.95	0.95	A
300	General Industrial (Industrial where no detail available)	0.80	0.88	0.95	0.95	A
310	Warehouse/Distribution Centers	0.85	0.94	0.95	0.95	A
320	Industrial IND-1, IND-2, IND-3	0.80	0.88	0.95	0.95	A
400	Office General (Office where no detail available)	0.85	0.94	0.95	0.95	A
410	Office Low Rise (1-4 stories)	0.85	0.94	0.95	0.95	A
420	Office Mid Rise (5-12 stories)	0.85	0.94	0.95	0.95	A
430	Office High Rise (13 stories or more)	0.85	0.94	0.95	0.95	A
510	Tourist and Visitor Accommodations (Hotels, motels and resorts)	0.85	0.94	0.95	0.95	A
520	Educational (Public schools, private schools and universities)	0.75	0.83	0.90	0.94	A
530	Institutional (Includes hospitals and churches)	0.85	0.94	0.95	0.95	A

Table 6.3 Rational Method Developed Condition C Coefficients

Land Use ¹		Return Period				K _b Type ²
FCDMC Land Class	Maricopa Association of Governments/County Zoning Classifications	2-, 5-, & 10- Year	25- Year	50- Year	100- Year	
540	Cemeteries	0.25	0.28	0.30	0.31	B
550	Public Facilities (Includes community centers, power sub-stations, libraries)	0.85	0.94	0.95	0.95	A
560	Special Events (Includes stadiums, sports complexes and fairgrounds)	0.85	0.94	0.95	0.95	A
570	Other Employment - low (Proving grounds and landfills)	0.85	0.94	0.95	0.95	A
580	Other Employment - medium	0.85	0.94	0.95	0.95	A
590	Other Employment - high	0.85	0.94	0.95	0.95	A
600	General Transportation (Transportation where no detail available)	0.95	0.95	0.95	0.95	A
610	Transportation (Includes railroads, rail yards, transit centers and freeways)	0.95	0.95	0.95	0.95	A
620	Airports (Includes public use airports)	0.80	0.88	0.95	0.95	A
700	General Open Space (Open space where no detail available)	0.40	0.44	0.48	0.50	B
710	Active Open Space (Includes parks)	0.25	0.28	0.30	0.31	A
720	Golf courses	0.25	0.28	0.30	0.31	A
730	Passive Open Space (Includes mountain preserves and washes)	0.55	0.61	0.66	0.69	D
740	Water	1.00	1.00	1.00	1.00	A
750	Agriculture	0.20	0.22	0.24	0.25	B

Table 6.3 Rational Method Developed Condition C Coefficients

Land Use ¹		Return Period				K _b Type ²
FCDMC Land Class	Maricopa Association of Governments/County Zoning Classifications	2-, 5-, & 10- Year	25- Year	50- Year	100- Year	
810	Business Park (Includes enclosed industrial, office or retail)	0.85	0.94	0.95	0.95	A
900	Vacant (Existing land use database only)	0.40	0.44	0.48	0.50	B
2000 ³	Landscaping with impervious under treatment	0.85	0.94	0.95	0.95	A
2001 ³	Landscaping w/o impervious under treatment	0.40	0.44	0.48	0.50	A
2002 ³	Pavement and Rooftops	0.95	0.95	0.95	0.95	A
2003 ³	Gravel Vehicular travel lanes & Shoulders	0.70	0.77	0.84	0.88	A

Table 6.4 Rational Method Natural Condition C Coefficients

Land Use		Return Period				K _b Type
Code	Category	2-, 5-, & 10-Year	25-Year	50-Year	100- Year	
NDR	Undeveloped Desert Rangeland. Little topographic relief, slopes <5%	0.40	0.44	0.48	0.50	B
NHS	Hillslopes, Sonoran Desert. Moderate topographic relief, slopes >5%	0.55	0.61	0.66	0.69	C
NMT	Mountain Terrain. High topographic relief, slopes >10%	0.80	0.88	0.95	0.95	D

³ Assigned by the District

6.3.3 Unit Hydrograph Method Criteria

[Table 6.5](#) contains rainfall loss, Time of Concentration equation and Lag equation parameters for use with the unit hydrograph method. Refer to Section 4.4.1 of the Hydrology volume for details of application. These parameters are for developed land use conditions corresponding with the Maricopa County Zoning Code. [Table 6.6](#) contains similar parameters for natural conditions. These are the default values contained in the DDMSW computer program. The most current DDMSW program should be used. **It is the engineers' responsibility to verify the applicability of these default values for the intended application.** These default values were originally developed based on large scale projects in the past and may not be applicable to specific projects. They were provided as the starting values in order for the software to run. **These defaults values shall be verified and changed based on the latest aerial photos and field visits.**

Table 6.5 Unit Hydrograph Method Developed-Condition Parameters

Land Use ⁴		IA ⁵ (inches)	RTIMP ⁶ (%)	VC ⁷ (%)	Soil Moisture Condition ⁸	K _n ⁹	K _b Type ¹⁰
FCDMC Land Class	Maricopa Association of Governments/County Zoning Classifications						
110	Rural Residential (<= 1/5 du per acre) Rural-190	0.30	5	30	normal	0.02	A
120	Estate Residential (1/5 du per acre to 1 du per acre) Rural-70, Rural-43	0.30	5	30	normal	0.02	A
130	Large Lot Residential - Single Family (1 du per acre to 2 du per acre) R1-35	0.30	15	50	normal	0.02	A
140	Medium Lot Residential - Single Family (2-4 du per acre) R1-18, R1-10	0.25	20	50	normal	0.02	A
150	Small Lot Residential - Single Family (4-6 du per acre) R1-8	0.25	30	50	normal	0.02	A

4 Originally from MAG 2000 Land Use Plan and Maricopa County Zoning Ordinance, the current MAG Existing Land Use Plan may be used. It is the users' responsibility to determine the appropriate Land Use types and parameter values.

5 Initial abstraction, inches

6 Percent impervious

7 Percent vegetation cover

8 For assigning a value of DTHETA

9 Average Manning's "n" for all of the channels within the subbasin for use in the S-Graph Lag Equation

10 For use in the evaluation of watershed resistance coefficient for the Clark Unit Hydrograph Time of Concentration Equation

Table 6.5 Unit Hydrograph Method Developed-Condition Parameters

Land Use ⁴		IA ⁵ (inches)	RTIMP ⁶ (%)	VC ⁷ (%)	Soil Moisture Condition ⁸	K _n ⁹	K _b Type ¹⁰
FCDMC Land Class	Maricopa Association of Governments/County Zoning Classifications						
160	Very Small Lot Residential - Single Family (>6 du per acre - includes mobile home) R1-7, R1-6	0.25	40	50	normal	0.02	A
170	Medium Density Residential - Multi Family (5-10 du per acre) R-2	0.25	45	50	normal	0.02	A
180	High Density Residential - Multi Family (10-15 du per acre) R-3	0.25	45	50	normal	0.02	A
190	Very High Density Residential - Multi Family (> 15 du per acre) R-4, R-5	0.25	45	50	normal	0.02	A
200	General Commercial (Commercial where no detail available) C-3	0.10	80	60	normal	0.02	A
210	Specialty Commercial (≤50,000 sq. ft.) C-S, C-O, C-1, C-2, C-3	0.10	80	65	normal	0.02	A
220	Neighborhood Commercial (50,000 to 100,000 sq. ft.)	0.10	80	65	normal	0.02	A
230	Community Commercial (100,000 to 500,000 sq. ft.)	0.10	80	75	normal	0.02	A
240	Regional Commercial (500,000 to 1,000,000 sq. ft.)	0.10	80	65	normal	0.02	A
250	Super-Regional Commercial (≥ 1,000,000 sq. ft.)	0.10	80	70	normal	0.02	A
300	General Industrial (Industrial where no detail available)	0.15	55	60	normal	0.02	A
310	Warehouse/Distribution Centers	0.10	80	75	normal	0.02	A
320	Industrial IND-1, IND-2, IND-3	0.15	55	60	normal	0.02	A

Table 6.5 Unit Hydrograph Method Developed-Condition Parameters

Land Use ⁴		IA ⁵ (inches)	RTIMP ⁶ (%)	VC ⁷ (%)	Soil Moisture Condition ⁸	K _n ⁹	K _b Type ¹⁰
FCDMC Land Class	Maricopa Association of Governments/County Zoning Classifications						
400	Office General (Office where no detail available)	0.10	80	75	normal	0.02	A
410	Office Low Rise (1-4 stories)	0.10	80	75	normal	0.02	A
420	Office Mid Rise (5-12 stories)	0.10	80	75	normal	0.02	A
430	Office High Rise (13 stories or more)	0.10	80	75	normal	0.02	A
510	Tourist and Visitor Accommodations (Hotels, motels and resorts)	0.10	80	75	normal	0.02	A
520	Educational (Public schools, private schools and universities)	0.29	45	80	normal	0.02	A
530	Institutional (Includes hospitals and churches)	0.10	80	75	normal	0.02	A
540	Cemeteries	0.10	5	90	normal	0.02	B
550	Public Facilities (Includes community centers, power sub-stations, libraries)	0.10	80	75	normal	0.02	A
560	Special Events (Includes stadiums, sports complexes and fairgrounds)	0.10	80	75	normal	0.02	A
570	Other Employment - low (Proving grounds and landfills)	0.10	80	75	normal	0.02	A
580	Other Employment – medium	0.10	80	75	normal	0.02	A
590	Other Employment – high	0.10	80	75	normal	0.02	A
600	General Transportation (Transportation where no detail available)	0.10	80	75	normal	0.02	A
610	Transportation (Includes railroads, rail yards, transit centers and freeways)	0.10	80	75	normal	0.02	A

Table 6.5 Unit Hydrograph Method Developed-Condition Parameters

Land Use ⁴		IA ⁵ (inches)	RTIMP ⁶ (%)	VC ⁷ (%)	Soil Moisture Condition ⁸	K _n ⁹	K _b Type ¹⁰
FCDMC Land Class	Maricopa Association of Governments/County Zoning Classifications						
620	Airports (Includes public use airports)	0.15	55	60	normal	0.02	A
700	General Open Space (Open space where no detail available)	0.10	5	90	normal	0.025	B
710	Active Open Space (Includes parks)	0.10	5	90	normal	0.02	A
720	Golf courses	0.10	5	90	normal	0.02	A
730	Passive Open Space (Includes mountain preserves and washes)	0.10	0	90	normal	0.03	D
740	Water	0.00	0	0	saturated	0.02	A
750	Agriculture	0.50	0	85	normal	0.02	B
810	Business Park (Includes enclosed industrial, office or retail)	0.10	80	75	normal	0.02	A
900	Open Space	0.35	0	25	dry	0.025	B
2000 ¹¹	Landscaping with impervious under treatment	0.10	95	30	normal	0.02	A
2001 ¹¹	Landscaping w/o impervious under treatment	0.20	0	30	normal	0.02	A
2002 ¹¹	Pavement and Rooftops	0.05	95	0	dry	0.015	A
2003 ¹¹	Gravel Vehicular travel lanes & Shoulders	0.10	5	0	dry	0.02	A

¹¹ Assigned by the District

Table 6.6 Unit Hydrograph Method Natural-Condition Parameters

Land Use		IA ¹² (inches)	RTIMP ¹³ (%)	VCD ¹⁴ (%)	Soil Moisture Condition ¹⁵	K _n ¹⁶	K _b Type ¹⁷
Class	Category						
NDR	Undeveloped Desert Rangeland. Little topographic relief, slopes <5%	0.35	0	varies	dry	0.025	B
NHS	Hillslopes, Sonoran Desert. Moderate topographic relief, slopes >5%	0.15	0	varies	dry	0.03	C
NMT	Mountain Terrain. High topographic relief, slopes >10%	0.25	0	varies	dry	0.05	D

6.3.4 Hydrologic and Hydraulic Design Criteria

Standard 6.3.1 Design Criteria. The following peak discharge and storm frequency related design criteria are to be applied for the listed drainage features.

Table 6.7 Minimum Drainage Design Criteria

Drainage Feature	Flood Event Return Interval	
	2-year through 50-year	100-year
STREETS		
Criteria for Street with Curb and Gutter (longitudinal flow) common to all Street Classifications	For all storm frequencies up to and including the 100-year: <ol style="list-style-type: none"> 1. Channel and/or storm drain systems installed as needed to meet street drainage criteria. 2. Historic drainage divides should be retained. Flows within existing streets should follow historic drainage paths. 3. Runoff to be contained 12-inches below the finished floor of adjacent buildings. 4. Q_{max} = 100 cfs. 5. V_{max} = Refer to Standard 6.2.2 	

12 Initial abstract, in inches

13 Percent impervious

14 Percent vegetation cover

15 For assigning a value of DTHETA

16 For use in the S-Graph Lag Equation

17 For use with the Clark Unit Hydrograph Time of Concentration Equation

Table 6.7 Minimum Drainage Design Criteria

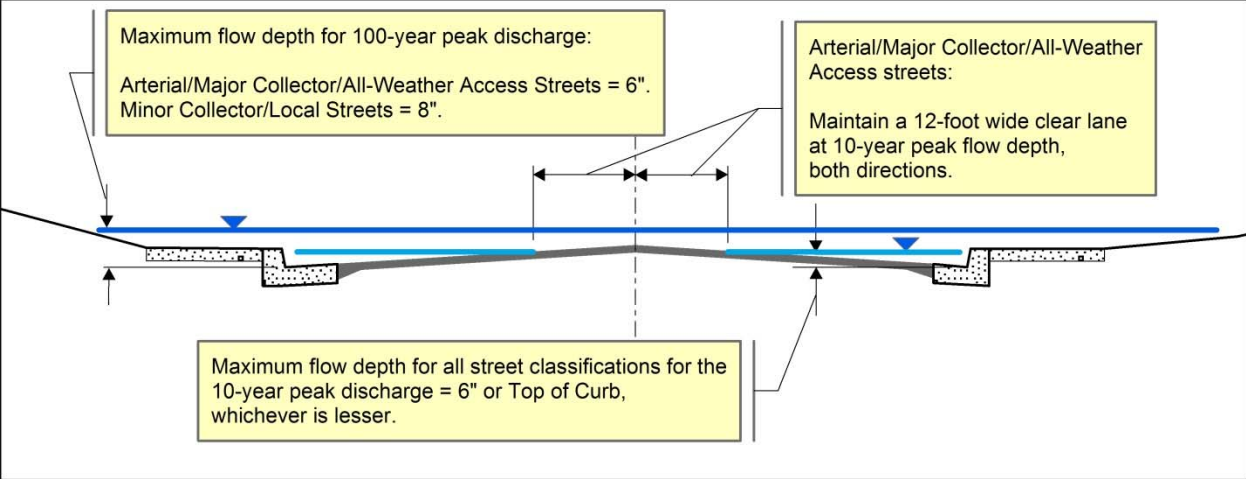
Drainage Feature	Flood Event Return Interval	
	2-year through 50-year	100-year
Arterial/Major Collector/All-Weather Access Streets	10-year: One 12-foot dry driving lane maintained in each direction, and flow depths not to exceed curb height.	d_{max} vehicular travel lane = 6-inches
Local Streets (MCDOT comment)	10-year: Flow depths not to exceed curb height.	d_{max} vehicular travel lane = 8-inches
<p>Example of Street Flow Depth Requirements, Flow Parallel to Street, with Curb and Gutter</p> 		
Criteria for Street without Curb and Gutter (longitudinal flow) common to all Street Classifications	<p>For all storm frequencies up to and including the 100-year:</p> <ol style="list-style-type: none"> 1. Historic drainage divides should be retained. Flows within existing streets should follow historic drainage paths. 2. Runoff to be contained 12-inches below the finished floor of adjacent buildings. 	
	<p>Runoff conveyed by channel with maximum water surface no greater than the lowest adjacent road subgrade or alternative design approved by County/District for the storm frequency listed below by street classification.</p> <p>Culvert outlet $V_{max} = 15$ fps</p>	<p>Runoff to be conveyed by channel with maximum flow depth in vehicular travel lane as specified below by street classification.</p>
Channel adjacent to Arterial/All-Weather Access streets	10-year frequency	d_{max} vehicular travel lane = 6-inches

Table 6.7 Minimum Drainage Design Criteria

Drainage Feature	Flood Event Return Interval	
	2-year through 50-year	100-year
Channel adjacent to Collector streets	10-year frequency	d_{max} vehicular travel lane = 6-inches
Channel adjacent to Local streets	10-year frequency	d_{max} vehicular travel lane = 8-inches
<p>Example of Street Flow Depth Requirements, Flow Parallel to Street, without Curb and Gutter</p>		
CULVERTS AND BRIDGES		
Criteria for Cross Road Culverts Common to all Street Classifications	Runoff to be conveyed by culvert with maximum water surface no greater than the lowest adjacent road subgrade or alternative design approved by County/District, for the storm frequency listed below by street classification. Culvert outlet $V_{max} = 15$ fps	Runoff to be conveyed by culvert with maximum depth in vehicular travel lane as specified below by street classification. Culvert outlet $V_{max} = 15$ fps. Where flow weirs over road, suitable erosion protection approved by County/District shall be provided.
Arterial/All-Weather Access streets.	50-year frequency	d_{max} vehicular travel lane = 6-inches
Collector Streets	25-year frequency	d_{max} vehicular travel lane = 6-inches
Local Streets	10-year frequency	d_{max} vehicular travel lane = 8-inches

Table 6.7 Minimum Drainage Design Criteria

Drainage Feature	Flood Event Return Interval	
	2-year through 50-year	100-year
<p>Example of Street Flow Depth Requirements at Culverts, with Normal Crown and C&G</p>		
<p>Example of Street Flow Depth Requirements at Culverts, Crown Removed</p>		

Table 6.7 Minimum Drainage Design Criteria

Drainage Feature	Flood Event Return Interval	
	2-year through 50-year	100-year
Bridges for all Street Classifications, including Pedestrian Bridges	N/A	Runoff to be conveyed under road with 2 foot freeboard below bridge low chord, with pier clogging factors per Standard 6.7.17 .
LOW WATER CROSSINGS		
Criteria for Low Water Crossings Common to all Street Classifications	<p>For all storm frequencies up to and including the 100-year:</p> <p>Allowable for long areas of shallow or distributary flow where the County/Community/District determines that construction of culverts is impractical, detrimental to public safety, or would result in adverse impacts to properties.</p> <p>Low water crossings shall have erosion protection as approved by County/Community/District.</p> <p>If exceptions to the 100-year flow depth are approved by County/Community/District, a flow monitoring-flooded roadway warning system together with road closure facilities shall be provided as required by County/Community/District. No exceptions to the 100-year flow depth requirement for subdivision all-weather access street classifications will be granted.</p> <p>V_{max} = Refer to Standard 6.2.2.</p>	
Arterial/Collector/All-Weather Access streets	NA	d_{max} vehicular travel lane = 6-inches
Local streets	N/A	d_{max} vehicular travel lane = 8-inches
OPEN CHANNELS PARALLEL OR ADJACENT TO STREETS		
Criteria for Open Channels Common to all Street Classifications	Runoff to be conveyed by open channel with maximum water surface no greater than the lowest adjacent road subgrade or alternative design approved by County/Community/District, for the storm frequency listed below by street classification.	<p>Runoff to be conveyed by open channel with maximum depth in vehicular travel lane as specified below by street classification.</p> <p>Channel design shall not result in adverse impacts to adjacent properties.</p> <p>Subject to freeboard requirements per Standard 6.8.7. Subject to flow regime requirements per Standard 6.8.3. (6).</p>

Table 6.7 Minimum Drainage Design Criteria

Drainage Feature	Flood Event Return Interval	
	2-year through 50-year	100-year
Arterial/All-Weather Access streets.	50-year frequency	d_{max} vehicular travel lane = 6-inches
Collector Streets	25-year frequency	d_{max} vehicular travel lane = 6-inches
Local Streets	10-year frequency	d_{max} vehicular travel lane = 8-inches
DELINEATED FLOODPLAINS - FEMA		
<p>It is the intent of the District that floodplains and floodways be delineated for areas meeting these criteria, and that those delineations be submitted to FEMA for approval. Delineations may be done by the District as funding permits. The Floodplain Administrator may elect to temporarily not submit a delineation to FEMA due to extenuating circumstances. The County/Community will require a developer to delineate floodplains for areas that meet this criterion, and the District/Community may require that the delineation be submitted to FEMA, particularly if lots or homes are proposed for construction within the defined flood hazard area. The District will regulate floodplains that are identified on the District Flood Management Maps.</p>		
Requirement to Delineated Floodplain	N/A	<p>At a minimum, delineate floodplain for:</p> <ol style="list-style-type: none"> 1. $Q_{100} \geq 500$ cfs. 2. Watershed areas ≥ 1 sq. mi. 3. Developments meeting criteria 1 or 2 that are 5 acres in area or greater or will have 50 or more lots.
Requirement for Delineated Floodway	N/A	<p>Delineate a Floodway where successive encroachments by development within the Delineated Floodplain may result in cumulative impacts, detrimental to public safety or property, to flood depths, velocities, erosion hazards or the uncertainty of distributary flow paths on adjacent, upstream or downstream properties.</p>

Table 6.7 Minimum Drainage Design Criteria

Drainage Feature	Flood Event Return Interval	
	2-year through 50-year	100-year
Lowest floor elevation for dwellings within a delineated floodplain on the District's Flood Management Maps.	N/A	<p>Lowest floor elevation to be the higher of:</p> <ol style="list-style-type: none"> 1. minimum of at or above the Regulatory Flood Elevation (RFE) (for manufactured homes, the bottom of the lowest structural frame along with all attendant utilities including ductwork shall be elevated at or above the RFE). Note that to file a CLOMR-F with FEMA and remove the dwelling from the floodplain for flood insurance purposes, the grade adjacent to the dwelling must be at or above the Base Flood Elevation. or 2. 14-inches above the lowest drainage outfall for the lot, or 3. 12-inches above the Highest Adjacent Grade within 10 feet of the foundation of the building.
DELINEATED FLOODPLAINS - NON-FEMA		
The County/Community may require that floodplains be delineated for areas meeting this criterion.		
Requirement for Delineated Floodplain	N/A	<p>$Q_{100} < 50$ cfs, Flow depth ≤ 3-inches: Limits do not have to be delineated, but lowest floor requirements within a Non-FEMA Delineated Floodplain apply.</p> <p>$Q_{100} \geq 50$ cfs or Watershed Area ≥ 0.25 sm: Floodplain limits and elevations are to be defined if required by the County/Community as part of a subdivision and/or drainage review.</p> <p>Floodplains shall be delineated, and shown on the Grading and Drainage Plans, and the Preliminary and Final Plats, for:</p> <ol style="list-style-type: none"> 1. $Q_{100} \geq 500$ cfs. 2. Watershed areas ≥ 1 sq. mi. 3. Developments meeting criteria 1 or 2 that are 5 acres in area or greater or will have 50 or more lots.

Table 6.7 Minimum Drainage Design Criteria

Drainage Feature	Flood Event Return Interval	
	2-year through 50-year	100-year
Requirement for Delineated Floodway	N/A	<p>$Q_{100} \geq 50$ cfs or Watershed Area ≥ 0.25 sm: Definition of floodway limits within a Delineated Floodplain may be required by the County/Community/District depending on flow depth and velocity. Floodway delineation may be required where a floodplain delineation is required and the floodplain has areas within the High Danger Zone shown on Figure 6.1 and Figure 6.2 where the flow depth ≥ 2 ft. in combination with velocity ≥ 4 fps.</p>
Lowest floor within a Non-FEMA Delineated Floodplain, and not on the District's Flood Management Map.	N/A	<p>Lowest floor elevation for houses that are to be located within a Delineated Floodplain shall be elevated a minimum of 12-inches above the highest adjacent BFE. Houses may be prohibited in flood hazard areas within the High Danger Zone shown on Figure 6.1 and Figure 6.2 where the flow depth ≥ 2 ft. in combination with velocity ≥ 4 fps.</p>
Lowest floor not within a FEMA or Non-FEMA Delineated Floodplain.	N/A	<p>Lowest floor elevation for houses shall be elevated a minimum of the following, whichever is higher:</p> <ol style="list-style-type: none"> 1. 14-inches above the lowest drainage outfall for the lot, or 2. 12-inches above the Highest Adjacent Grade within 10 feet of the foundation of the building, or 3. If 100-year WSEL's are known, then 12-inches above the highest adjacent 100-year WSEL, <p>The lowest floor elevation may also be determined through engineering analysis and must be certified to be free from flooding by an Arizona registered civil engineer.</p>

Table 6.7 Minimum Drainage Design Criteria

Drainage Feature	Flood Event Return Interval	
	2-year through 50-year	100-year
STORMWATER STORAGE BASINS		
Retention Basin	N/A	100-year 2-hour storm for determining stormwater storage volume.
Detention Basins are STRONGLY discouraged and may only be used if specified by an adopted ADMP/WCMP or with special approval by the County Drainage Review Board, the Community's City or Town Council, or Drainage Review Board.	2-, 10- and 50-year peak discharge: Q _{post} reduced to < Q _{pre} And First flush per policy 3.6.6	Q _{post} reduced to < Q _{pre} and First flush per policy 3.6.6

6.4 STORMWATER QUALITY

The following minimum standards will be utilized for protection of stormwater quality in Maricopa County.

Standard 6.4.1 First Flush. Discharges into a structure owned or operated by the District must comply with Policy 3.6.6 First Flush, and County-wide all discharges may be required to meet the First Flush requirements of Policy 3.6.6 by providing stormwater runoff control (Policy 3.11.1). The First Flush requirement can be addressed by retaining the required minimum First Flush volume, treating the first flush discharge, or utilizing a combination of both approaches.

The minimum First Flush volume is calculated as follows:

$$V_{FF} = C \frac{P}{12} A$$

where

- VFF = minimum First Flush volume in ac-ft.,
- C = runoff coefficient (set = 1),
- P = first 0.5 inches of direct runoff, and
- A = area of project site, in acres.

The minimum First Flush treatment discharge is calculated as follows, based on an unpublished paper by T.R. Adams titled *Designing Stormwater Quality Facilities to Comply with Volume-Based Treatment Requirements*:

$$Q_{FF} = C I_{FF} A$$

Where:

Q_{FF} = minimum First Flush discharge in cfs.

C = runoff coefficient (set =1).

I_{FF} = maximum first flush intensity in in/hr.

$$\text{where: } I_{FF} = \frac{P_{FF}}{T_c}$$

$$P_{FF} = 0.5 \text{ inches}$$

T_c is the Time of Concentration of the upstream watershed in hours.

A = area of project site, in acres.

6.5 STREET DRAINAGE

The conveyance of stormwater in a roadway is influenced by the typical roadway cross-section, cross-slope, longitudinal slope and roadway material. The following are standards to be used in the evaluation of roadway conveyance:

Standard 6.5.1 Construction Plans. Construction plans for street drainage improvements are to meet the requirements of Section 6.16 and the MCDOT Roadway Design Manual.

Standard 6.5.2 Building Finished Floor Elevations. Refer to [Table 6.7](#), Section 5.2 and Section 5.3.

Standard 6.5.3 Sizing Inlets and Laterals. Runoff calculations for the sizing of inlets and lateral connection pipes shall be based on acceptable hydrologic criteria.

Standard 6.5.4 Manning's n-value. A Manning's n-value of 0.015 shall be used for paved street flow unless special conditions exist.

Standard 6.5.5 Inverted Crowns. The use of inverted crown roadways is not permitted within the County's/Community's/District Right-of-Way.

Standard 6.5.6 Valley Gutters. Valley gutters will normally only be allowed between intersections on local streets. The minimum slope for valley gutters shall be as defined in the MCDOT Roadway Design Manual.

Standard 6.5.7 Curb Return Gutter Slope. Curb return gutters shall have a minimum slope of 0.0025 feet of fall for every 1.0 feet of gutter length.

Standard 6.5.8 Maximum Flow Depth in Street Sections. Refer to [Table 6.7](#).

Standard 6.5.9 Maximum Catch Basin Spacing. For arterial, collector streets and all-weather access streets, the maximum distance that drainage may be carried in the street is based

on maintaining a 12-foot dry lane in each direction for the 10-year event, and 10-year peak flow depths shall not exceed the top-of-curb for local streets.

Standard 6.5.10 On-Grade Catch Basins. Catch basins constructed on a continuous grade are generally not required to intercept 100% of the design flow. Such catch basins shall be designed to meet the requirements of Standard 6.5.9. 100% interception of the design flow may be required at intersections.

Standard 6.5.11 Maximum Catch Basin Curb Opening Height. The curb opening for a catch basin shall not be greater than 6-inches in height.

Standard 6.5.12 Inlet Grate Types. The use of grated catch basins is discouraged within street sections. If a grated catch basin is used within a street section, only those grate types with bars transverse to traffic, or reticuline types, are acceptable. The reduction factors, as identified in [Table 6.8](#), shall be applied to the specified variable to obtain the interception capacity used for design.

Table 6.8 Catch Basin Clogging Factors

Condition	Inlet Type	Clogging Factor
Sump	Curb Opening ¹⁸	1.25L
Sump	Grate ^{19, 20}	2.0P
Sump	Combination ²¹	1.25L and 2.0P
Continuous Grade	Curb Opening ²²	1.25L _t
Continuous Grade	Longitudinal Bar Grate ²³	0.75R _f and 1.25L
	with recessed transverse bars ²³	0.60R _f and 1.5L
	with transverse bars ²³	0.40R _f and 2.0L
	Reticuline Grate ²³	0.35R _f and 2.25L
Continuous Grade	Combination ²⁴	Apply factor 1.25L _t to curb opening only
Shallow Sheet Flow ²⁵	Slotted Drains	1.25L ²⁶

18 Applied to total length, L, per Example 5 in Chapter 3 of Hydraulics volume

19 Grated inlets in sump condition should be avoided whenever possible.

20 Applied to total grate perimeter, P, per Example 6 in Chapter 3 of Hydraulics volume

21 Apply clogging factors to both curb opening and grate

22 Applied to L_t per Example 2 in Chapter 3 of Hydraulics volume

23 Applied to R_f and L per Example 3 in Chapter 3 of Hydraulics volume

24 Applied to L_t per Example 4 in Chapter 3 of Hydraulics volume

25 Slotted drains are most effective for shallow sheet flow conditions or sumps. With greater depths and flows, a different type of inlet should be used.

26 Applied to total length of slotted drain.

6.6 STORM DRAINS

The following minimum standards including the requirements in [Table 6.9](#) to be met for the design of storm drains that will be placed into the MCDOT, Community or District maintenance systems:

Standard 6.6.1 Construction Standards. The MAG Standards shall be used for construction of storm drain systems. ADOT Standards may be used for items not covered by the MAG Standards.

Standard 6.6.2 Pipe Selection Requirements. The selection of pipe materials for storm drains shall be done in conformance with the MCDOT Roadway Design Manual. Minimum cover requirements may also be per the manufacturer’s specifications, at the discretion of the design engineer. ADOT (1996) methods may also be used, with prior approval by County/Community/District.

Standard 6.6.3 Flow Velocity. Storm drains with flow velocities less than 3 fps for $0.5 \times Q_{design}$, less than 5 fps for Q_{design} , or in excess of 15 fps shall require prior approval by County/District.

Table 6.9 Storm Drain Hydraulic Design Standards

Design Variable	Design Standard
Minimum Velocity.	5 fps for Q_{design} The lesser of 3 fps for $0.5 \times Q_{design}$ or 3 fps at flow depth = 1'
Maximum Velocity.	15 fps
Minimum Pipe Size. Main Line Lateral and Connectors	18-inches 15-inches
Pipe Diameter Changes.	The elevation of pipe crowns, not inverts, are to be matched at manholes and structures.
Maximum Distance to First Catch Basin.	10-year storm frequency: Maintain one 12-foot lane in each direction for Arterial, Collector and All-weather Access Streets. 10-year peak discharge flow depth shall not exceed the top-of-curb for Local streets.
Manhole Spacing (SD = Storm Drain Diameter).	≤ 30 inches SD (straight) = 330 feet max 33-45 inches SD = 440 feet max 48-84 inches SD = 660 feet max >84 inches SD = 1,320 feet max
Maximum Hydraulic Grade Line Elevation, Q_{design} .	Shall not be higher than 12 inches below inlet gutter flowline elevation
Maximum Energy Grade Line Elevation, Q_{design} .	Shall not exceed gutter flowline elevation

Table 6.9 Storm Drain Hydraulic Design Standards

Design Variable	Design Standard
Manning's n-values.	
Reinforced Concrete Pipe (RCP)	0.013
Corrugated Metal Pipe-(CMP) Concrete Lined	0.013
Corrugated Metal Pipe (CMP), connector pipes only	0.024
High-Density Polyethylene Pipe (HDPE)	0.013
Cast-In-Place-Pipe (CIPP). Increase minimum size required for hydraulics by 6-inches.	0.013

Standard 6.6.4 Storm Drain Profiles. Storm drain pipes and manholes shall be shown in profile along with existing and proposed grades. Typically designs also require that the Hydraulic Grade Line be shown in profile view to ensure it falls below proposed gutter elevations. Catch basin and connector pipe profiles shall be provided in the design drawings. The pipe slope to four significant figures and the pipe size shall be shown. All existing and proposed utilities crossing over and under the proposed storm drain shall be shown to scale at their actual location and elevation. Clearance with utilities shall be a minimum of 1 foot (horizontal & vertical) except for Salt River Project utilities that require a minimum of 2 feet clearance horizontally and 1 foot vertically. The information provided in profile format shall include: pipe stationing, pipe size, pipe discharge (Q), pipe velocity, pipe material, pipe invert elevations, hydraulic grade line, energy grade line, gutter flowline, inlet locations, and finish grade over pipe. Where alternative pipe materials are allowable, the design information for each pipe material type shall be included. A separate storm drain plan that relates to the hydraulic model and the construction plan set may be required. See Section 6.16 and the MCDOT Roadway Design Manual for construction plan requirements.

Standard 6.6.4.a Utility Profiles

Vertical alignments of proposed utility, water and sewer lines must be carefully evaluated and designed when coming into contact with existing drainage infrastructure. Minimum separation between the proposed utility line and existing drainage infrastructure shall be four feet (4') vertical as measured from the bottom of the existing structure and two feet (2') as measured from the top of the existing infrastructure. The utility line shall be placed so that there is no change in grade as it crosses the existing infrastructure. Refer to Flood Control District of Maricopa County Standard Detail FCD404-1. In cases where a new utility line is installed at the same time as the new District drainage infrastructure, the separation should be two feet (2') both top and bottom.

Standard 6.6.5 Hydraulic and Energy Grade Lines. Storm drain systems shall be designed for Q_{design} so that the hydraulic grade line is at least 12 inches below the inlet gutter flowline elevation, and the energy grade line shall not exceed the elevation of the gutter flowline. Hydraulic and energy grade line information for all main line and connector storm drain pipes shall be prepared by the design engineer and submitted to the County/Community/District for approval.

Standard 6.6.6 Tabular Information Requirement. The information provided in tabular format in the drainage design report shall include: pipe stationing, pipe size, pipe discharge (Q), pipe velocity, pipe material, hydraulic grade line, energy grade line, inlet locations, finish grade over pipe, gutter flowline and inlet elevations.

Standard 6.6.7 Soil Boring Requirements. Soil boring logs shall be provided with the design documentation for all storm drains within a proposed right-of-way or easement. Procedures other than those listed herein require administrative County/Community/District approval. Storm drains less than 660 feet in length shall have at least one soil boring. Storm drains longer than 660 feet shall have multiple borings at intervals not to exceed 1,320 feet. Boring depth shall be a minimum of 5 feet below the pipe invert. If cemented or rock material is encountered during drilling which results in refusal, then a rock core shall be taken to identify the type and extent of refusal to 2 feet below proposed pipe invert. Borings will be located in plan and tied to the same datum as the proposed project. Resistivity and pH testing of the soils shall be required to support pipe design in terms of material selection. If resistivity readings fall below 1500 ohms per cubic centimeter, additional readings shall be made at intervals of not less than 25 feet or more than 100 feet until the area of low resistance soil is fully defined. Boring log data shall include the following information.

1. The name of the company that produced the soil report.
2. The date the test boring was made.
3. The type of equipment used to drill the hole and take the samples.
4. The size of the auger used.
5. A description of caving that occurred during the excavation, if any.
6. Horizons of each type of soil encountered.
7. Description of the soil.
8. Classifications by the Unified Soil Classification System.
9. Plasticity index.
10. Water encountered.
11. Pavement structure (A.C. thickness, sub-base thickness, if applicable).
12. Relative moisture content (specify depth taken).
13. Representative unit weight of native material (specify depth taken)
14. Laboratory calculated optimum moisture content.
15. Resistivity and pH readings.

Standard 6.6.8 Storm Drain Junctions.

1. Junctions for storm drains shall be prefabricated "T"s, manholes, or designed junction structures. Connection to an existing storm drain shall be per an approved detail.
2. Manholes are required at, or immediately next to, all storm drain pipe size changes and junctions.

Standard 6.6.9 Storm Drain Connector Pipes

1. Opposing connector pipes, except at manholes or junction structures, shall be offset a minimum of 5 feet horizontally as measured from the centerline of each pipe.
2. Prefabricated pipe fittings are to be used on all connections to the main storm drains where a new main is being installed and the connection is not at a manhole location.
3. On projects where the storm drain main is existing, connections are to be made with an approved detail.

Standard 6.6.10 Horizontal and Vertical Deflections.

1. Alignment changes using joint deflections shall be allowed only using joint deflections within the pipe manufacturer's specified tolerances. When pipe alignment changes are to be made by deflecting pipe joints, the maximum deflection per joint shall be noted on the construction plans.
2. Manholes are required at all horizontal angle points where the total deflection angle exceeds the manufacturers' tolerances for a single joint. If the alignment change is accomplished with a pipe fitting or poured collar, a manhole is required immediately upstream or downstream of the bend.
3. Manholes are required at all vertical grade breaks of a storm drain.
4. Concrete pipe collars may be used to create vertical bends on connector pipes.

Standard 6.6.11 Right-of-Way Width Requirement. A county-owned property, dedicated right-of-way, or privately owned drainage tract/easement shall be a minimum of 16 feet wide for underground storm drains if not under a designated road right-of-way. A greater width may be necessary depending on equipment used and trench depth required.

Additional standards pertaining to Storm Drains are listed in Section 6.2, Public Safety.

6.7 CULVERTS AND BRIDGES

Bridges are defined as structures designed to span a watercourse, including bridges for vehicular roadways and pedestrian-only uses. Culverts are buried pipe or box hydraulic conveyance structures designed to convey stormwater from one side of a roadway, embankment, or service area to the other side. The following minimum standards are to be employed in the design of culverts and bridges that will be placed into the MCDOT/Community or District maintenance systems or on privately owned drainage tract/easement within a subdivision:

Standard 6.7.1 Requirement to Provide Culverts or Bridges. Except where low water crossings are allowed as specified in [Table 6.7](#), watercourses found to meet the following conditions are to be culverted or bridged:

1. A watercourse with a 100-year peak discharge of 25 cfs or greater,
2. A watercourse that is a regulatory area designated as "Waters of the United States" under Section 404 of the Clean Water Act (refer to Section 4.5), or

3. As necessary in order to preserve natural flow patterns and prevent adverse impacts on adjacent, upstream and downstream properties.

Standard 6.7.2 Construction Plans. Construction plans for culvert and bridge drainage improvements are to meet the requirements of Section 6.16 and the MCDOT Roadway Design Manual.

Standard 6.7.3 Pipe Selection Requirements. The selection of pipe materials and section type for culverts shall be done in conformance with the requirements of the MCDOT Roadway Design Manual.

Standard 6.7.4 Design Storms. Culverts are to be designed to convey, as a minimum, the storm frequency peak discharge listed below by street classification with no flow crossing over the roadway and the ponded water surface elevation shall not exceed the lowest adjacent roadway subgrade elevation unless an alternative design is approved by County/Community/District.

Arterial and All-Weather Access Streets: 50-year storm frequency

Collector Streets: 25-year storm frequency.

Local Streets: 10-year storm frequency.

Refer to [Table 6.7](#) for flow depth limitations.

Standard 6.7.5 Ponding Outside of Right-of-Way. Backwater ponding limits that extend outside of the roadway right-of-way shall be delineated and a drainage easement or right-of-way obtained from the property owner. Drainage easements shall be recorded and attached to the deed for the property.

Standard 6.7.6 Low Water Crossings. Low water crossings and dip sections are not allowed without approval in writing by the County/Community/District. Refer to the requirements in [Table 6.7](#).

Standard 6.7.7 Headwall Requirements. Headwalls are required at the inlet and outlet of all culvert installations unless otherwise approved by the County/Community/District. Pipe sizes of 30-inch or greater shall have concrete headwalls. Pipe sizes less than 30-inch shall have concrete headwalls if trash racks are required to comply with requirements specified in [Table 6.1](#). Otherwise, pipe sizes less than 30-inch shall have flared end sections or concrete/masonry headwalls.

Standard 6.7.8 Minimum Pipe Diameter. Refer to the MCDOT Roadway Design Manual for minimum required pipe diameters for County-maintained culverts.

Standard 6.7.9 Maintenance Access. Ramped, vehicular access for maintenance is required at the upstream and downstream ends of all culverts that are not accessible from the roadway. The maintenance access route shall be within public right-of-way or a County approved easement.

Standard 6.7.10 Requirement for Upstream Ponding Areas. A County-owned property, right-of-way, or privately-owned drainage tract or easement shall be provided for the area

inundated by backwater from the culverts for the peak 100-year event. The 100-year floodplain limits shall be delineated and shown on the subdivision Final Plat or Map of Dedication.

Standard 6.7.11 Velocity Requirements.

1. Design velocity requirements shall conform to those specified in [Table 6.9](#).
2. Culverts are to be designed with consideration to the guidelines presented in the Culverts and Bridges, and Sedimentation chapters in the Hydraulics volume.
3. The culvert shall be designed so minimum velocities facilitate sediment transport to keep the culvert clean.
4. The maximum velocity in the culvert should be consistent with channel stability requirements at the culvert outlet. Aggradation or degradation at culvert crossings must be examined in the design of culverts.

Standard 6.7.12 Outlet Protection Requirements. Culvert outlet requirements shall conform to the requirements set forth in [Table 6.10](#). The size, depth, and lateral extent of outlet protection, including energy dissipaters, shall be designed in conformance with the Culvert and Bridges, and the Hydraulic Structures, chapters of the Hydraulics volume.

Standard 6.7.13 Cut-off Wall Requirements. Culverts with headwalls shall have cut-off walls where dictated by scour depth. If cut-off walls are determined to be necessary, then minimum cut-off wall depths shall be as indicated in [Table 6.11](#). For pipes larger than 24 inches, cut-off wall depth shall be dictated by the greater of the depth shown in the table or that depth calculated using the depth of scour equation identified in the Culvert and Bridges chapter of the Hydraulics volume.

Table 6.10 Design Criteria for Culvert Outlets

Outlet Protection	Natural Channel	Artificial Channel
None	Up to 1.3 times existing channel velocity	Up to maximum allowable velocity for channel lining
Riprap or other suitable transition apron	1.3 to 2.5 times existing channel velocity	1.0 to 2.5 times allowable channel lining velocity
Energy Dissipater ⁽¹⁾	Velocities greater than 2.5 times existing channel velocity	Velocities greater than 2.5 times allowable channel lining velocity

(1) Chapter 5.4.2 of the Drainage Design Manual for Maricopa County – Hydraulics

Table 6.11 Design Criteria for Culvert Cut-off Walls

Pipe Diameter	Minimum Inlet & Outlet Cutoff Wall Depth (feet)
---------------	---

24" to 42"	2.0
42" to 84"	4.0

Standard 6.7.14 Bridge Freeboard Requirements. Bridges shall be designed to have a minimum freeboard of 2 feet below the low chord elevation for the 100-year event. For supercritical flows, see Standard [6.7.17](#) for additional freeboard requirements.

Standard 6.7.15 Design Floating Debris Allowance.

Hydraulic Analysis of Bridges: Bridge pier sizes shall be modeled as twice their structural width or 2 foot on each side, whichever is greater. When warranted by the potential for debris from the watershed, larger debris width increases may be required.

Hydraulic Analysis of Box Culverts: When warranted by the potential for debris from the watershed, an allowance of 1 foot of debris on each side of box culvert inlets and at interior walls shall be considered when calculating the hydraulic capacity of box culverts.

Bridge Pier Modeling For Local Scour Calculations: The following minimum modifications to the pier shape shall be applied in hydraulic models for structural design purposes to calculate pier local scour depth and water pressure on piers. These minimum modifications are intended to supplement AASHTO LRFD Bridge Design Specifications (AASHTO, 2004), unless otherwise directed by County/Community/District.

1. To account for drift/debris build-up, increase pier column width/diameter, within the top 12 feet of water depth (per ADOT Bridge Design Guidelines), to twice the design value, but no less than two feet on each side.
2. Larger pier width increases up to half span length on each side may be considered when warranted by the potential for debris from the watershed,
3. For deep drilled shaft foundations, in the area below the bottom of casing, increase the shaft design diameter by one foot on each side.

Standard 6.7.16 Bridge Design Erosion Requirements. Bridges crossing undisturbed watercourses with designated erosion setbacks shall span the lateral migration erosion hazard zone which can be estimated by lateral-erosion hazard zone estimation method in FCDMC (2018). Alternatively, if structural erosion protection is proposed, the total scour depth should be computed for the erosion protection structures based on FCDMC (2018) to support the design and show that there are no adverse impacts to adjacent properties. If a channel excavation is required to pass the design flow under the bridge, a sediment transport analysis should be required to support that no sedimentation will cause channel capacity loss and violation of required freeboard. The sediment transport analysis can also quantify the deposition volume for sediment removal by operation and maintenance crew after major flood events. The sediment transport analysis may also be required to show that use of a similar design for other potential future crossings within limits of a study reach established by the District do not result in cumulative adverse impacts within the study reach.

Standard 6.7.17 Supercritical Flow Requirements.

1. For channels functioning in a supercritical flow regime for the design discharge, there shall be no reduction in cross sectional area at bridges or culverts, or any obstructions (including bridge piers) in the flow path, up to the maximum practical span for the structure type as approved by MCDOT. For cases where bridge piers must be constructed because of maximum practical span considerations, piers shall be placed in the areas of lowest velocity whenever possible.
2. Bridge freeboard below the low chord elevation shall be the greater of 2 feet or the computed velocity head ($\frac{V^2}{64.4}$) for channel velocities.

Additional standards pertaining to culvert and bridges are listed in Section 6.2, Public Safety.

6.8 OPEN CHANNELS

The following minimum standards will be employed in all designs of open channels (does not apply to undisturbed drainage ways). This section is in addition to Chapter 6, Open Channels in the Drainage Design Manual for Maricopa County, Hydraulics:

Standard 6.8.1 Construction Plans. Construction plans for open channel drainage improvements are to meet the requirements of Section 6.16.

Standard 6.8.2 Floodplain Encroachment Requirements.

1. All channelization and/or floodplain encroachments within FEMA mapped floodplains must be designed so that the cumulative effect of the encroachment does not raise the 100-year water surface (or energy grade line for supercritical flow) above the floodway water surface elevation, or more than 1 foot for FEMA mapped floodplains without a defined floodway. In addition, when determining encroachments of fill or other development, the “equal conveyance from both sides of channel” rule shall apply. The maximum 1 foot rise in water surface may not come from one side of the channel at the expense of the adjacent property owner. In the event that the rise criteria will be exceeded and the construction of levees are proposed, the levees shall be designed and constructed in accordance with, and certified to meet, FEMA and District criteria Levees are only for governmental agency’s projects. The Flood Control District of Maricopa County will not accept maintenance responsibility for a non-District project.
2. In accordance with the Drainage Provisions (Section 1205 of the Maricopa County Zoning Ordinance) a drainage clearance shall be required for any development or substantial improvement which may have an adverse effect on existing drainage. Channelization and/or floodplain encroachments may result in adverse impacts on existing drainage and thus are subject to the requirements of the Community Drainage Regulation/Drainage Provisions (Section 1205 of the Maricopa County in addition to the requirements of the Floodplain Regulations for Maricopa County.
3. Encroachment and/or stabilization on one bank may result in increased erosion potential on the opposite bank. Such adverse effects shall be evaluated and mitigated as a part of the design.

Standard 6.8.3 Channel Lining Requirements

General.

1. Due to erosion and scour of erodible channels and safety concerns with excessively high velocities, the recommended upper limit of Froude Number (Fr) shall be 2.0. The limiting Froude Number for all types of channel linings designed for the subcritical flow regime shall be $Fr < 0.86$. In areas of steeper slopes, where the natural channel is near the critical flow regime, the critical flow regime may be acceptable after the channel is modified and improved provided the Froude Number is less than 1, the flow depth is less than 2 feet, the sediment transport capacity is maintained, adequate protection from scour is provided and adjacent structures are elevated above the elevation of a possible hydraulic jump. For concrete, soil cement, and pneumatically placed concrete lined channels designed to function in the supercritical flow regime, the additional range of $1.13 < Fr < 2.0$ is allowed, provided a sediment analysis is approved that substantiates that sediment loading will not change the flow regime from supercritical to subcritical. At locations where there are to be planned hydraulic jumps, concrete, soil cement, and pneumatically placed concrete lined channels may pass through $0.86 < Fr < 1.13$. No other linings may be used in channels that fall in the Froude number range of 1.13 to 2.0. A 100-year floodplain delineation based on subcritical conditions will be required if a channel designed to be supercritical may change flow regimes unpredictably due to sedimentation issues and flow will exceed the channel banks for the subcritical condition.
2. Earthen bottom channels with lined side slopes buried below the depth of expected total scour are allowed with supporting engineering justification including sediment transport analysis, scour analysis; soil boring logs, and long term watershed yield analysis to support equilibrium longitudinal slopes. Riprap, gabions, soil cement, structural concrete or pneumatically placed concrete may be used to line side slopes.
3. Gabions are not allowed on channel bottoms used for vehicular maintenance access or bed load conveyance except at grade control, drop structures, or similar hydraulic structures.

Concrete Lined Channels:

1. Concrete and pneumatically placed concrete lined channels shall be designed per Chapter 6.6.1 of the Drainage Design Manual for Maricopa County, Hydraulics with the following additions:
2. Pneumatically placed concrete channels are to be designed to the same structural integrity as concrete channels.
3. All sloping and flat concrete, pneumatically placed concrete, and soil cement finished surfaces shall have roughened surfaces (e.g. embedded rock, grooves, etc.) to discourage inappropriate recreational use, if not considered a programmed element to the facility.
4. The lining for channel bottoms that will require maintenance vehicle access must be designed for a minimum of 18 kip axle loads assuming one loading per week for the design life of the channel.

Riprap Lined Channels:

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Riprap lined channels shall be designed per Chapter 6.6.3 of the Drainage Design Manual for Maricopa County, Hydraulics with the following additions:

1. Riprap lined channels and other improvements shall be underlain with a suitable filter, either a granular filter as per the FCDMC (2018) Hydraulics or fabric filter in accordance with Table 6.11a below:

	Table 6.11a Recommended Geotextiles for Various Soil Types						
	Silty Gravel w/Sand (GM)	Well-Graded Sand (SW) #1	Well-Graded Silty Sand (SW) #2	Silty Sand (SM)	Clayey Sand (SC)	Sandy Silt (ML)	Lean Clay (SL)
Apparent Opening Size (AOS) U.S. Sieve (mm)	40 (0.425)	40 (0.425)	50 (0.30)	70 (0.212)	40 (0.425)	100 (0.15)	100 (0.15)
Permittivity in gal/min/ft ²	50	50	15	7	50	50	50
Geotextile Type For Use Under Riprap	Woven	Woven	Woven	Woven	Woven	Non-Woven	Non-Woven

- For placement of riprap that is underwater at time of construction, the riprap thickness should be increased by 50 percent as compared with the thickness calculation method by FCDMC (2018).

Earthen and Turf Lined Channels:

- Earthen and Turf lined channels shall be designed per Chapter 6 of the Drainage Design Manual for Maricopa County, Hydraulics.

Standard 6.8.4 Design Technical Guidelines. Channels shall be designed consistent with the guidelines provided in the Open Channels, Friction Losses in Open Channels, and Sedimentation chapters of the Hydraulics volume. Material and placement shall be designed per Maricopa Association of Governments’ Uniform Standard Specifications for Public Works Construction Specification 220 & 703.

Standard 6.8.5 Maximum channel velocities will be governed by the following tables:

Table 6.2 of the Drainage Design Manual for Maricopa County, Hydraulics
Maximum Permissible Velocities for Roadside Drainage Channels

Table 6.3 of the Drainage Design Manual for Maricopa County, Hydraulics
Maximum Permissible Velocities for Grass-Lined Roadside Channels

**Table 6.12 Criteria for Artificial Channels
Non-concrete Artificial channels**

Type of Channel Lining ⁽¹⁾	Maximum Side Slope, H:V (%)	Maximum Velocity, fps
Soil Cement	2:1 (50%)	15 ⁽²⁾
Riprap	3:1 (33%)	Varies ⁽³⁾
Grouted Riprap	2:1 (50%)	15 ⁽⁵⁾
Gabion Baskets	⁽⁶⁾	9 ⁽⁴⁾
Earth / Grass	4:1 (25%)	Varies, See DDM Hydraulics Tables 6.2, 6.3 & Figure 6.6

(1) The values in this table are for channel sections with the same lining material for bottom and sides. For conditions where the bottoms and sides of the channels are different, the most critical applicable criteria are to be used.
 (2) The minimum thickness for soil cement for bank protection is 4-ft. When 6-inch thick layer lifts are constructed on a 2:1 slope, a minimum width of 8-ft is required to achieve 4-ft thickness measured normal to the slope.
 (3) The maximum allowable velocity for riprap depends upon the size of the riprap. The riprap median size and gradations can be computed based on Chapter 6 for a design channel velocity.
 (4) Per manufacturer's specifications. It is highly recommended to review the supporting technical documents for the maximum allowable velocity specified by the manufacturer. A higher value may be used. A prior approval from an authorized agency is needed.
 (5) Per manufacturer's specifications.
Note: The criteria listed in this table are boundary values. The designer is responsible for determining the adequacy of criteria for each specific application. For design of lining materials, analyses of soil conditions and subsurface drainage may be required.

Concrete Artificial Channels

Maximum Allowable Velocity for Concrete Channel (trapezoidal or vertical)				
Clear-Water Condition or No Major Erosion/Abrasion Due to Sediment/Gravel/Cobble		Major Erosion/Abrasion Due to Sediment/Gravel/Cobble		
Bottom Slab Minimum Concrete Thickness (inches)	Side Slopes Minimum Thickness (inches)	Bottom Slab Minimum Concrete Thickness (inches)	Side Slopes Minimum Thickness (inches)	Max Allowable Velocity (ft/s)
6	6	7	7	10
8	6	9	7	15
9	7	10	8	20
10	8	11	9	25

1. A minimum 3-inch clearance from the top of concrete to the rebar placement for corrosion and abrasion protection is required for 6-inch thick bottom slab and side slope. When the required thickness for the bottom slab and side slope is more than 6 inches, the additional concrete shall be added to the water side of the bottom slab and side slope.
 2. The concrete shall be continuously reinforced and the reinforcement requirements in ADOT (1989) shall be

- followed.
3. The trapezoidal concrete channel side slope shall not be steeper than H:V = 1.5:1. When a steeper or vertical concrete channel is used, additional design requirements for retaining walls shall be followed based on ADOT (1989).
 4. The designer is responsible for determining the adequacy of criteria for each specific application. For design of lining materials, analyses of soil conditions and subsurface drainage may be required.
 5. The above criteria were developed based on ADOT (1989) and USACE (2007).

Other types of artificial channel linings from commercial vendors can be submitted with the technical specifications, testing result, installation procedures and previous project references to the District for consideration. The consideration shall be reviewed by a group of District employees that are from various branches and can include employees from MCDOT.

Standard 6.8.6 Curved Channel Radius Requirement. For channels with Froude Numbers less than 0.86, the ratio of the channel radius, r_c , (at the centerline) to the design width of the water surface shall be greater than 3.0.

For channels with Froude Numbers greater than or equal 1.2 and less than 2.0, the minimum radius of curvature should be computed using Equation (6.3).

$$r_{sc} = C \left(\frac{V^2 W}{0.5g} \right)$$

where:

- r_{sc} = minimum radius of channel centerline curvature in ft.,
- C = coefficient, Where C = 1
- V = mean channel velocity in ft/s,
- W = channel width at elevation of centerline water surface in feet, and
- g = acceleration due to gravity in ft/s².

Equation (6.3) incorporates an allowance for superelevation and standing waves for supercritical flow in rectangular and trapezoidal channels with rigid lining and using a simple circular curve to define channel horizontal alignment transitions. For these conditions, use a value of C equal to one. If the total rise in water surface (superelevation plus surface disturbances) is less than 0.5 feet, the normally determined channel freeboard from Equation 6.4 is adequate. If the total rise is greater than or equal to 0.5, that depth shall be added to the freeboard from Equation 6.4. Equation (6.3) is derived from Section 2-5 of USACE (1994).

For curved channels with $0.86 < F < 1.2$ the greater of 3 times the design width and equation 6.3 shall be used as the minimum radius of channel centerline curvature. Extra care shall be taken in the design of bank protection on both the inside and outside of curves, using estimates of maximum velocity and considering eddies. The guidance in Chapters 8 and 11 of the Hydraulics volume shall be carefully followed and applied.

Standard 6.8.7 Freeboard Requirements.

1. Required freeboard is computed according to the following formula:

$$FB = 0.25 \left(Y + \frac{V^2}{2g} \right)$$

where:

FB = freeboard in feet,

Y = depth of flow in feet,

V = velocity of flow in ft/s; and

g = acceleration due to gravity in ft/s².

In all instances, the freeboard required is additive to any increases in water surface due to superelevation or channel curvature

2. The minimum freeboard value for rigid channels shall be 1 foot for subcritical and 2 feet for supercritical flows. The minimum freeboard value for curved rigid channels shall be 1.5 feet for subcritical and 2.5 feet for supercritical flows. If the minimum channel radius requirements of Standard 6.8.6 are to be reduced as a part of a more detailed design, the freeboard requirements are to be added to the superelevated water surface elevation at channel bends for both subcritical and supercritical flow conditions, as computed using guidance in Sections 2-5 and 2-6 of USACE (1994). Using a smaller freeboard in specific cases requires prior approval by County/Community. Freeboard exceeding the minimum standard is strongly recommended.
3. For sand-bed channels, when the Froude Number is equal to or larger than 0.7, the freeboard shall be the larger value of $0.027V^2$ or $0.25(y+V^2/(2g))$ where V is the channel velocity and y is the flow depth.
4. Levees are only allowed to be used in a governmental agency project. The uses of levees are strongly discouraged. If used, levees must meet FEMA and USACE freeboard requirements as a minimum.
5. In all FEMA jurisdictional floodplains, the greater of the above equation or FEMA's freeboard requirement shall prevail for design use.
6. Every constructed channel that is capable of supporting vegetation growth is to be designed for an appropriate range of n-values in conjunction with an approved vegetation maintenance plan. The procedures in Chapter 7, Friction Losses in Open Channels, of the Hydraulics volume shall be followed. The maintenance plan shall include an agreement, approved by the County/Community/District, for perpetual maintenance of the channel. If this is not feasible, then additional freeboard shall be required. For this case, standard freeboard requirements shall be added to the water surface elevation for the design storm hydraulics computed using the expected worst-case roughness condition assuming no on-going maintenance of vegetation.

Standard 6.8.8 Minimum Easement Width Requirement for Constructed Channels. A dedicated right-of-way, or privately owned drainage tract shall be a minimum of the top width of an appropriately sized open channel plus 2 feet contiguous on both sides. If vehicular maintenance access is not provided within the channel bottom, add 16 feet of width to the top on one side.

Standard 6.8.9 Minimum Landscape and Maintenance Guidelines. Landscaping and revegetation must not impede access for maintenance. The vegetation must comply with the design intent of the channel in terms of conveyance and freeboard. Landscaped channels must be designed using minimum and maximum expected n-values for the interval between

maintenance operations, with minimum freeboard as specified above. Landscape and maintenance considerations should be accommodated and designed in conjunction with overall project design.

Additional standards pertaining to open channels are listed in Section 6.2, Safety.

6.9 HYDRAULIC STRUCTURES

The following minimum standards will be utilized in the design of hydraulic structures:

Standard 6.9.1 Construction Plans. Construction plans for hydraulic structure drainage improvements are to meet the requirements of Section 6.16.

Standard 6.9.2 Trash Rack Clogging Factor Requirement. A minimum clogging factor of 50 percent shall be used in the hydraulic analysis of all trash racks. A clogging factor of 100 percent shall be used in the structural analysis of all trash racks.

Standard 6.9.3 Drop Structure Requirements.

1. Hydraulic jump analyses shall be conducted for the 2-, 10-, and-100-year peak discharges, since flow characteristics at the drop vary with discharge. These analyses are to be used to support the design of the structure and erosion control measures.
2. Drop structures having loose riprap on a sloping face are discouraged for private development and within District right-of-way due to a high failure rate and excessive maintenance costs.
3. Open channels are recommended in lieu of pipes for conveyance of low flows through drop structures. Pipes may plug or frequently overtop, leading to additional maintenance problems. Pipes, if approved for conveying low flows through drop structures, should be no smaller than 24 inches in diameter.

Standard 6.9.4 Aesthetic Treatment Requirement. For District projects where hydraulic structures are located within or adjacent to undisturbed or naturalistic drainage ways, the structures should mimic natural features in design. If space limits opportunities to include mimicked natural features, built structures should have aesthetic treatments applied to match the surroundings. Trash racks should be painted, stained, or colored in some manner to match the surrounding color of the adjacent structural features, as intended to match the surrounding native soil and landscape character of the area.

Standard 6.9.5 Levees. The use of levees, are only allowed to be used in a governmental agency project. The uses of levees are strongly discouraged and must be approved in concept by County/Community/District prior to beginning design. If used, levees shall be designed to meet as a minimum FEMA and USACE requirements for certification by both agencies.

Additional standards pertaining to hydraulic structures are listed in Section 6.2, Public Safety.

6.10 STORMWATER STORAGE

The analysis and design of stormwater storage facilities shall be to the following minimum standards:

Standard 6.10.1 Construction Plans. Construction plans for stormwater storage drainage improvements are to meet the requirements of Section 6.16 and the DDM (all three volumes).

Standard 6.10.2 Minimum Design Storm. All new developments, regardless of lot size, shall make provisions to retain the stormwater runoff from a 100-year, 2-hour duration storm falling within its boundaries. On-lot retention is permitted (but not encouraged) only if the lots are greater than one (1) acre in gross area. On-lot retention is not permitted for lots less than one (1) acre in gross area. Residential lots not in a subdivision are not required to retain stormwater. Water harvesting by individual lot owners is allowed, this is not to be use as part of the required retention volume for the subdivision or development.

Standard 6.10.3 Sediment Storage Requirement for Offsite Flows. Sedimentation basins, which may be required, are to be located at the upstream (inlet) portions of stormwater storage facilities. The sediment settling basins shall be easily accessible by maintenance equipment (such as backhoes) and should have a minimum storage volume equal to 100-year flood event sediment yield plus n times the annual sediment yield where n is the maintenance interval in year in addition to the designed stormwater runoff volume required for the stormwater retention basin. The annual sediment yield and the 100-year event sediment yield can be estimated based on FCDMC (2018).

Standard 6.10.4 Detention Basin Requirements. The use of a detention basin in lieu of a retention basin is not allowed without an approved variance in accordance with the Drainage Regulations or Drainage Provisions. In the special case when a variance from the requirement to retain the 100-year 2-hour runoff volume is approved, the stormwater quality requirements must still be met. In addition, post-development peak discharges may not exceed pre-development peak discharges for the 2-, 10-, 50-, and 100-year storm events for the design of detention basins. First flush water quality criteria per Policy 3.6.6 requirements must be met. Possible special cases where detention basins may be considered are as follows:

1. A major drainageway or watercourse is available to accept runoff from the subject site that has sufficient hydraulic capacity to safely convey the 100-year pre-development peak discharge. To be approved: 1) watershed timing issues must be studied and determined to not be an issue for downstream properties, 2) system sediment balance must not be significantly affected, and 3) cumulative impacts of applying such a policy throughout the watershed must not be detrimental to public safety or property.
2. Riparian vegetation in a downstream watercourse would be adversely affected by application of the retention basin policy.

Standard 6.10.5 Retention Volume Calculations. Retention basin volume calculation shall be by the following equation:

$$V = C \left(\frac{P}{12} \right) A \quad (6.5)$$

where:

- V = calculated volume in acre-feet,
- C = Runoff coefficient (see Section 6.3.2, & for subdivisions see Section 6.10.5.1),
- P = 100-year, 2-hour rainfall depth in inches; and
- A = drainage area in acres.

1. Method of Calculating Runoff Coefficients for Subdivisions

a. Run-Off Coefficient for Building Lots

1. Maricopa County has adopted a standardized list of runoff Rational Method coefficients for zoning classifications which are contained in [Table 6.3](#). These values may be used to determine the required retention volume for a subdivision or other development.
2. Applicants also have the option of determining run-off coefficient for building lots which shall be weighted runoff coefficients based on the zoning classification. The runoff coefficients shall be developed based on the maximum lot coverage for the zoning classification and a standardized percentage of impervious area for the lots; with the remaining area calculated as open space.

Equation 6.5a shall be used to calculate the runoff coefficient for subdivisions.

$$a. CL = [(((R*L)*1.5)*.95) + ((L - ((R*L)*1.5))*0.5)] / L \quad (6.5a)$$

CL = Composite C Value for a Lot

L = Minimum Lot Area

R = Maximum Lot Coverage

b. Composite C Values - Subdivisions

The default runoff coefficient values from Table 6.3 will be used for open space and roads/right-of-ways. The engineer can calculate the total amount of area for each land use based platted boundaries and apply the land use code for each area. Drainage tracts for subdivisions will use the runoff coefficient for Class 700 - General Open Space (0.50) regardless of ground cover. Roadway right-of-ways will use the runoff coefficient for Class 600 - General Transportation (0.95).

A sample calculation for a subdivision's composite C Value is as follows:

SAMPLE SUBDIVISION

A 250 lot subdivision is zoned R1-6 and contains a gross area of 70 acres, of which 45 acres are residential lots, 10 acres are right of way, and 15 acres are open space/landscaping/drainage tracts (i.e. retention basins).
(250 lots/45ac=5.5DU per acre use .84)

Lots 45 ac X .84 = 37.8 Right of Way 10 ac X .95 = 9.5

Open Space 15 ac X .50 = 7.5

$$C_{\text{Subdivision}} = (37.8 + 9.5 + 7.5) / 70 = 0.78$$

The composite runoff coefficient (C) for this subdivision is 0.78. This value shall be used to calculate the required retention volume for the subdivision.

- 2 Freeboard Requirement for Retention Basins.** Retention basins are required to provide one foot of freeboard to the top of slope or lowest adjacent gutter elevation whichever is lower.

Standard 6.10.6 Retention Basin Design Requirements.

- 1. Depth.** Stormwater retention basins should typically have a maximum water depth of 3 feet for the 100-year, 2-hour storm event. Deeper water depths for the design event should address safety issues. Refer to Section 6.2 and the Hydraulics volume.
- 2. Adjacent to Streets.** The required stormwater retention volume shall not intrude upon the public road right-of-way without the written approval of the governing jurisdiction. The basin side slope should not begin closer than 2 feet from back of sidewalk. If there is no sidewalk, stormwater retention shall begin no closer than 6 feet from the back of curb.
- 3. Berms.** Berms are not to be placed closer than 13 feet from the back of the curb, or 8 feet from the back of the sidewalk. Berms are not to be higher than 2-1/2 feet above grade on the downhill side. Berms higher than 2.5 feet require a maintenance agreement that is approved by County/Community/District. Berms must have a minimum top width of 8 feet. An overflow area (emergency spillway) shall be provided in accordance with Standard 6.10.14. In Special Flood Hazard Areas or Special Flood Hazard Areas shown on the Flood Management Maps for Maricopa County, the high water level for the 100-year event shall be below the adjoining ground to avoid a levee like structure.
- 4. Side Slopes.** Side slopes of stormwater retention facilities are to be no steeper than 4:1 unless prior approval is received for a steeper slope, considering safety issues and erosion control. Stormwater retention basin sides, edges, or top of slopes should be of irregular geometry.
- 5. Revegetation.** Basins should incorporate native materials (including native stone and boulders) and be revegetated in a manner consistent with: the engineering intent of the facility, the desired community and landscape character, and the proposed level of maintenance appropriate for the facilities as designed.

Standard 6.10.7 Within Parking Lots. The maximum depth of ponded water within any public parking lot location shall be 1 foot. Parking lot retention areas shall not be adjacent to buildings and not be sited in travel lanes. No more than 25% of the parking lot area may be used for stormwater storage. The minimum longitudinal slope permitted within parking lot storage facilities is 0.005 ft/ft, unless concrete valley gutters are provided. With concrete valley gutters, a minimum longitudinal slope of 0.002 ft/ft may be permitted.

Standard 6.10.8 Rooftop Storage. Rooftop storage is allowed, subject to all other applicable County/Community Building Code requirements.

Standard 6.10.9 Underground Storage. Underground storage is allowed. It shall meet the requirements of Standard 6.10.10. Underground storage retention facilities shall be designed for

a minimum service life of 75 years and address the design concerns soil corrosivity, maintenance access, and long-term maintenance responsibility.

Standard 6.10.10 Stormwater Storage Basin Drain Time Requirement. Stormwater storage facilities shall be designed to completely drain within 36-hours after the runoff event has ended. The purpose for the 36-hour drain time is vector control and to allow for the probability of a second severe storm following the previous storm. The preferred method for draining retention basins is by infiltration/percolation. The next preferred method is the use of dry wells, or a combination of infiltration and dry wells. These options shall be used unless one or both are not possible due to geologic constraints and/or aquifer protection or groundwater quality permitting issues. If the use of infiltration/percolation and/or dry wells is not possible, then disposal options include pumping to an approved facility or gravity bleed-off to the existing surface drainage system. Where bleed-off pipes are used as the primary means of draining a retention-type stormwater storage basin, the outlet pipe shall be designed to drain the 100-year 2-hour (design) stormwater storage volume within 36 hours, but in no less than 24 hours. As a part of the design of the bleed-off system, the design engineer shall evaluate and demonstrate that the bleed-off discharge does not adversely affect downstream peak discharges or District's/Communities' structures. Retention systems using a bleed-off method shall meet the first flush requirements of Policy 3.6.6. The minimum allowable pipe size for primary outlet structures is 18-inches in diameter. The proposed diameter of a basin drain pipe should be rounded up to the nearest standard size made by pipe manufacturers. The bleed-off flow rate will typically be much less than the capacity of an 18-inch diameter pipe. Therefore, a permanently attached, hinged orifice plate shall be used to limit the discharge flow rate in conformance with Figure 9.5 of the Hydraulics volume. Bleed-off time shall be calculated by the Modified Puls storage routing method. Refer to the Hydraulics manual for example computations.

The required basin drain time may be extended, with prior approval by the County/Community/District, for major storage basins (> 50 acre-feet). Vector control provisions will be one of the requirements for approval of an extended drain time.

Standard 6.10.11 NPDES Requirement. Discharges from stormwater facilities must be in compliance with 40 CFR 122, the National Pollution Discharge Elimination System (NPDES), and the AZPDES.

Standard 6.10.12 Percolation Test Requirement for Retention Basins. To obtain the percolation rates for use in the design of the stormwater storage facility; the field investigations shall be performed and it shall include soil borings and percolation tests taken at the bottom of the proposed basin. The standard procedure to be used is ASTM D 3385-03, Double Ring Infiltrometer. If the soils present are outside the accepted range for application of ASTM D 3385-03, then the use of drywells or shallow retention basins is recommended. Soils outside the acceptable range for ASTM D3385-03 are typically very pervious or very impervious with a saturated hydraulic conductivity greater than about 14 inches/hour or less than about 0.0014 inches/hour. Very impervious soils that are outside the range of applicability for ASTM D3385-03 are not suitable for stormwater percolation disposal system applications. Dry wells may be a better choice for these conditions. If there is a question regarding the applicability of this method for the soils at a particular site, ASTM D 3385-03 should be applied and the results checked against the acceptable range of values of hydrologic conductivity. ASTM D 3385-03 may also not be applicable for dry or stiff soils that will fracture when the rings are installed, or gravels that do not allow penetration by the rings. The EPA Method may be used to test soils that are unsuitable for the ASTM D 3385-03 test method with prior approval by the County/Community/District.

Number of Tests (each test includes one soil log hole and one percolation test):

- i. A minimum of two (2) tests are required per retention basin.
- ii. Each soil log boring hole shall extend at least 10-feet below the bottom of the proposed basin. A soil horizon log shall be prepared for each boring to obtain the approximate soil texture of each soil layer (horizon) observed and to identify soil horizons that may impede percolation.

Additional tests shall be performed based on proposed basin floor percolation area as set forth in Table 6.13:

Table 6.13 Minimum Quantity of Soil Log Hole/Percolation Tests Required

Retention Basin Bottom Area, sf	Minimum Number of Tests Required
<10,000	2
≥10,000 and <20,000	3
≥20,000 and <30,000	4
≥30,000 and ≤43,560	5
>43,560	A minimum of 5. Additional percolation tests may be required if the soil borings indicate variation in soil texture within the proposed percolation area.
The tests should be distributed evenly throughout the retention basin using engineering judgment. For example, when 5 tests are required, the typical distribution assuming a square basin would be a test in each corner and one in the middle.	

Field percolation test values should be reduced by a safety factor when designing any percolation facility (Stahre and Urbonas, 1990). This is necessary because soils will tend to clog with time, which has proven to be a significant cause for basin failure to drain within 36-hours in Maricopa County. The design factors for the ASTM method are de-rating safety factors. The design factor to be applied shall be selected from [Table 6.14](#) for the subsurface conditions identified by the soil boring holes. The measured percolation rate shall then be adjusted for design purposes using equation (6.6). The tests shall be performed by a testing laboratory, and the results sealed by a civil engineer, licensed to practice in the State of Arizona. Stormwater disposal by percolation is not allowable if the percolation rate, after application of the design factor, is less than 0.5 inches per hour. Stormwater disposal by percolation is not allowable if groundwater or an impermeable layer is encountered within 4-feet below the bottom of the basin.

$$P_d = P(D_r)$$

where:

- Pd = Design percolation rate, in inches/hour,
- P = Lowest measured percolation rate, in inches/hour, and
- Dr = Design factor from Table 6-16.

Basin drain time is estimated by using equation (6.7).

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$$T_d = \frac{V}{A_p \frac{P_d}{12}}$$

where:

T _d	=	Retention basin drain time in hours,
A _p	=	Percolation area (basin bottom), in acres
P _d	=	Design percolation rate, in inches/hour, and
V	=	Retention basin design storage volume, in acre-feet.

Only the bottom area of the retention basin may be used for computing the basin drain time by infiltration/percolation. The side slope areas shall not be used in the drain time computation unless the basin configuration is “V” shaped without a flat bottom. For a “V” shaped basin without a flat bottom, the bottom area available for percolation shall be computed using equation (6.8).

$$A_p = \frac{(D/3) * (SS_L + SS_R) * L}{43,560}$$

where:

A _p	=	Percolation area (approximate), in acres,
D	=	Design ponding depth, in feet,
SSL	=	Left Basin side slope, in feet horizontal/foot vertical,
SSR	=	Right Basin side slope, in feet horizontal/foot vertical, and
L	=	Length of retention basin, in feet.

Table 6.14 Percolation Design Factors for Retention Basin Design

Condition	ASTM Method Design Factors
(1)	(2)
No groundwater or impermeable layer is encountered within 10-feet below the bottom of the basin, and the soils are of similar texture to those where the percolation test is taken. The geotechnical engineer may specify a higher de-rating factor based on analysis of the soil conditions below the basin bottom.	0.500
Groundwater or an impermeable layer is encountered within 4-feet to 10-feet below the bottom of the basin.	0.250

EPA Method: EPA Falling Head Percolation Test Procedure from Design Manual - Onsite Wastewater Treatment and Disposal Systems (EPA, 1980). An adaptation of this procedure is outlined in [Table 6.15](#). The EPA Method may be used to test soils that are unsuitable for the ASTM D 3385-03 test method. Use of this method requires prior approval by County/Community/District. The following information shall be provided to document the procedures followed and the results obtained:

1. Photographs of the test holes prior to testing that clearly show the excavated hole prior to adding gravel and after gravel is added. A measurement staff must be standing in the test hole and be clearly visible and the depth scale legible so the depth to the bottom of the excavated hole before and after the addition of gravel can be verified. A photograph documenting the diameter of the test hole shall also be provided.
2. A table documenting the duration of the pre-soaking of each test hole and every testing measurement made for determination of the percolation rate.
3. The calculations for determining the design percolation rate, including application of the design factor.

The EPA Method may be applied using a 12-inch diameter bore hole where it is not practical to excavate a pit for performing the test. The same procedures shall be applied as set forth in [Table 6.15](#), except that measurements shall be taken with a water level sounder with a measuring tape that meets or exceeds federal specification US GGG-T-106E, with a vertical accuracy of at least 0.008%. The measuring tape shall be able to be accurately read to 0.01 foot. In the event the bore hole is unstable a pit shall be excavated to facilitate use of the ASTM Method or the EPA Method.

Use of the EPA Method requires application of a design factor. The design factors for the EPA Method includes a de-rating factor and negation of sidewall percolation using a sidewall correction factor. The EPA Method design factor is the product of the sidewall correction factor and the de-rating factor. Refer to [Table 6.16](#).

Table 6.15 Falling Head Percolation Test Procedure

Step	Description
Number and Location of Tests	A minimum of two percolation tests shall be performed within the bottom area proposed for the stormwater storage basin. Test holes are to be spaced uniformly throughout the area proposed for percolation, as defined in Table 6.13 . If soil conditions are highly variable, more tests will be required with quantity and location based on engineering judgment.
Preparation of Test Hole	The diameter of each test hole are to be a uniform dimension of 12 inches, dug or bored to the proposed depth of the absorption system or to the most limiting soil horizon. To expose a natural soil surface, the sides of the hole are to be scratched with a sharp pointed instrument and the loose material removed from the bottom of the test hole. Two inches of 1/2 to 3/4 inch gravel are to be placed in the hole to protect the bottom from scouring action when the water is added. Each test hole shall have a total minimum depth of 14-inches below the proposed bottom of the basin.
Soaking Period	The hole is to be carefully filled to a depth of 12 inches water (above the gravel) with clear water. This depth of water shall be maintained for at least 4 hours and preferably overnight if clay soils are present. A funnel with an attached hose or similar device may be used to prevent water from washing down the sides of the hole. Automatic siphons or float valves may be employed to automatically maintain the water level during the soaking period. It is extremely important that the soil be allowed to soak for a sufficiently long period of time to allow the soil to swell to obtain accurate results. In sandy soils with little or no clay, soaking is not necessary. If, after filling the hole twice with 12 inches of water, the water seeps completely away in less than ten minutes, the test can proceed immediately.
Measurement of the Percolation Rate	<p>Except for sandy soils, percolation rate measurements should be made 15 hours but no more than 30 hours after the soaking period begins. Any soil that sloughed into the hole during the soaking period is to be removed and the water level adjusted to 6 inches above the gravel (or 8 inches above the bottom of the hole). At no time during the test should the water level be allowed to rise more than 6 inches above the gravel.</p> <p>Immediately after adjusting the depth to 6-inches, the water level is to be measured from a fixed reference point to the nearest 1/16 inch at 30 minute intervals. The test shall be continued until two successive water level drops do not vary by more than 1/16 inch. At least three measurements are to be made.</p> <p>After each measurement, the water level is to be readjusted to the 6 inch level. The last water level drop shall be used to calculate the percolation rate. In sandy soils or soils in which the first 6 inches of water added after the soaking period seeps away in less than 30 minutes, water level measurements are to be made at 10 minute intervals for a 1 hour period. The last water level drop shall be used to calculate the percolation rate.</p>

Step	Description
Calculation of the Percolation Rate	<p>The percolation rate is calculated for each test hole by dividing the magnitude of the last water level drop by the time interval used between measurements. The percolation calculation results should be in terms of inches per hour (in/hr).</p> <p>Example: If the last measured drop in water level after 30 minutes is 5/8 inch, the percolation rate = (5/8 in) / (0.5 hrs.) = 1.25 in/hr</p> <p>To determine the percolation rate for the area, the lowest rate obtained from all tests in the basin shall be selected.</p>

Table 6.16 Percolation Design Factors for the EPA Method

Condition	EPA Method Design Factors		
	Sidewall Correction Factor	De-rating Factor	Design Factor (2)*(3)
(1)	(2)	(3)	(4)
No groundwater or impermeable layer is encountered within 10-feet below the bottom of the basin, and the soils are of similar texture to those where the percolation test is taken. The geotechnical engineer may specify a higher de-rating factor based on analysis of the soil conditions below the basin bottom.	0.333	0.500	0.167
Groundwater or an impermeable layer is encountered within 4-feet to 10-feet below the bottom of the basin.	0.333	0.250	0.083

Standard 6.10.13 Drywells. Drywells shall be designed, operated, and maintained in conformance with the most current ADEQ guidelines. EPA (1980) procedures may be used for estimating initial design percolation rates. The final design rate shall be based on a constant-head percolation test performed on each completed well at the site. The test results for each well shall be de-rated (divided by a de-rating factor) based on the in-situ soil conditions. A de-rating factor of 2 shall be applied for coarse-grained soils (cobbles, gravels and sands). A de-rating factor of 3 shall be applied for fine grained soils (silts and loams). A de-rating factor of 5 shall be applied for clay soils. These de-rating factors are required to compensate for deterioration of the percolation capacity over time in addition to providing a factor of safety for silting and grate obstruction. The accepted design disposal rate for a dry well, after application of the de-rating factor, shall not be less than 0.1 cfs per well. The maximum allowable rate, after application of the de-rating factor, shall not exceed 0.5 cfs per drywell in any case for design purposes. It shall be the owner's, or owner's representatives', responsibility to clean and maintain each dry well to ensure that each remains in proper working order. Under no condition shall the regular maintenance schedule exceed 3-years. Drywells that cease to drain a retention basin with 36-hours shall be replaced or refurbished by the owner or his representative. Maintenance requirements shall be written in the CC&R's for subdivisions where dry wells are used to drain

retention basins. In accordance with ADEQ requirements, the installation of any subsurface drainage structure must be located into a permeable porous strata at least 10-feet above saturated soils and 100-feet away from any water supply well.

Standard 6.10.14 Emergency Spillway Requirement.

1. Emergency spillways shall be provided for all stormwater storage basins. For basins with all the design storage volume situated below existing grade (i.e. without a berm/dam), the spillway may be nothing more than grading to ensure that basin overflows will follow the downstream predevelopment drainage pattern in a safe manner. Refer to Section 3.4.
2. Emergency spillways must be designed to safely convey the peak discharge from the storm listed in Table 6.17 Emergency Spillway Design Capacity Requirements, exclusive of the attenuation effects of the basin.

Table 6.17 Emergency Spillway Design Capacity Requirements

For an Embankment Berm/Dam that is not Regulated by ADWR	
Berm/Dam Height	Spillway Design Capacity
H < 6 ft.	Unattenuated 100-year inflow
6 ft. <= H < 25 ft.	½ Probable Maximum Flood

where:

Berm/Dam height is the vertical distance from the lowest point along the downstream slope to the crest of the emergency spillway.

100-year inflow is the unattenuated peak discharge from the pre- or post-development 100-year 6-hour or 24-hour storm, whichever is larger.

Refer to Section 4.7 for information regarding dams regulated by ADWR.

3. Emergency spillways shall be designed to convey the design peak discharge and provide erosion protection in accordance with the Hydraulics volume.
4. Down-gradient properties are to be protected from flow depths and velocities in excess of pre-development conditions.
5. A 1 foot minimum freeboard is required between the berm crest and the water surface elevation of the 100-year peak discharge in the emergency spillway (without attenuation from basin storage), except where the berm crest is designed to function as the emergency spillway.
6. The finished floor elevation of adjacent structures must be at least 1.0 feet above the 100-year peak water surface elevation of the flow passing through the emergency spillway.

Standard 6.10.15 Landscaping. Proposed landscaping is to be approved for the stormwater storage area prior to the issuance of a grading permit. The landscaping design should support County-wide water conservation efforts by utilizing xeriscaping concepts with low-water, desert-tolerant plant materials in conjunction with rainwater harvesting and stormwater reuse features, when possible to reduce potable water use for outdoor irrigation. Designs should allow for access by commonly used maintenance equipment. Landscaping components should not adversely affect the basin hydrologic and hydraulics functions, while integrating local landscape and community desired character and potential water conservation and multiple-use opportunities. Stormwater storage basins are to be privately maintained and located within a designated drainage tract.

Additional standards pertaining to stormwater storage are listed in Section 6.2, Public Safety.

6.11 PUMP STATIONS¹

Standard 6.11.1 Construction Plans. Construction plans for pump station drainage improvements are to meet the requirements of Section 6.16.

Standard 6.11.2 Stormwater Quality Requirement. The requirements of Section 6.4 will be met for stormwater discharge from pump stations.

Standard 6.11.3 Pump Capacity. Pump capacity shall be sufficient to empty the facility within 36 hours. The requirements of Standard 6.10.10 shall be met.

Standard 6.11.4 Clean Water Act. Pump discharges must conform to the requirements of the Clean Water Act or other applicable federal, state and local laws or regulations if discharging into a Water of the U.S., a tributary to Waters of the U.S., or into a District or County/Community-owned structure.

¹Allowable use only for Public project.

6.12 SEDIMENTATION

Recognizing that sedimentation and sediment transport is either supply or transport control driven (see the Hydraulics volume, Chapter 11, Sedimentation) and that stormwater runoff may produce sedimentation or erosion, the following minimum standards are to be applied.

Standard 6.12.1 Construction Plans. Construction plans for scour and erosion protection drainage improvements are to meet the requirements of Section 6.16.

Standard 6.12.2 Culvert and Bridge Design Requirements. For arterial, collector, and all-weather access streets crossing a distributary flow area or alluvial fan, the following minimum standards shall apply for the design of culverts or bridges:

1. Culverts shall be box culverts, a minimum of 4 feet high (5 feet high is preferred), set to equilibrium grade (inverts may be buried a maximum of 6-inches for sediment continuity, but the minimum clear opening above the channel invert shall be a minimum of 4 feet) . Culverts shall be sized so that the sediment transport capacity of flow does not vary more than 5% from the existing condition.

2. Policy 3.9.7, the requirements of [Table 6.7](#) and Section 6.7 also apply.

6.13 NUMERICAL MODELS

This section provides a list of models that meet FCDMC minimum requirements for flood hazard identification activities, drainage design, assessment of hydraulic structures, or storm drain design and modeling. They are organized by category with possible limitations noted. Other models may be used on a case by case basis with prior written approval by FCDMC. Approval requirements may depend on the availability of the model to FCDMC staff and the ability of FCDMC staff to review model results, and applicability of the model for the intended application.

6.13.1 Hydrology

6.13.1.1 One dimensional (1D) Modeling

Watersheds that exhibit 1D characteristics such as tributary systems without significant distributary channel systems or large areas of sheet flow may be modeled using 1D hydrologic models as follows:

1. Nationally accepted models that meet National Flood Insurance Program (NFIP) requirements for flood hazard mapping activities as set forth on the FEMA web site:

<http://www.fema.gov/>

2. US Army Corps of Engineers (USACE) HEC-1 *Flood Hydrograph Package*, Version 4.1 Stipulations:
 - Version 4.1 is the preferred version for new studies. Prior versions may be used for consistency with older models with prior written approval by FCDMC.
 - HEC-1 is preferred to be applied using the FCDMC *Drainage Design Management System for Windows* (DDMSW) software available from the FCDMC web site. HEC-1 is installed as a part of this software package. <http://www.fcd.maricopa.gov>
 - Apply using the methodology set forth in the Drainage Design Manual for Maricopa County – Hydrology (DDM Hydrology).
3. Rational Method (DDMSW). Apply using the methodology set forth in the DDM Hydrology.

6.13.1.2 Two dimensional (2D) Modeling

Watersheds that exhibit 1D and 2D characteristics such as tributary systems, distributary systems, and/or large areas of sheet flow may be modeled using 2D hydrologic models as follows:

1. FLO-2D 2009.06 and FLO-2D Pro, all builds. Reference the FCDMC *FLO-2D Verification Report*, May 2016, for an assessment of model capabilities and application recommendations. Extreme care should be taken when applying this method because

FLO-2D computes both rainfall loss and transmission loss. The transmission loss component can easily be overestimated.

6.13.2 Hydraulics

6.13.2.1 1D Modeling

The most current version of the following models are preferred, older models may be used with prior approval. The following are 1D models accepted as meeting the minimum requirements of the FCDMC for the identified purposes:

1. Nationally accepted models that meet National Flood Insurance Program (NFIP) requirements for flood hazard mapping activities as set forth on the FEMA web site: <http://www.fema.gov>
2. USAACE HEC-RAS *River Analysis System*, all 1D versions. Acceptable for floodplain and floodway delineations, culvert and bridge modelling, side weir and levee analyses and simple flow split modeling.
3. Federal Highway Administration HY-8 *Culvert Analysis Program*. Acceptable for culvert analysis and design when normal depth tailwater, and no external inflows affecting tailwater, can be assumed.
4. USACE HEC-2 *Water Surface Profiles*. Acceptable for use with legacy models, particularly when reproducing a legacy model for update to HEC-RAS. May also be appropriate for bridge analyses.
5. USACE HEC-6 *Scour and Deposition in Rivers and Reservoirs*. Acceptable for sediment transport modeling as set forth in the *Drainage Design Manual for Maricopa County – Hydraulics* (DDM Hydraulics) chapter 11, Sedimentation.
6. MBH software, Inc. HEC-6T *Sedimentation in Stream Networks*. Acceptable for sediment transport modeling as set forth in the *Drainage Design Manual for Maricopa County – Hydraulics* (DDM Hydraulics) chapter 11, Sedimentation.
7. EPA-SWMM. Acceptable for storm drain system modeling.

6.13.2.2 2D Modeling

The following are 2D models accepted as meeting the minimum requirements of the FCDMC for the identified purposes:

1. FLO-2D Software, Inc, FLO-2D. Reference the FCDMC *FLO-2D Verification Report*, May 2016, for an assessment of model capabilities and application recommendations. This software should not be exclusively applied to a river system where a FEMA floodway is to be defined. The following are approvals by build:
 - a) Version 2009.06. Hydraulic structures are to only be modeled using the rating table or rating curve methods. The 1D channel component may be applied but care should be exercised in properly setting up the transitions between floodplain grids and the

- beginning and end of each 1D channel segment. In Addition, very wide cross sections may result in isolated grid elements within the channel not being excluded from the mode.
- b) FLO-2D Pro build 12.10.02 through 15.07.12. Hydraulic structures are to only be modeled using the rating table or rating curve methods. The 1D channel component may be applied but care should be exercised in properly setting up the transitions between floodplain grids and the beginning and end of each 1D channel segment. In Addition, very wide cross sections may result in isolated grid elements within the channel not being excluded from the model. The SWMM storm drain component was under development for these builds. Models using the storm drain component should be based on build 15.10.13 for final results.
 - c) FLO-2D Pro Build 15.10.13 and Newer. Hydraulic structures may be modeled using the rating table, rating curve, or general equations methods. The 1D channel component may be applied but care should be exercised in properly setting up the transitions between floodplain grids and the beginning and end of each 1D channel reach. Application of the SWMM storm drain component is allowed.
 - d) Future Program Releases. Program releases after build 15.10.13 must receive prior approval by the FCDMC Engineering Division before application on FCDMC projects or for modeling that will require FCDMC approval.
2. USAACE HEC-RAS River Analysis System, version 5.0.3 or latest version.
 3. Other industry-common 2D software may be used with justification provided by the engineer of record that the software is appropriate for the use. This may include FEMA-approval and/or documentation illustrating that the software is appropriate to use in the given situation.

6.14 HYDROLOGY AND HYDRAULICS REPORTS (Non-FIS)

6.14.1 Report Organization

Hydrology and hydraulics reports for purposes other than flood insurance studies should, as a minimum, include the following information:

Documentation for new and revised hydrology and hydraulic models.

Design assumptions and parameters for each drainage system component.

Source and date of topographic data, including the control used for the DTM, as well as the vertical and horizontal datum used.

Minimum building pad and finished floor elevations for areas within floodplains and backwater ponding from structures or roadway embankments.

Retention basin design parameters and rating curves.

If a variance from stormwater retention criteria is being requested, a Stormwater Quality Plan documenting permanent stormwater quality features including First Flush provisions shall be

provided in addition to documentation addressing the variance requirements in the Drainage Regulation.

It is also recommended that a Stormwater Pollution Prevention Plan (SWPPP), as filed with ADEQ, documenting recommended BMP's and recommended BMP locations for the various phases of the construction process, be included as a part of the Final Drainage Design Report.

The Table of Contents must be sealed by a Civil Engineer licensed to practice in the State of Arizona. The Final Drainage Report should be organized to include sections as follows (as a minimum):

TABLE OF CONTENTS

1.0	Completed Hydrology and Hydraulics Report General Checklist
2.0	Introduction/Purpose
3.0	Location
4.0	Site Description and Proposed Development
5.0	FEMA Floodplain Classification
6.0	Off-site Drainage Description
6.1	Background
6.2	Proposed Offsite Flow Management
7.0	On-site Drainage Design Description
8.0	Hydrology (similar to ADWR SS 1)
8.1	Methodology
8.2	Parameters
8.3	Results
8.4	Confidence Checks and Sensitivity Analyses
9.0	Hydraulics (similar to ADWR SS 1)
9.1	Methodology
9.2	Parameters
9.3	Results
9.4	Confidence Checks and Sensitivity Analysis
10.0	Stormwater Retention and First Flush Requirements
11.0	Minimum Finished Floor Elevation Requirements
12.0	Stormwater Pollution Prevention Plan (SWPPP)
13.0	Sedimentation and Erosion Hazards Discussion
14.0	Stormwater Permits Requirements (401/404, Floodplain, Right-of-Way, Stormwater Quality, and other permit requirements)
15.0	Conclusions and Recommendations
16.0	References

FIGURES

Figure 1	Area Location Map
Figure 2	Site Aerial Photo Map
Figure 3	FIRM Map
Figure 4	Off-site Watershed Map
Figure 5	On-site Watershed Map
Figure 6	On-Site Drainage and Grading Plan

APPENDICES

Appendix A	Offsite Hydrology Documentation
Appendix B	On-Site Hydrology Documentation
Appendix C	Channel Design and Floodplain Hydraulics Documentation
Appendix D	Street Capacities & Storm Drain Analysis Documentation
Appendix E	Stormwater Storage and First Flush Documentation
Appendix F	Stormwater Quality Documentation
Appendix G	Sediment and Erosion Hazard Documentation
Appendix H	Digital Data/Model Input and Output Files

6.14.2 Hydrology and Hydraulics Report Checklists

Each report should contain the applicable hydrologic and hydraulic analysis checklists shown in [APPENDIX A](#), completed as appropriate for the proposed project.

6.14.3 Additional Report Requirements

Hydrology/Hydraulic reports shall include, but not be limited to, the following items:

1. Professional engineer seal, signed and dated, on the Title page and Table of Contents.
2. A drainage map that shows the discharges at points of concentration and clearly identifies the existing drainage system. Minimum scale will be 1 inch equals 500 feet. Where drainage areas are large or otherwise inappropriate, other scales may be approved. Streets, Section corners, and other local features shall be labeled for reference.
3. Detailed street hydraulic analysis and storm drain analysis (where required).
4. Calculations for the proposed stormwater retention facilities showing storage volume required and retention volume provided, and First Flush calculations. If more than one facility is proposed, calculations must be separated for each area, and each tributary area referenced to its respective stormwater storage facility. Analysis confirming basin draining within 36 hours of the end of the design precipitation event is required.
5. If the adjacent land drains into or it is diverted around the development, then the adjacent contributory drainage area must be shown and quantified. Size of the adjacent drainage area and slope of the land information shall be shown.
6. A lined drawing of the proposed drainage system in plan view showing design flow and capacity. Location and invert elevation at the drainage outfall shall be labeled.
7. Sufficient information to determine the path of the water entering and leaving the project property under pre-development and post-development conditions. Sufficient information to show that proposed conditions do not pond water on adjacent properties or change the historical flow path and pre-development hydrologic and hydraulic characteristics of stormwater leaving the property.
8. Typical cross sections of all street classifications.

9. FEMA floodplains in and adjacent to the project area as an exhibit or figure.
10. Summary of previously prepared drainage reports pertinent to the subject area.

6.15 HYDROLOGY AND HYDRAULICS REPORTS (FIS)

6.15.1 Report Organization

Hydrology and hydraulics reports documenting floodplain delineation studies for approval by the District and/or FEMA shall be prepared in accordance with ADWR State Standard 1. The checklists 2 and 3 in [Appendix A.3](#) & [A.4](#) of this document should be used and a completed copy of both provided with the submittal. The Technical Data Notebook (TDN) prepared using ADWR State Standard 1 shall be based on the considerations listed in Technical Data Notebook Additional Requirements.

6.15.2 Technical Data Notebook Additional Requirements

Checklist 4 in [Appendix A.5](#) of this document shall be used in preparation of the TDN, and a completed copy included with the submittal.

6.16 GENERAL CONSTRUCTION DRAWING REQUIREMENTS

Standard 6.16.1 Construction Documents. Construction documents shall comply with requirements in the MCDOT Roadway Design Manual for items to be installed or constructed in public rights-of-way or easements.

Standard 6.16.2 Preparation by Licensed Professional. All plans for engineered drainage improvements shall be prepared under the direction of a Civil Engineer licensed to practice in the State of Arizona, and sealed, dated and signed by that engineer. The seal shall include the date of expiration.

Standard 6.16.3 Plan Requirements for Q100<50 cfs. Engineered drainage improvements designed for flows less than 50 cfs may be shown in plan view with spot elevations, flow direction arrows, and typical sections. The plan shall show the horizontal alignment and dimensions as well as the type and extent of the proposed work. Other elements from Standard 6.15.5 may be required.

Standard 6.16.4 Plan Requirements for Q100≥50 cfs.

1. All drainage improvement plans may be required to contain a plan and profile as well as adequate cross sections to describe geometry.
2. The profile, if required, shall show the following: proposed invert, estimated water surface profile, energy grade line, hydraulic jump location and length, original ground at channel center line, top of slope, all utilities and structure crossings, and if necessary, top of proposed embankment and fill including freeboard as required.

3. Other elements from Standard 6.15.5 may be required.

Standard 6.16.5 Plan Requirements for Q100≥500 cfs. The following are general requirements for drainage improvement plans:

1. Information to determine drainage patterns.
2. Information to determine that an adjacent property drainage pattern will not be adversely affected.
3. A HEC-RAS or otherwise approved hydraulic analysis for designed channels and existing washes shall be provided. The model characteristics and results shall be submitted in plan and profile at a scale not to exceed 1"=100'. The plan view shall show existing and proposed ground contours, depict the exact location of the beginning and end point locations of each cross section, the left and right bank station alignments, the limits of defined reaches, and 100-year floodplain limits. Profiles shall include the existing ground, design water surface, and the energy grade line. This information is to be provided with the design data sheet(s) from the hydrology/hydraulics report. The following data shall also be included in addition to the HEC-RAS standard output tables:
 - A. Delta water surface elevation change between cross sections.
 - B. Left bank freeboard.
 - C. Right bank freeboard.
 - D. Velocity distribution for each cross section.
4. Profiles of storm drains and catch basins and connector pipes shall be provided. These profiles shall show gutter elevation, top of curb elevation, catch basin type, depth, size and cross-section, connector pipe invert at the catch basin and at the inlet to the main line storm drain (as well as any grade breaks), connector pipe size and slope in ft/ft, and the location and size of existing and proposed utilities along the profile and in the vicinity of the catch basin. Each catch basin profile shall be labeled by road centerline station or main storm drain stationing if different. Profiles shall also include:
 - A. The finished street elevation over the storm drain pipe.
 - B. Both existing and proposed pipe profiles and sizes with the Hydraulic Grade Lines labeled.
 - C. The design peak discharge (cfs) in each storm drain pipe segment.
 - D. The velocity (fps) in each storm drain pipe segment Junction types and invert elevations at pipe entrances and exits
 - E. Appropriate stationing.
5. On the storm drain plan sheets, the engineer should show the rim and invert elevations at all existing sanitary sewer manholes.

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6. In plan and profile, existing and proposed underground utilities shall be labeled according to size and type. Corresponding alphanumeric labels shall be shown for each utility and depicted in the legend. If the utility is an underground conduit, give all the details such as the number of ducts and whether or not the conduit is encased in concrete. Any utilities to be constructed prior to the project shall be shown and so indicated. Conflicts between existing utilities and proposed construction are to be identified. Utilities that are abandoned or to be abandoned shall be indicated as well as those designated to be relocated or removed. The engineer shall contact the appropriate utility if any questions arise about types or locations of underground facilities. Existing and proposed underground tanks shall also be shown.
7. The minimum vertical clearance between a proposed storm drain and all existing utilities shall be 1 foot unless otherwise required by the given utility.
8. Below ground utilities shall be dimensioned from the road center or monument line.
9. Above ground utilities such as power poles, light poles, guys and anchors, irrigation structures, utility pedestals, transformers, switching cabinets, gas regulators, waterline back-flow prevention units, and other features shall be called out including size and pad elevation, and shown in plan, and stationed relative to the adjacent road monument line or centerline from the street side face of the utility (e.g. 12+33 R 32').
10. When below ground appurtenances (utilities, monuments, tanks, valve boxes, and other features) depicted on As-Built or "Record" drawings cannot be field located, they shall be shown and labeled as "not found".
11. The following items shall be shown and may require a separate storm drain plan and set of profile sheets that relate to both the hydraulic design model and the construction plan set:
 - A. New storm drain pipe
 - B. Manholes/Junction structures
 - C. Catch basins
 - D. Connector pipe
 - E. Pipe collars
 - F. Prefabricated pipe fittings
 - G. Other drainage appurtenances (headwalls, trash racks, drop inlets, hand rails, pipe supports, etc.).
12. Where new street paving work joins existing side streets, pavement crown and gutter elevations are required to be displayed and shall be shown in plan view for a minimum of 100 feet beyond the curb return on the side street intersections. Where new street paving work joins an existing street linearly, the existing pavement crown and gutter elevation shall be a minimum of 300 feet beyond the new work to ensure proper drainage and a smooth ride for vehicular traffic.
13. All storm drain plans shall have the following format:

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- A. Storm drain designs shall be depicted on single plan/profile sheets.
- B. Main line storm drain plans shall be 1 inch=20 feet horizontal and 1 inch=2 feet vertical, unless otherwise approved.
- C. Scales for connector pipe/catch basin profiles shall be 1 inch=5 feet horizontal and 1 inch=5 feet vertical, unless otherwise approved.
- D. Profile slopes shall be shown in feet per foot dimensions to four significant figures.
- E. Grade breaks shall be stationed with elevations shown. Station and elevations shall also be shown at sheet match lines and at the beginning/end of the storm drain.
- F. Centerline stationing shall be shown on plan and profile. Stationing shall run from the low point, or outfall, and increase toward the high point or inflow. Where the storm drain is being installed in conjunction with a paving project (i.e. depicted on corresponding paving plans), the stationing shall be correlated with the paving project stationing.
- G. All plans for Flood Control District of Maricopa County projects shall use standard Flood Control District of Maricopa County symbols, available on the District web site at www.fcd.maricopa.gov, or MCDOT approved symbols.
- H. Final plan sheets shall be 24 inch x 36 inch, and may be submitted as paper copies or in Adobe PDF digital format. The District requires a sealed original of the plan set cover sheet for signature of approval by the Chief Engineer and General Manager for District projects.
- I. For Flood Control District of Maricopa County projects letter size on full size drawings shall be 14 point minimum.
- J. For Flood Control District of Maricopa County projects title blocks shall be located in the lower right-hand corner of the plans and shall include the title "Grading and Drainage Plans".
- K. Storm drain diameters shall be shown in plan and profile with reference to material type.

6.17 REFERENCES

American Association of State Highway and Transportation Officials (AASHTO), 2004, *AASHTO LRFD Bridge Construction Specifications* (including all interim revisions).

Arizona Department of Transportation (ADOT), Intermodal Transportation Division, undated, *ADOT Bridge Design Guidelines*.

Arizona Department of Transportation (ADOT), 1989, Urban Highways, Channel Lining Design Guidelines

Arizona Department of Transportation (ADOT), 1996, *Pipe Selection Guidelines and Procedures*.

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7 INDIVIDUAL LOT DEVELOPMENT OUTSIDE OF SUBDIVISIONS

This chapter is not applicable to development on alluvial fans, piedmonts areas or areas of flows greater than 500 cfs. This chapter is not applicable for Conditional Letter of Map Revisions or Letter of Map Revisions. This section contains information from the entire document that is pertinent to individual development provided in one place for the reference for the user.

This section does not supersede or replace the Floodplain Regulations for Maricopa County. If there are any conflicts with the Floodplain Regulations for Maricopa County then the Floodplain Regulations for Maricopa County will prevail.

7.1 COUNTY/DISTRICT REGULATIONS, ORDINANCES AND POLICIES AND STANDARDS

The County/Community/District regulations and ordinances that these policies help implement include the following:

Floodplain Regulations for Maricopa County, latest revision with text amendments.

Maricopa County or Community Zoning Ordinance, latest revision with text amendments.

Additional District policies and standards include:

Drainage Design Manual - Hydrology, (2018) or most current edition.

Drainage Design Manual - Hydraulics, (2018) or most current edition.

Drainage Design Manual – Erosion Control, (2013) or most current edition.

A complete list can be found at the Floodplain Directory of Documents at: <http://www.fcd.maricopa.gov/permitting/document-directory.aspx> and the specific community's websites.

7.2 WHAT CONSTITUTES DRAINAGE PLANNING

Good drainage planning is a complex process. Drainage planning consists of the following considerations:

1. Drainage planning should not be done after all the other decisions are already made as to the layout. It is this latter approach that creates drainage problems, and often requires costly corrective action.

2. When flood or erosion hazards are involved, the planner should take these hazards into consideration in land planning to avoid unnecessary complications when designing the infrastructure.

For simple projects with minimal drainage considerations, the detail and length of the report is intended to be minimal.

There is a significant amount of existing information available to the hydrologist or drainage engineer that should be considered when undertaking a drainage plan. Refer to table 2.1.

All drainage plans and construction drawings shall meet District and Maricopa County/Community regulations.

Design Hydrology and Hydraulics:

The drainage engineer should determine if there is existing hydrologic and hydraulic information available for the upstream watershed and project site that is suitable for use in design of the project improvements. This includes researching the information sources listed in [Table 2.1](#). In particular, review of the District ADMS or ADMP that encompasses the project area provides the design team with valuable information pertaining to the magnitude of stormwater discharges and volumes affecting the project. The design engineer must either concur with the ADMS, ADMP and/or WCMP by statement, or submit additional documentation addressing and substantiating any differences. The FEMA Flood Insurance Rate Maps (FIRM) should also be reviewed to establish if regulated floodplains cross the project. Where existing studies are not available, the drainage engineer should contact the District, as it has an aggressive schedule to undertake the study of new areas. "In-progress" information is often available, and if not, staff experience regarding these issues is extensive. **Study and FIRM information may be available on the District's website.**

In the event there is insufficient hydrology or hydraulic information available, then the drainage engineer will have to generate new information using the Hydrology and Hydraulics volumes and the policies and standards herein. At the drainage plan level, the drainage engineer should concentrate on quantifying off-site flows that may impact the project, and determine the means for conveying that flow through the project site. A reasonable estimate of the design peak discharge is necessary to approximate the channel or drainage structure type and capacity, with a goal to maintain historic conditions. Again, the improvements presented in a drainage plan shall not adversely impact adjacent property owners.

Where WCMP's have been completed, setbacks for erosion hazard zones may have been identified. If setbacks have not been defined as part of the WCMP, then erosion hazard areas should be approximated following the methodologies identified in ADWR (1996) and the District's Hydraulics volume (FCDMC 2018) Hydraulics. Detailed lateral migration and long-term erosion analyses would be performed as part of final design in those circumstances.

For a drainage plan, the level of analysis necessary to establish artificial channel widths may vary. If the artificial channel is for a watercourse with a 100-year peak discharge of 50 cfs or greater, a detailed floodplain analysis may be required (see [Table 6.7](#)). The level of analysis is also dependent upon the existing or proposed land use and whether encroachments, such as road culvert embankments, affect the flow regime. Otherwise, simple "normal depth flow" calculations may suffice. Where channel slopes exceed 0.5% to 1.0%, supercritical flow analysis may be warranted.

Another key component of planning for a channel at the drainage plan level is the transitioning of flow into and out of a proposed channel. County/Community/District policy (Policy 3.4.2) require that proposed facilities do not exacerbate flooding conditions for adjoining properties. Thus, any drainage improvement must not increase water levels or result in erosive velocities greater than pre-development conditions. Interceptor channels (and other low impact development techniques, such as: bioswales, microbasins) may be required/needed to collect offsite flow into an onsite channel. Similarly, spreading basins or 4:1 channel expansions may be necessary to transition from an artificial channel to the existing downstream floodplain.

7.3 COUNTY/DISTRICT/COMMUNITY POLICIES

The following are County/District/Community policies from chapter 3 related to drainage planning for private developments. **See Chapter 3 for a complete list of all of the policies.**

Policy 3.3.1 Compatibility with Studies of Record. Developments shall acknowledge and assess their project for compatibility with any ADMSs, ADMPs, WCMPs, or flood insurance studies.

Policy 3.3.2 Watercourse Master Plan Requirements. Where a WCMP has been completed, the approved plan for erosion setbacks, structural and non-structural measures, existing and/or future condition floodplain and floodway requirements should be followed.

Policy 3.3.3 Permits. There are numerous federal, state, county, and community permits that may be required prior to the start of construction of a project (see Chapter 4 and Chapter 5). It is not the County's/Community's/District's responsibility to ensure that the plans for a proposed project satisfy state and federal permit requirements. It is the County's/Community's/District's policy that all such permits must be obtained, but it is the owner's responsibility to determine which permits are required and to obtain them as appropriate for the timing of the project. County/Community/District-issued permits may be withheld pending written proof that required State and/or Federal permits have been obtained.

Policy 3.4.2 Historic Drainage Patterns. Historic drainage patterns, where runoff enters and exits a property, shall be maintained.

Policy 3.4.3 Alteration of On-Site Drainage Patterns. Activities on a property that affect drainage shall not result in adverse impacts on adjacent properties. At a minimum, such drainage activities, including wash relocations and the concentration of sheet flows or braided washes, shall not adversely change water surface elevations and flow characteristics. Such drainage activities shall require an engineered report that substantiates there are no adverse impacts.

Policy 3.7.1 Best Available Technical Information. New or updated information for FEMA defined floodplains and floodways is constantly being prepared, both by the District and by others. It is the District's policy, in conformance with FEMA Guidelines, to use this information for regulatory purposes and to provide it to the public as the "Best Available Technical Information". However, until the effective FIRM is revised, the requirements from the effective FIRM will also be used. Examples of "Best Available Technical Information" follow:

1. New studies that have not yet been submitted to FEMA. This information is usually from studies that are in progress but could also be completed studies that are being held pending further investigations such as completion of an ADMS, ADMP or WCMP. This information may be shared with the public if appropriate and approved for release by the

Chief Engineer and General Manager of the District. It will be stamped preliminary, and the recipient will be notified that the information is subject to change and is used only at-risk. This information may be used for regulatory purposes, particularly if the floodplain and/or floodway widths or 100-year water surface elevations exceed those of the effective FEMA Flood Insurance Study (FIS).

2. New studies that have been submitted to FEMA but not yet approved. The same conditions from item 1 apply here. The effective FEMA FIS will be used for regulatory purposes for all other cases.
3. Floodway delineation in a new study prior to submittal to FEMA.

Policy 3.7.4 Location of Structures. The developer should locate proposed structures outside of a FEMA-designated floodplain if at all possible. District staff will attempt to work with the developer on building placement and issue a Floodplain Clearance if the proposed structure(s) is successfully placed outside the floodplain.

Policy 3.7.6 Development in the floodway. Any development within the floodway that results in any increase in the effective flood elevation or extent either vertically or horizontally will require a CLOMR (44 C.F.R. § 60.3.d(4)). The increase is measured from the effective study. This also applies to floodways shown on the Flood Management Maps for Maricopa County.

If there are no increases, then a no rise certification and analysis per Sections 405 & 602 of the Floodplain Regulations for Maricopa County is required. A CLOMR is not required (C.F.R. § 6.3.d(3)).

Policy 3.7.7 Scour Protection for Utilities. Underground transmission lines (example: electrical, Natural Gas, Gasoline, Oil, fiber optic, cable, water, sewer) shall be protected against scour within the Special Flood Hazard Area or those area shown on the District's Flood Management Maps. The scour depth is to be calculated as set forth in chapter 11 of FCDMC (2018) Hydraulics.

The scour depth for Individual lot utility service connections (except gas and electric lines) shall be protected against scour within the Special Flood Hazard Area or those area shown on the District's Flood Management Maps. The scour depth is to be calculated as set forth in chapter 11 of FCDMC (2018) Hydraulics. In addition, the scour depth may be calculated as set forth in ADWR (1996) except for gas and electric lines.

The scour depth is to be designed by a Professional Civil Engineer.

Policy 3.7.9 Erosion Protection. The need for erosion protection needs to be determined. One form of erosion protection is setting the building outside of the calculated erosion zone. Building pads and foundations may be required to have an additional setback or be protected from erosion and scour in conformance with the procedures in the Hydraulics volume. As an alternative to structural protection, building setbacks from washes may be required for protection from erosion hazards, as set forth in ADWR (1996) and FCDMC (2018) Hydraulics. Erosion protection is regulated by the District for areas within the designated floodplain. Areas outside of the floodplain are regulated by the County/Community.

Policy 3.7.10 Lot Grading. Lots are to be graded to drain so as not to adversely affect adjacent property owners. Runoff redirected from its natural flow location may drain onto or through an

adjacent property if a drainage easement(s) or tract(s) is provided. Such easements or tract(s) must be recorded against the deed(s) of the affected properties. A legal description and exhibit drawing of every easement, sealed by an Arizona registered land surveyor, must be included as a part of the recorded documents.

Riverine Areas

Policy 3.8.1 Riverine Erosion Hazard Zones. Erosion hazard guidelines (ADWR, 1996), as a minimum, apply to:

- Structures that could fail or incur significant damage as a result of erosion or deposition.
- Proposed structures that, if built, could result in adverse impacts to adjacent properties.
- Watercourses that do not have erosion hazard zones approved by the District.
- Watercourses within existing or proposed subdivisions, including residential and non-residential.
- Watercourses identified by the District as having significant potential flood hazards.
- Watercourses with drainage areas equal to, greater than 30 acres, or a 100-year peak discharge estimate of more than 50 cfs, as estimated using the procedures in the Hydrology and Hydraulics volumes.

Erosion zones consistent with ADWR (1996) may be required for all properties developed in which the watercourses are to be left in an undisturbed state. Depending on the geomorphic conditions of the area, if the erosion limits are suspected by the District/County/Community to exceed those estimated using a Level I analysis, as defined in ADWR (1996), a Level II or Level III analysis may be required. A detail methodology for lateral erosion setback can be found in the FCDMC (2018) Hydraulics.

Distributary Flow Areas

Policy 3.8.2 Watercourse Stability Analysis. Stability of the watercourse divergence point(s) and divergent wash(es) should be determined prior to the approval of a proposed structure.

Policy 3.8.3 Proposed Watercourse Alterations. Proposed modifications should not disturb the natural divergence location(s), especially if upstream, downstream or adjacent parcels may be adversely impacted.

Policy 3.8.4 Erosion Hazard Zones. Erosion hazard guidelines (FCDMC, 2018) should be applied to all divergent watercourses adjacent to the proposed structure.

Sheet Flow/Unconfined Flow Areas

Policy 3.8.5 Vegetation Removal and Flow Concentration. Erosion potential directly relates to vegetation removal and concentration of flows. Proposed development should limit vegetation removal and concentration of flow to a minimum, especially in undisturbed natural desert conditions.

Policy 3.8.6 Single-lots. Flows will not be concentrated beyond the typical shallow swale around the structure. These swales should daylight and broaden to the original sheet flow conditions on the downstream side of proposed structures. Erosion protection may be required.

Street Drainage

Policy 3.9.1 No Adverse Impacts. Street design should identify any increase in peak discharge and flow velocities and account for them in the roadway design so there are no adverse impacts to other properties, pedestrians and cyclists. The County/Community/District encourages the use of green infrastructure and low impact development techniques in concert with these street drainage policies to improve water-harvesting potential, improve water quality, and reduce the impacts of increased run-off downstream. Streetscape and drainage designs should be developed as an integrative solution with multiple community benefits included.

Conveyance Facilities

Policy 3.10.5 Levees and Berms. Levees or berms should not obstruct side or interior drainage to a channel. These are only allowed as public projects, with maintenance oversight of a governmental agency.

Policy 3.10.6 Irrigation Canals. Irrigation canals may not be used as an outfall for stormwater runoff without written approval by the agency that owns the facility.

Policy 3.10.10 Stormwater Conveyance During Construction. Stormwater conveyance is to be provided at all times during construction in such a manner as to not increase flood depths, sedimentation, or erosive velocities above pre-construction levels for the areas adjacent to, and downstream of, construction projects.

Ownership and Maintenance of Drainage Facilities

Policy 3.13.2 Ownership and Maintenance (Lot Splits). A privately-owned drainage tract should be provided for all new lot splits. Common-use stormwater conveyance and storage facilities must accommodate access for maintenance. Such developments shall dedicate common-use rights-of-way, and easements or tract(s); it needs to include a maintenance agreement and it must be recorded against the deed(s) of the affected properties.

Policy 3.13.6 Maintenance of Privately-Owned Drainage Facilities. The County/Community/District will not maintain privately-owned drainage facilities of any type.

Policy 3.13.11 Section 404 Permits. Where required, Section 404 permits shall be obtained prior to the start of maintenance activities that fall under Section 404 permit requirements.

7.4 Design Criteria

Construction in Special Flood Hazard Areas

The lowest floor of all residential structures constructed in the SFHA must be constructed to a minimum of the Regulatory Flood Elevation (RFE). Building structures located within the SFHA (but not within the Floodway) may be protected from floods up to and including the 100-year flood by placement of fill to elevate the structure to or above the RFE. See FEMA guidelines for further specifications. Basements of residential structures located in the SFHA must be elevated above the RFE.

The NFIP regulations allow nonresidential buildings (commercial structures, garages, warehouses, etc.) the option to flood-proof rather than elevate as a means of protection from the

base flood. Non-residential structures can be flood-proofed to or above the RFE instead of being elevated. Detached garages, barns, and storage sheds are some examples of buildings that may not have to be elevated or dry flood-proofed if openings are installed to allow floodwaters to enter or exit a structure and meet all other wet flood-proofing requirements. Wet flood-proofing requires the use of flood-resistant materials below the RFE and elevating items subject to flood damage above the RFE. Flood-proofed structures must comply with appropriate sections of the NFIP regulation 60.3 and the Floodplain Regulations. A minimum of two (2) openings, on at least two (2) sides, having a total net area of not less than one (1) square inch for every square foot of enclosed area subject to flooding shall be provided. The bottom of all openings shall be no higher than one (1) foot above finished grade. Openings may be equipped with screens, louvers, valves, or other coverings or devices provided they allow the automatic entry and exit of floodwaters. See FEMA guidelines for further specifications.

Modular buildings must have the bottom of the structure (bottom of lowest beam and utilities) raised, as a minimum, to or above the Regulatory Flood Elevation (RFE) regardless of its use.

All new construction and substantial improvements shall be constructed with electrical, HVAC, plumbing, and other service facilities that are designed and/or located so as to prevent water from entering or accumulating within the components during conditions of flooding. Mechanical and electrical equipment must be installed at or above the RFE as a minimum. Below ground tanks such as propane and water tanks must be anchored against flotation. Above ground tanks are considered structures for floodplain management purposes.

Under no circumstances can filling or other construction activity be allowed within a floodway that may cause any rise in the water surface elevation above the designated floodway elevation. Any development or changes in floodway elevation, width or location will require approval of FEMA by a Conditional Letter of Map Revision and a Letter of Map Revision.

An "Elevation Certificate" (FEMA Form 81-31) must be completed for each structure constructed in the SFHA prior to the electrical clearance and final acceptance for that structure. One copy of the "Elevation Certificate" is to be submitted to the Flood Control District of Maricopa County and one copy is to be submitted to the community Floodplain Administrator for incorporated communities. See Federal Code for a complete list of requirements.

Building Permit

A Building Permit is required for development activities that include excavation, fill, drainage swales and channels, drainage structures and pipes, detention/retention areas, and dry wells.

Floodplain Use Permit

A floodplain use permit is required for all new or substantial improvements per the Floodplain Regulations for Maricopa County. This permit ensures that development will comply with NFIP criteria, State, and Federal law and provides proper documentation to assess flood insurance rates if needed.

Rational Method Criteria

[Table 6.3](#) and [Table 6.4](#) contain C Coefficients for use with the Rational Method and are to be applied for most applications. It is the engineers' responsibility to verify the applicability of these values for the intended application. Higher values may be approved, within the ranges specified in Table 3.2 of the Hydrology volume, based on an analysis of planned and/or actual percent imperviousness and vegetation and soils conditions.

Unit Hydrograph Method Criteria

[Table 6.5](#) contains rainfall loss, Time of Concentration equation and Lag equation parameters for use with the unit hydrograph method. Refer to Section 4.4.1 of the Hydrology volume for details of application. These parameters are for developed land use conditions corresponding with the Maricopa County Zoning Code. [Table 6.6](#) contains similar parameters for natural conditions. These are the default values contained in the DDMSW computer program. The most current DDMSW program should be used. It is the engineers' responsibility to verify the applicability of these default values for the intended application. These default values were originally developed based on large scale projects in the past and may not be applicable to specific projects. They were provided as the starting values in order for the software to run. These default values shall be verified and changed based on the latest aerial photos and field visits

7.5 DESIGN GUIDELINES

7.5.1 2-Dimensional Results

FLO-2D computes depth, velocity and discharge in 8 directions in and/or out of each grid element. The peak discharge we are showing on the web site is the ESTIMATE of the total outflow peak discharge exiting that particular grid element and the direction of the highest flow rate from the 8 directions. Not reported is the remaining peak discharge leaving the grid in the other 7 directions, which could be zero but might be a significant value. Remember, it is a 2D model. The downstream grid Cell is receiving discharge from all grid elements adjacent to and upstream of it.

The directions of flow are as follows:

1 North, 2 East, 3 South, 4 West, 5 Northeast, 6 Southeast, 7 Southwest, 8 Northwest

The grid sizes for a given model are all the same size. The size can vary from model to model. The grids are square, the same dimension on each side.

The elevations shown are the average for the center of the grid. Elevation for points not on the center of the grid must be determined by linear interpolating between the grid both in the North-South and then the East-west directions (the order of interpolation does not matter). Interpolating is by the following equation.

Upstream grid elevation - [(upstream grid elevation – downstream grid elevation)/ (cell size)]*(horizontal distance from upstream grid elevation).

The highest point on the upstream side of the structure is to be used.

The flow for a wash or a desired section is determined by adding the flows in grids along a cross section. Cross sections should be cut perpendicular to the direction of flow.

7.5.2 Guidelines for Determining the Highest Natural Grade for AO Zones

Guidelines for determining the highest natural grade for SFHA AO Zones:

- The lowest floor elevation needs to be one foot above the flooding depth shown on the FIRM,
- Choose the highest point of natural ground that is within the foot print of the structure and that is located within the Zone AO floodplain,
- If part of the structure is located outside of the Zone AO, the whole structure is considered in the floodplain.

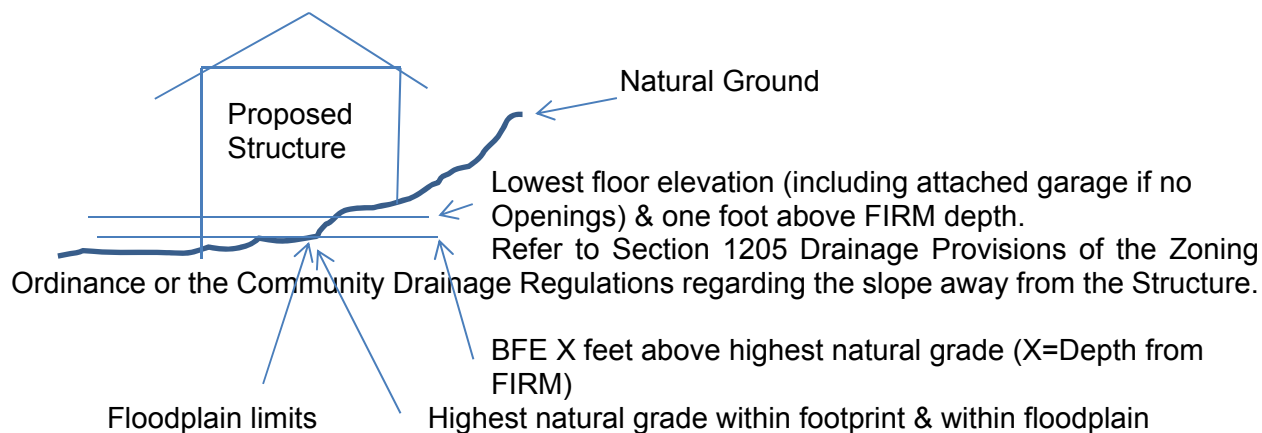


Figure 7.1 Guideline for determining the highest natural grade for SFHA AO Zones

7.5.3 Guidelines for Engineered Openings in Nonresidential Structures in SFHA A, AE, AH & AO Zones:

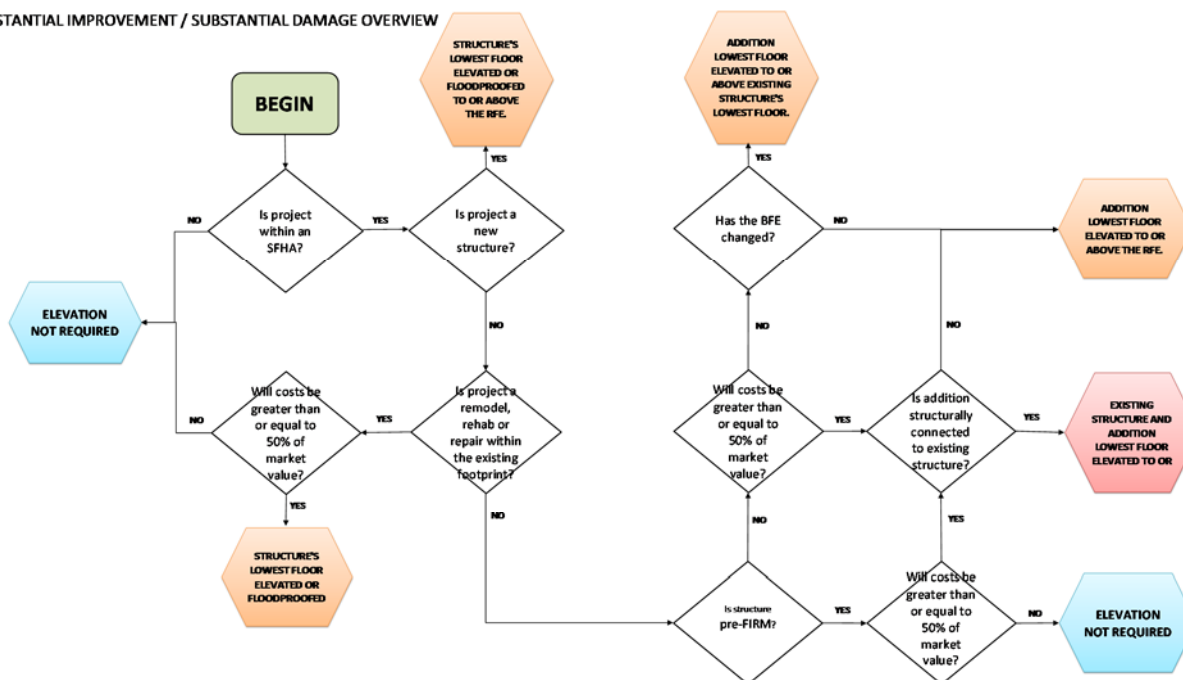
- May only have door(s) for openings, if a structural engineer certifies the structure can withstand hydrostatic pressure to the Regulatory Flood Elevation and is designed with flood resistance materials to the RFE;
- May use commercial flood vents certified by FEMA. The opening equivalent is per manufacture specifications.

7.5.4 Zone A with pending Study

In Zone A where a detail study was completed by the District and approved by FEMA; and waiting on FEMA for publication on the FIRM, any development within the Zone A or the pending SFHA will need to have a floodplain use permit. The BFE will be determined from the pending study data.

7.5.5 Substantive Improvement / Substantive Damage

SUBSTANTIAL IMPROVEMENT / SUBSTANTIAL DAMAGE OVERVIEW



Notes: Local requirements and implementation of SI/SD may vary. Refer to FEMA P-758 SI/SD Desk Reference Manual for additional guidance.
 All new and relocated service equipment elevated or floodproofed to or above the Regulatory Flood Elevation (RFE)
 Certification of elevation required

Figure 7.2 Substantive Improvement / Substantive Damage flowchart

7.6 Reports (for non FEMA Map Change Submittal)

HYDROLOGY AND HYDRAULICS REPORTS (Non-FIS) - Report Organization

Hydrology and hydraulics reports for purposes other than flood insurance studies should, as a minimum, include the following information:

- Documentation for new and revised hydrology and hydraulic models.
- Design assumptions and parameters for each drainage system component.
- Minimum building pad and finished floor elevations for areas within floodplains and backwater ponding from structures or roadway embankments.
- The Table of Contents must be sealed by a Civil Engineer licensed to practice in the State of Arizona.

The Final Drainage Report should be organized to include sections as follows (as a minimum):

TABLE OF CONTENTS

- 1.0 Completed Hydrology and Hydraulics Report General Checklist
- 2.0 Introduction/Purpose
- 3.0 Location
- 4.0 Site Description and Proposed Development
- 5.0 FEMA Floodplain Classification
- 6.0 Off-site Drainage Description
 - 6.1 Background
 - 6.2 Proposed Offsite Flow Management
- 7.0 On-site Drainage Design Description
- 8.0 Hydrology (similar to ADWR SS 1-97)
 - 8.1 Methodology

Maricopa County Drainage Policies and Standards

- 8.2 Parameters
- 8.3 Results
- 8.4 Confidence Checks and Sensitivity Analyses
- 9.0 Hydraulics (similar to ADWR SS 1-97)
 - 9.1 Methodology
 - 9.2 Parameters
 - 9.3 Results
 - 9.4 Confidence Checks and Sensitivity Analysis
- 10.0 Minimum Finished Floor Elevation Requirements
- 11.0 Sedimentation and Erosion Hazards Discussion
- 12.0 Conclusions and Recommendations
- 13.0 References

FIGURES

- Figure 1 Area Location Map
- Figure 2 Site Aerial Photo Map
- Figure 3 FIRM Map
- Figure 4 Off-site Watershed Map
- Figure 5 On-site Watershed Map
- Figure 6 On-Site Drainage and Grading Plan

APPENDICES

- Appendix A Offsite Hydrology Documentation
- Appendix B On-Site Hydrology Documentation
- Appendix C Channel Design and Floodplain Hydraulics Documentation
- Appendix D Digital Data/Model Input and Output Files

7.7 CHECKLIST

Checklist – use checklist on the County/Community websites if available.

<http://www.fcd.maricopa.gov/downloads/permitting/FloodplainUsePermitChecklist.pdf>

8 REVISION PROCESS

Maricopa County and the Flood Control District of Maricopa County (FCDMC) utilize a multi-disciplinary multi-division committee to review and recommend proposed changes to the Drainage Policies and Standards Manual. This committee is made up of multi-disciplined professionals in order to best reflect the multitude of societal resources influenced by stormwater runoff. Representatives from the FCDMC, MCDOT, Planning and Development Services, Environmental Services, Parks and Recreation, the Flood Control District of Maricopa County Advisory Board, the Planning and Development Services Drainage Review Board, and representatives from communities that have adopted this manual may serve on this committee to represent the concerns of their respective divisions, Maricopa County departments, and elected officials.

Those seeking changes to policies or standards must make a formal submittal to the committee stating the present policy/standard, identifying the proposed change(s), and providing comprehensive justification for the change. Requested changes may be submitted electronically or in writing to the Policy, Planning, and Coordination Manager at firminfo@mail.maricopa.gov.

The committee may convene periodically to review requested changes. If proposed changes are found appropriate by the review committee, the manual may be revised in draft form. The Draft revised document will be routed to Maricopa County Agencies and other committee members prior to posting for review to verify and agree upon the proposed changes. The draft document will be sent to the cities and towns in Maricopa County, and a notice regarding the availability of the new draft document for review and comment and the review period will be posted on the web pages listed below. Public review comments received will be considered and changes may be made if appropriate.

Once updated, the latest Drainage Policies and Standards Manual or a link will be posted on the following web pages:

Enhanced Regulatory Outreach Program: <http://www.maricopa.gov/2838/Enhanced-Regulatory-Outreach-Program-ERO>

Planning & Development: <http://www.maricopa.gov/797/Planning-Development>

Flood Control District of Maricopa County: <http://fcd.maricopa.gov/3847/Flood-Control-District>

Maricopa County Department of Transportation: <http://www.maricopa.gov/156/MCDOT>

Environmental Services: <http://www.maricopa.gov/631/Environmental-Service>

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9 GLOSSARY

Glossary terms defined in the Zoning Ordinance and the Floodplain Regulations are included herein by reference.

All Weather Access. Each lot within a subdivision shall have at least one vehicular access route which, regardless of street width design classification, provides access to and from the lot for private and emergency vehicles during flood events up to and including the 100-year event. Such routes are referred to as “All Weather Access” routes.

Best Management Practices (BMPs). Schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to prevent or reduce the discharge of pollutants to stormwater discharges. BMPs also include treatment requirements, operating procedures, and practices to control site runoff, spillage or leaks, sludge or waste disposal, or drainage from outdoor storage areas.

First Flush. The initial or early stages of stormwater runoff from a storm event which commonly delivers a disproportionately large amount of previously accumulated pollutants due to the rapid rate of runoff. The first flush is defined as the first one-half (1/2) inch of direct runoff from the contributing drainage basin.

Flood Management Map. An official map for Maricopa County on which the District Floodplain Administrator has delineated floodplains and other flood related flood hazard zones for the purpose of floodplain administration.

Pollutant. Fluids, contaminants, toxic wastes, toxic pollutants, dredged spoil, solid waste, substances and chemicals, pesticides, herbicides, fertilizers and other agricultural chemicals, incinerator residue, sewage, garbage, sewage sludge, munitions, petroleum products, chemical wastes, biological materials, radioactive materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt and mining, industrial, municipal and agricultural wastes or any other liquid, solid, gaseous or hazardous substances.

Major Drainageway or Watercourse. A watercourse with a contributing watershed of a minimum of ten (10) square miles.

Minor Land Division. The definition from the current version of the Maricopa County/Community Subdivision Regulations is used for the purposes of this document.

Subdivision. The definition from the current version of the Maricopa County/Community Subdivision Regulations is used for the purposes of this document.

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APPENDIX A CHECKLISTS

A.1 PURPOSE

These checklists are intended for two purposes as follows:

1. Internal use by County/Community/District employees as a guide for reviewing drainage studies, reports and construction plans, including those submitted by the public and prepared internally at the County/Community/District and by other agencies.
2. External use by the public for preparing drainage studies, reports and construction plans that will be reviewed by the County/District.

This should help expedite the review process and help the public better understand what the County/Community/District will be looking for when performing a review. These checklists are not intended to be applicable for every situation. Checklist items that do not apply to a given situation should have the “N/A” box checked. The column headed with an “*” should be checked if more information or comments are necessary. Additional information and comments should be placed in the “COMMENTS” section provided at the end of each table, with the appropriate checklist item number listed at the start of the comment. Such additional information or comments may also be provided on additional pages.

The engineer is to provide the appropriate checklist as a part of the study or report, as shown in Section 6.14 and Section 6.15. The general intended uses for each checklist are as follows:

Checklist 1: Drainage Design Report General Checklist. Drainage Design Reports for subdivision preliminary and final plats, street improvement projects and drainage improvement projects. Portions of the checklist may also be appropriate for grading and drainage plans.

Checklist 2: Hydrology Specific Checklist. This checklist is to be applied for flood insurance studies, drainage planning studies, and for Drainage Design Reports where new hydrology calculations or modeling is prepared.

Checklist 3: HEC-RAS Hydraulics Specific Checklist. This checklist is to be applied for flood insurance studies, drainage planning studies, and for Drainage Design Reports and drainage and grading plans where new hydraulic modeling is done using HEC-RAS (preferable) or HEC-2.

Checklist 4: Technical Data Notebook Checklist. This checklist is to be applied for flood insurance studies.

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A.2 Checklist 1: Drainage Design Report General Checklist

Item	Description	YES	NO	N/A	*
SECTION 1: GENERAL					
1	PROJECT NAME: _____ REVISION NO: _____ DATE: _____				
2	SELECT PROJECT TYPE: Preliminary Plat <input type="checkbox"/> Final Plat <input type="checkbox"/> Street Imp. <input type="checkbox"/> Drainage Design <input type="checkbox"/> Grading and Drainage Plan <input type="checkbox"/> Other <input type="checkbox"/>				
3	REVIEWED BY: _____				
4	Is this a complete drainage report, sealed by a professional Civil Engineer currently licensed to practice in Arizona?				
5	Is the <i>Hydrology Specific Checklist</i> included and completed, if appropriate?				
6	Is the <i>HECRAS Hydraulics Specific Checklist</i> included and completed, if appropriate?				
7	Is this report for floodplain delineation purposes, requiring use of the TDN format and checklist?				
8	Does the report discuss whether the site is in a subsidence area or if there are fissures present?				
9	If in a subsidence area or fissures are present, are facilities appropriately sited and designed?				
10	If a construction project, has an SWPPP been developed and an NOI submitted per ADEQ requirements?				
11	If a construction project, has a copy of the SWPPP and NOI been included in the report?				
12	Have all permit requirements been met (i.e., Floodplain, Drainage Clearance, Right-of-Way, Zoning, Stormwater Quality, 401/404, etc.)?				
13	Is there a section on Conclusions and Recommendations, and is it adequate?				
SECTION 2: FIELD SURVEY AND MAPPING					
1	Are company name, project number, and dates of surveying specified?				
2	Is the report sealed and signed by a professional Land Surveyor currently registered in the State of Arizona?				
3	Are the mapping and map control used in the study fully described?				
4	Are both horizontal and vertical mapping datums specified?				
5	Are the date of aerial photography, mapping scale, and contour interval specified?				
6	Other. _____				
SECTION 3: DRAINAGE AREA MAP					
1	Is there a drainage area map at an appropriate scale?				
2	Is each sub-basin area delineated and uniquely labeled with alpha-numeric characters in a consistent manner on the Drainage Area Map?				
3	Are directional drainage arrows shown on all streets, parking lots, paved areas, and vacant land?				
4	Is the existing zoning shown on each parcel?				

A.2 Checklist 1: Drainage Design Report General Checklist

Item	Description	YES	NO	N/A	*
5	Are existing and proposed catch basins shown and clearly identified?				
6	Does each catch basin number correspond to the number of the sub-basin area which contributes to it?				
7	Are catch basins numbered, beginning with number 1 as the first catch basin contributing to the storm drain at the upstream end? The following catch basins contributing should be numbered consecutively.				
8	Is the same catch basin number used throughout the project – on the drainage area map, in the design report, on the Storm Drain Design Summary Sheet, and on the plans?				
SECTION 4: STORMWATER COLLECTION SYSTEMS					
1	Are the hydrologic design criteria described and do they match the jurisdiction's requirements?				
2	Is the street drainage network described (i.e. longitudinal and cross slopes, curb height, gutter width).				
3	Is the storm drain network described (i.e. inlet and catch basin design).				
4	Is a Storm Drain Design Summary Sheet included?				
5	Is conformance with previous drainage studies checked and differences discussed?				
6	Has a Hydraulic & Energy Grade Line Profile been submitted?				
7	Is the pipe velocity for $0.5 \cdot Q_{\text{design}} \geq 3$ fps, $Q_{\text{design}} \geq 5$ fps, and ≤ 15 fps?				
8	Are dry lane requirements met?				
9	Are appropriate drainage runoff volumes and discharges used?				
10	Are the diameter, length, slope, and construction material of storm drainpipe (RCP, CMP, or other) specified?				
11	Are appropriate clogging factors applied for inlets, in conformance with the jurisdiction's requirements?				
12	Is the maximum hydraulic grade line ≥ 1 ft. below the grate elevation of all catch basins and inlets?				
13	Is the maximum energy grade line at or below the adjacent gutter flow line elevation?				
14	Other.				
SECTION 5: CULVERTS					
1	Is the application described (i.e., roadway classification, design setting, erosion/deposition concerns)				
2	Is the hydrologic design criteria used described and does it meet or exceed the minimum standards?				
3	Are the number, diameter, length, and construction material specified appropriately? (i.e., CMP, RCP, or other)				
4	For existing condition studies, are appropriate n-values assigned for pipe condition?				
5	Are appropriate clogging factors applied for inlets, in conformance with the jurisdiction's requirements?				

A.2 Checklist 1: Drainage Design Report General Checklist

Item	Description	YES	NO	N/A	*
6	Does the culvert design for Q_{design} meet the requirements of Table 6.7?				
7	Does the inlet headwater elevation for Q_{100} meet the requirements of Table 6.7?				
8	Does the flow depth over the road for Q_{100} meet the requirements of Table 6.7?				
9	Does backwater at the inlet overtop adjacent land features and drain elsewhere, other than through the culvert?				
10	Does backwater at the inlet affect adjacent parcels of land, requiring ponding easements or establishment of minimum finish floor elevations?				
11	Is the outlet velocity ≤ 15 fps?				
12	Is outlet protection necessary?				
13	If a low water crossing is specified, are cut-off walls provided along the upstream and downstream edges of pavement to limits of flow?				
14	Is a profile provided for each culvert depicting length, slope, cover, road side slopes, design headwater elevation, and any utility conflicts?				
15	Other.				
SECTION 6: RETENTION BASINS					
1	Is the hydrologic design criteria used described and does it match the jurisdiction's requirements?				
2	Have stormwater storage and first flush requirements been met?				
3	Are stormwater storage and first flush calculations included and documented in the report?				
4	Does the maximum basin depth meet the jurisdiction's criteria?				
5	Is an emergency spillway/overflow identified in an appropriate location, and adequately protected from scour?				
6	Are side slopes 4:1 or flatter?				
7	Are appropriate clogging factors applied for inlets, in conformance with the jurisdiction's requirements?				
8	Are debris barriers specified for inlets?				
9	Are access barriers specified for outlets 18 inches in diameter and greater?				
10	Is an upstream siltation basin included if necessary?				
11	Other.				
SECTION 7: FCDMC FLOOD RETARDING STRUCTURES					
1	Name of structure(s):				
2	Identify phase of FCDMC Structures Assessment Program and any hydrologic investigations performed as part of the program.				
3	Specify hydrologic design criteria for reservoir, i.e. SPF, 100-yr.				
4	Specify inflow design flood for spillway, i.e. 100-yr, or % PMF (dependent on hazard classification).				

A.2 Checklist 1: Drainage Design Report General Checklist

Item	Description	YES	NO	N/A	*
5	Other.				
SECTION 8: CANALS					
1	Are any canals located within the project boundaries?				
2	Is a discussion of backwater and overtopping issues provided, and are they adequately addressed?				
3	Other.				
SECTION 9: CONSTRUCTION PLANS					
1	Are all underground utilities identified in plan & profile?				
2	Is a utility "potholes requested" letter (as needed) for capital improvement projects provided?				
3	Are water, sewer, and natural gas service taps shown in plan & profile?				
4	Are all sanitary sewer manhole rims and invert elevations shown on plans?				
5	Is any existing Portland Cement concrete pavement underlay shown?				
6	Are storm drain conflicts with other utilities identified and addressed?				
7	Have SRP, RID, and private irrigation facilities been checked for conflicts?				
8	Are waterline thrust block conflicts identified and addressed?				
9	Are pipe support locations for sanitary sewer lines above main storm drains identified?				
10	Are existing topography and buildings shown at least 30 feet beyond street R.O.W.?				
11	Are intersecting side street elevations at least 100 feet beyond curb returns noted on plans?				
12	Are potential ponding locations behind sidewalks checked and resolved?				
13	Are driveway/catch basin conflicts checked and resolved?				
14	Are finished floors appropriately elevated relative to the peak 100-year water surface elevations?				
15	Is one typical full-street cross-section with storm drain and applicable other underground utilities shown to scale on each storm drain profile sheet?				
16	Does the mainline storm drain have a minimum of 5-foot of cover (unless otherwise approved)?				
17	Is the farthest upstream catch basin located to meet the flow depth criteria in Table 6.7?				
18	Do all catch basins have a maximum spacing meeting the criteria in Table 6.9?				
19	Have soil boring(s) extending at least 2 feet below the proposed storm drain been taken and shown on the plans or provided in a report?				
20	Are soil boring logs and information including pH and resistivity shown on plans or provided in a report?				

A.2 Checklist 1: Drainage Design Report General Checklist

Item	Description	YES	NO	N/A	*

A.3 Checklist 2: Hydrology Specific Checklist

Item	Description	YES	NO	N/A	*
SECTION 1: PROJECT DETAILS					
1	PROJECT NAME: NO: DATE:	REVISION			
2	SELECT PROJECT TYPE: ADMS <input type="checkbox"/> ADMP <input type="checkbox"/> WCMP <input type="checkbox"/> FDS <input type="checkbox"/> Development Review <input type="checkbox"/> Regulatory Review <input type="checkbox"/> Hydrology Study <input type="checkbox"/> Other <input type="checkbox"/>				
3	REVIEWED BY:				
4	Are both hard and electronic copies of HEC-1 input and output files included with submittal?				
5	Is the report sealed and signed by a professional Civil Engineer currently licensed to practice in Arizona?				
6	REPORT TITLE:				
7	CONSULTANT:				
8	LIST SOFTWARE, VERSION, and FILE NAMES:				
9	Is this a CIP PROJECT?				
10	Is the development located in a flood hazard area? Check Category: Floodway <input type="checkbox"/> Floodplain: A <input type="checkbox"/> AH <input type="checkbox"/> AE <input type="checkbox"/> AO <input type="checkbox"/> X <input type="checkbox"/> EHZ <input type="checkbox"/>				
11	Is there a section on Conclusions and Recommendations, and is it adequate?				
SECTION 2: HYDROLOGY MAPS					
1	Is a map provided that shows study area boundary, sub-basin boundaries, and concentration points?				
2	Check the sub-basin delineation. Are areas, soil and land use types, and topography homogenous for each sub-basin?				
3	Check sub-basin areas. Are areas measured correctly?				
4	Is the naming convention for sub-basins, concentration points, routing reaches, reservoir routes, and flow diversions identified?				
5	Is a map provided that shows time of concentration and hydrograph routing paths?				
6	Is a map provided that shows soils boundaries?				
7	Is a map provided that shows land use boundaries for both existing and developed conditions?				
8	Is the basis and method for estimating vegetation cover (existing and developed) described? Is the method appropriate?				
9	Was "no contributing runoff" assumed for properties with existing 100-year on-site retention, or properties with plans for 100-year on-site retention, which have been reviewed and approved by Maricopa County Planning & Development Services?				
10	Is there a description of watershed condition and watershed resistance? Is selection of K_b and/or K_n values discussed appropriately in that context?				
11	Other.				
SECTION 3: RATIONAL METHOD					
1	Is the maximum individual basin area less than or equal to 160 acres?				
2	If not, then the unit hydrograph method must be used.				
3	Are Runoff C Coefficients and K_b values selected appropriately for each land use type per Tables 6.3 and 6.4?				
4	Have existing land use runoff coefficients been used where contributory land is vacant or developed prior to stormwater storage requirements?				

A.3 Checklist 2: Hydrology Specific Checklist

Item	Description	YES	NO	N/A	*
5	If the Runoff C Coefficients or K_b values do not match the values for the appropriate land use categories in Tables 6.3 and 6.4, is there appropriate written justification and computations?				
6	Are there multiple land use types within individual basins?				
7	If so, are Runoff C Coefficients and K_b values area-averaged appropriately?				
8	Are site specific Depth-Duration-Frequency (D-D-F) values computed properly using PREFRE, and a printout and digital input/output files provided?				
9	Is the T_c path of appropriate location and length on the map?				
10	Is the T_c computed using the District's Rational Method computer program?				
11	If so, is a printout provided and do the input parameters match the report values?				
12	If not, check the iterative computations closely for each basin. Are they correct?				
13	Is each T_c value at least 5-minutes?				
14	Is the peak discharge for each basin computed properly and are the values reasonable?				
15	Is the Rational Method being used to compute peak discharges at intermediate locations within a drainage area less than 160 acres in size?				
16	If so, is the procedure outlined in Section 3.6.2 of the Hydrology Manual followed?				
17	Other.				
SECTION 4: UNIT HYDROGRAPH METHOD					
1	HEC-1 JOB CONTROL RECORDS				
a.	ID record. Are dates, project name, and modeler's name specified? Are they consistent with reports?				
b.	ID record. Are model revisions clearly identified on subsequent ID records?				
c.	IT record (NMIN). If NMIN has been revised, or changed for different models, were dependent parameters (UI, RM, NSTPS) adjusted appropriately?				
d.	IT record (NMIN). Is $0.1 T_c \leq NMIN \leq 0.25 T_c$ for the average value of T_c for the watershed, and the maximum and minimum values? Double check sub-basin delineation if extreme values of T_c make NMIN significantly outside the range.				
e.	IT record (NMIN). Is $NMIN < 0.25 * T_c$ for the sub-basin with the shortest T_c ?				
f.	IT record (NMIN). Can NMIN be adjusted so that NMIN is approximately equal to $0.15 T_c$ for the average value of T_c ?				
g.	IT record (NMIN). Is $60/NMIN$ an integer?				
h.	IT record (NMIN). Is NMIN equal to or evenly divisible by JXMIN on the IN record?				
i.	IT record (NMIN, NQ). Is $NMIN * NQ$ at least as long as the storm duration?				
j.	IN record (JXMIN). Is the IN record used correctly?				

A.3 Checklist 2: Hydrology Specific Checklist

Item	Description	YES	NO	N/A	*
k.	Is *DIAGRAM specified for at least one HEC-1 model in the study? One for each model with differences other than storm frequency.				
l.	IO record (IPRT). Is Level 3 or lower output used for at least one HEC-1 model in the study? One for each model with differences other than storm frequency? Level 3 should be used for the model of the largest storm.				
m.	JP record. Is $(NPLAN * NRATIO) < 45$?				
n.	JP record. Is $(NPLAN * NRATIO * NQ) < 4800$?				
o.	JD record. Are JD records used and applied appropriately?				
p.	JD record. When using JD records for FRS volume computation, were the interpolated volumes from each sub-basin used?				
q.	Other.				
2	PRECIPITATION AND RAINFALL DISTRIBUTION				
a.	Check rainfall frequency and duration in the report and HEC-1 files. Identify the source of rainfall data, i.e. NOAA Atlas 2, HMR-49. Is the source appropriate for the study area and type?				
b.	PB record. Specify rainfall depth. Is areal reduction applied correctly and discussed in the text?				
c.	PI and PC records. Were PC or PI records checked against the IN record?				
d.	PI and PC records. Were PC or PI records checked against distribution patterns?				
e.	Are design storm distributions applied correctly?				
f.	Other.				
3	RAINFALL LOSSES				
a.	Are Green-Ampt loss rate parameters specified and are the selected values for IA, DTHETA, XKSAT, PSIF, and RTIMP reasonable?				
b.	Is the watershed moisture condition assumption described for the selection of DTHETA?				
c.	Are there different moisture condition land uses present within individual sub-basins (agricultural and natural, for instance)?				
d.	If so, are the values area averaged appropriately?				
e.	Is area averaging of Green & Ampt parameters performed using the current version of DDMSW or by external means or old versions of DDMSW/MCUHP? Check those that use older versions of DDMSW/MCUHP more closely. Check those using external means very closely.				
f.	Is bare ground XKSAT adjusted for vegetation cover? Is the adjustment appropriate?				
g.	Does the watershed span multiple NRCS (SCS) Soil Surveys? Are differences in soil texture between adjacent soil surveys discussed in the text and addressed if necessary in the models?				
h.	Is there a discussion of natural RTIMP present in the watershed?				
i.	Is natural RTIMP assumed to be hydraulically connected, have any adjustments been made to the percentages listed for the soil types, and are the revisions reasonable and adequately documented?				
j.	Other.				
4	HYDROGRAPHS				
a.	Specify method of hydrograph generation, i.e., Clark, S-graph. Is the method appropriate?				

A.3 Checklist 2: Hydrology Specific Checklist

Item	Description	YES	NO	N/A	*
b.	UC record (T_c). Are T_c parameters L, S, and K_b reasonable?				
c.	Is $T_c < 90$ minutes for each sub-basin?				
d.	Does T_c exceed the duration of rainfall excess for any sub-basin? This should be documented in the text.				
e.	UC record (R). Is $R \geq 0.5 \times NMIN$?				
f.	UC record (T_c). Check against similar sub-basins. Are T_c values reasonable?				
g.	UC record (T_c). Were T_c values checked to ensure that average velocities throughout the watershed are reasonable?				
h.	HC record. Are hydrographs combined properly?				
i.	HC record. Is $HC \leq 5$?				
j.	HC record (TAREA). Is total area correct? Was area above the concentration point manually recalculated for diverted hydrographs?				
k.	Other.				
5	CHANNEL/PIPE ROUTING METHODS				
a.	Are specific channel/pipe routing method(s) specified, i.e. modified Puls, normal depth, Muskingum, Muskingum-Cunge, kinematic wave, and are the methods appropriate?				
b.	RC record (RLNTH). Check reaches lengths. Were lengths measured correctly?				
c.	RC record (ANL, ANCH, ANR). Were Manning's "n" values developed using methodology in <i>Estimated Manning's Roughness Coefficients for Stream Channels and Flood Plains in Maricopa County, Arizona</i> (April 1991)?				
d.	RC record (ANL, ANCH, ANR). Are Manning's "n" values reasonable?				
e.	RX and RY records. Are cross sections typical for the routing reach? If not, does the reach need to be broken into multiple reaches?				
f.	Are NSTPS generally equal to $L / (V_{avg} * NMIN)$?				
g.	Is NSTEP for each reach within +/- 1 of $TT/NMIN$, where TT is the travel time for the reach computed by HEC-1?				
h.	Are transmission losses modeled? If so, is there an acceptable discussion of the reasons for modeling losses, and the source of the parameters?				
i.	Are there questionable routing operations identified above that warrant plotting and visual examination of the hydrograph?				
j.	Other.				
6	RESERVOIR (STORAGE) ROUTING METHODS				
a.	Are USGS, FCDMC, NWS, or other rain or stream gages used in hydrologic analysis or model calibration identified and discussed?				
b.	Are stage-storage relationships modeled correctly?				
c.	Are stage-discharge relationships modeled correctly?				
d.	RS record. Are NSTPS = 1? If NSTPS is changed, travel time and attenuation will be affected.				
e.	RS record (ITYP, RSVRIC). Are starting conditions modeled appropriately?				
f.	Are rating curves for storage and outflow hydraulics included? Are the rating curves reasonable?				

A.3 Checklist 2: Hydrology Specific Checklist

Item	Description	YES	NO	N/A	*
g.	Is there an acceptable discussion of the basis for estimation of storage and outflow parameters in the text, and a discussion of reservoir routing results?				
h.	Other.				
7	DIVERSION DATA				
a.	DI/DQ records. Are diversions/split flows modeled correctly?				
b.	Are hydraulic computations for diversions done appropriately and included in the report?				
c.	Are rating curves for each diversion plotted and included in the report?				
d.	Are watersheds areas corrected using the HC record where diverted hydrographs are recalled into the model?				
e.	Other.				
SECTION 5: HEC-1 OUTPUT					
1	ERROR AND WARNING MESSAGES				
a.	Are there error or warning messages related to hydrograph generation or combination that are not adequately addressed in the test, or are critical?				
b.	Are there error or warning messages related to routing that are not adequately addressed in the text? Specifically check for peak discharge outside of specified range warnings and lack of hydraulic capacity for the reach cross-section.				
c.	Have error and warning messages been checked and corrected? Are error and warning messages explained adequately?				
d.	Other.				
2	SCHEMATIC DIAGRAM				
a.	Compare the schematic to the watershed map. Is the structure logical? Are all points labeled clearly? Specify any problems.				
b.	Are there < 9 hanging hydrographs?				
c.	Have all of the diverted hydrographs been accounted for?				
d.	Are all sub-areas attached and combined in the proper sequence?				
e.	Other.				
3	DRAINAGE AREA				
a.	Has the area associated with all returned diverted hydrographs been returned?				
b.	Check total drainage area. Is it accurate?				
c.	Other.				
4	RAINFALL LOSSES				
a.	Check the total rainfall, total losses, and total runoff for each sub-basin. Are there zeros or very small numbers? Explain.				
b.	Other.				
5	HYDROGRAPH ROUTING				
a.	Is outflow peak discharge < inflow peak discharge?				
b.	Is flow contained within x-sections?				
c.	Check travel time. Does travel time appear to be too short or too long? If so, check input parameters for routing. Check routing steps in the input against the output velocity.				
d.	Is attenuation of peak flows reasonable?				
e.	For kinematic wave routing, is the peak flow attenuated? If so, check model and revise.				

A.4 Checklist 3: HEC-RAS Hydraulics Specific Checklist

Item	Description	YES	NO	N/A	*
SECTION 1: PROJECT DESCRIPTION					
1	PROJECT NAME: NO: DATE:				REVISION
2	SELECT PROJECT TYPE: ADMS[] ADMP [] WCMP [] FDS [] Development Review [] Regulatory Review [] Hydrology Study [] Other []				
3	REVIEWED BY:				
4	Is there a project description?				
5	Does the description include the study name, District contract number, consultant name and address?				
6	Does the description include the purpose of the model (floodplain delineation study, channel project, ...)?				
7	Are the data sources identified?				
8	Are general assumptions listed?				
9	Are the events being modeled identified (100-year, SPF, multiple years, ...)?				
10	Is the project file name appropriate for the project? Names like a, b, job 1, and FIS are not acceptable.				
11	Is there an adequate map that shows the topography, cross sections, thalwegs, labels, floodplain and floodway limits, and left and right bank locations?				
12	Is the version of the hydraulic model used to do the study listed?				
13	Is there a section on Conclusions and Recommendations, and is it adequate?				
SECTION 2: FILES					
1	Note the number of geometry, flow data, and plan files. Should multiple models be created?				
2	Are the file names appropriate?				
3	Do the file names reflect the project name, and what each file includes?				
SECTION 3: FLOW DATA					
1	Are the changes in discharge input at the correct locations, and are the values correct?				
2	For floodplain studies are Floodplain (or FP) and Floodway (or FW) being used for the profile names?				
3	For other studies do the profile names reflect what is being modeled (25-yr, 50-yr, ...)?				
4	Are the upstream and downstream boundary conditions appropriate for the model?				
5	Are any internal rating curves or fixed changes in water surface elevations being used?				
SECTION 4: GEOMETRY FILE					
1	Are rivers and reaches named correctly? Names like a, b, and Job 1 are not acceptable.				
2	Are the junction names acceptable?				
3	Are the cross sections identified in river miles for floodplain delineations (feet may be used for Non-FEMA delineations)?				
4	Do cross section start and stop locations and length on the map match the geometry file?				
5	Are cross sections oriented with stationing from left to right looking downstream?				

A.4 Checklist 3: HEC-RAS Hydraulics Specific Checklist

Item	Description	YES	NO	N/A	*
6	Are cross sections stationed using 10,000 at the thalweg?				
7	Are comments included where appropriate in the cross section descriptions?				
8	Are reach lengths measured correctly? They should be measured at the center of the mass of flow.				
9	Are the bank station locations appropriate? Bank stations can be different for different events.				
10	Are contraction/expansion coefficients appropriate? (note: culverts may use larger values than bridges)				
11	Are blocked flow, levees, or ineffective flow being used, and used correctly?				
12	Are the n values appropriate? Do they include provision for mature landscape, both existing and proposed? (for design projects there should be a range of n values)				
13	Are bridges and culverts being modeled correctly? Is there pressure flow, weir flow, or both?				
14	Are any inline weirs or spillways being used?				
15	If yes, are weir coefficients acceptable and are they modeled appropriately?				
16	Are interpolated cross sections being used? If yes, why?				
SECTION 5: CALCULATIONS					
1	Does the plan file have an adequate description?				
2	Are the correct flow and geometry files being used?				
3	Is an appropriate starting WSEL method used and explained, and is it applied correctly?				
4	Are ineffective flow areas identified and addressed appropriately?				
5	Are there any breakouts?				
6	Are bridges and culverts modeled appropriately, including ineffective flow?				
6	Is the correct flow regime (sub, mixed, or super) being used (subcritical only for floodplain studies)?				
8	Are encroachments used?				
9	If encroachments are used, are they applied properly using the water surface or energy grade line and show < 1.0 foot increases at every cross section?				
10	Are the floodplain and floodway delineations done in accordance ADWR State Standards 2-96, 3-94 and 9-02?				
11	Is the flow distribution option turned on, if appropriate?				
12	Is the appropriate method used for conveyance calculations and the friction slope?				
SECTION 6: REPORT FILE					
1	Does the Report File printouts of all the input data including (geometry, flow, and plan)?				
2	Are all the profiles included in the output results?				
3	Are appropriate summary tables included?				
SECTION 7: REVIEWING THE RESULTS					
1	Check the Froude numbers; does critical flow (or close to critical flow) occurs anywhere?				
2	Does at least a portion of the flow occupy the channel?				

A.5 Checklist 4: Drainage Report/TDN Checklist

Item	Description	YES	NO	N/A	*
SECTION 1: COVER SHEET					
1	Is the Study Name included, and is it correct?				
2	Is the date correct?				
3	Are revision dates included?				
4	Is the consultant's name (address and telephone number) included?				
5	Is the District's contract number included?				
6	Are the cover and Table of Contents sealed by a professional Civil Engineer currently licensed to practice in Arizona?				
SECTION 2: DOCUMENT FORMAT AND LAYOUT					
1	Is the document prepared in accordance with ADWR SS 1?				
2	If new topographic mapping, survey notes and data are included, are they sealed by professional Land Surveyor currently licensed to practice in Arizona?				
3	Does the TDN Binder include all the labels and logos of the study partners, including FEMA?				
4	Are Section Corners labeled on the Study Maps?				
SECTION 3: MODEL PRINTOUT					
1	Are printouts from the hydrologic and hydraulic models included? Hydrologic and hydraulic models need to be fully documented in a way that isn't subject to change; therefore, printouts of the models must be included in the TDN.				
2	Do the printouts include the input data and the results?				
3	For HEC-RAS models, is a HEC-RAS generated report included?				
4	Do HEC-RAS report files include both the input data and the detailed calculation results? Printouts which contain only HEC-RAS summary tables are not acceptable.				
5	Do the units shown on the flood profiles, such as River Miles, match those used in the hydraulic models?				
6	Are all modeled reaches included in the Floodway tables?				
SECTION 4: COMPACT DISKS					
1	Are electronic copies of the hydrologic and hydraulic models included on CD? (mandatory) CDs are the only acceptable mediums at this time.				
2	Are all of the input and output files for all computer models used included on CD? (mandatory) In general the input files shouldn't be zipped, but if space is a problem it is acceptable to zip the output files.				
3	Is the CD labeled with such items as the study name, contract number, consultant's name, date, general description of what is on the CD, the names of all the watercourses studied or the names of all the files on the CD? (mandatory)				

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APPENDIX B STANDARD DRAINAGE EASEMENT

B.1 PURPOSE

The purpose of this appendix is to provide standard drainage easement language for conformance with Policy 3.13.3 and Policy 3.13.9. The user is advised to consult with legal counsel for the purpose of addressing individual issues specific to their situation. Drainage easements SHALL NOT be dedicated to the public, Maricopa County, to the Community or the Flood Control District of Maricopa County.

B.2 STANDARD DRAINAGE EASEMENT

For good and valuable consideration, receipt of which is hereby acknowledged, that ____ ENTER TRUST NAME AND NUMBER _____, AS OWNER (“DECLARANT”), hereby creates, conveys, and assigns to _____ SUBDIVISION NAME _____ HOMEOWNERS’ ASSOCIATION, AN ARIZONA NON-PROFIT CORPORATION (“HOA”), a drainage easement in perpetuity over and across that portion of the real property more particularly described hereon which is designated as a “Drainage Easement” hereon this final plat map.

HOA as the owner and holder of the Drainage Easement shall have the right (I) to access same at any time, and from time to time, without the permission or consent of the owner of any underlying fee interest of the property encumbered thereby or any third party, (II) to remove from or change the location of any obstructions within the Drainage Easement in order to promote and enhance such area as a channel for flood waters and natural runoff, (III) to trim or remove vegetation growing therein, (IV) to grade, excavate, channel or otherwise change the ground surface therein as may be required from time to time to maintain the drainage easement as a channel for flood waters and natural runoff, (V) to construct and maintain within the bounds of the drainage easement such drainage ways or other flood control structures or devices, as it may deem necessary or appropriate from time to time to utilize the drainage easement for flood control purposes, (VI) to install riprap and such other erosion control devices that may be appropriate from time to time in the drainage easement, and (VII) to take any and all such other actions and make any and all such other improvements as it may deem appropriate from time to time to promote the health, safety and general welfare.

No portion of the land included within the Drainage Easement as shown in final plat hereto shall hereafter be used by DECLARANT or any successor or assign in the ownership thereof to construct or maintain any wall, fence, building or any other above ground structure, except that with the prior written consent and approval of both the HOA and Maricopa County/Community, _____ ENTER TRUST NAME AND NUMBER _____, and its successors and assigns as the owners thereof may from time to time install riprap or other flood control devices provided the plans for such improvements have been specifically approved and authorized in writing by MARICOPA COUNTY/Community in its sole and reasonable discretion prior to the construction or installation thereof. Any such device or structure placed by an owner in the

drainage easement area shall thereafter be maintained in a state of good repair by an owner of the property where such device or structure is located. No portion of the land included within the drainage easement as shown in final plat hereto shall be used by DECLARANT or any successor or assign in the ownership thereof as the site for any septic tank. No landscaping plants or materials shall be placed by DECLARANT or any successor or assigns in the drainage easement, except for maintenance of native plant material now existing therein, unless such landscaping plants and materials are reflected on a landscaping plan that has been submitted to and specifically approved and authorized in writing by MARICOPA COUNTY/Community in its sole and reasonable discretion prior to installation thereof.

If at the time of the recording of the final plat for the real property more particularly described on final plat hereto the boundaries of the "Drainage Easement" as shown on the preliminary plat attached hereto as final plat shall have been changed or modified in any fashion, then, with the prior written consent and joinder of HOA, and the prior written consent of MARICOPA COUNTY/Community, the Drainage Easement created hereby shall be modified and amended to conform to the boundaries of the Drainage Easement as shown on such final plat, such amendment to become effective upon the execution and recording of a written amendment hereto executed by DECLARANT, HOA, and MARICOPA COUNTY/Community.

The Drainage Easement created hereby is and shall be a covenant that runs with the land encumbered hereby in perpetuity, but it is and shall remain an easement in favor of HOA and shall not be construed or interpreted to a dedication in favor of the public or any party other than HOA. No change, modification or amendment to this Drainage Easement shall be effective without prior written consent and agreement of both HOA and MARICOPA COUNTY/Community. MARICOPA COUNTY/Community may require any action or impose any restriction that MARICOPA COUNTY/Community considers reasonably necessary to meet the district's obligations, if any, to comply with local, state or federal water quality laws.

B.3 FINAL PLAT DRAINAGE EASEMENT MAINTENANCE AND DEDICATION

DRAINAGE EASEMENTS AMONG OWNERS: Drainage Easements Among Owners: Wherever drainage flows from one lot onto, under or through one or more lots, said drainage flow shall not be impeded, diverted or otherwise changed. No wall, fence, building or any other above ground structure shall be erected within the defined drainage easements as depicted on the final plat. No vegetation shall be planted within the drainage easements, which might impede the flow of flood waters or natural runoff, nor shall any lot owner alter the grade within the drainage easement.

MAINTENANCE: Drainage easements as shown on the final plat for (name of subdivision), are for the collection and conveyance of stormwater from off-site and on-site drainage sources. The owners of lots within (name of subdivision) that abut drainage easements platted hereon shall be jointly and severally responsible for maintaining said easements in a clean and debris-free condition, such that stormwater flows from upstream sources and from on-site sources shall not be slowed, impeded, redirected or diverted from said drainage easements. In the event the maintenance of any drainage easement requires expenditures of funds, then each owner abutting said easement shall contribute to the cost of such maintenance on a prorated basis. In the event the need for maintenance within any drainage easement is the result of actions or failure to act by a lot owner or lot owners abutting said easement, then the cost of such maintenance shall be borne solely by the abutting lot owners who brought about the need for the maintenance. Failure

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by any lot owner abutting a drainage easement to contribute his or her share of the costs of maintaining said easement shall entitle the other lot owners or any individual lot owner to enforce, by any proceeding at law or in equity the maintenance of said drainage easement. In the event a property owners association is formed, the maintenance of drainage easements platted hereon shall be assumed by the property owners association.

DEDICATION: Easements are provided hereon in the above-described premises as shown.

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REVISIONS

Because of ongoing regulatory and technical changes in the fields of drainage, floodplain, and stormwater management, revisions to this manual will be required from time to time. Such revisions will take place in accordance with the procedures contained in Chapter 8. Hard copy (printed) revisions will not be distributed. It is the holder's responsibility to keep the document current by periodically checking the web page for new digital versions. The revision history of this document is listed below.

Dates of Revisions

1st Edition: February 7, 2007

2nd Edition Draft: November 19, 2012

Section 4.4. Updated per changes in the Federal Register dated in March and May 2007.

Policy 3.11.1 Stormwater Retention for Developments. Added "Stormwater retention is not required for single (un-subdivided) residential parcels greater than one (1) acre in area".

Standard 6.2.1 Subsidence and Fissures. Changed title from "Subsidence and Fissures" to "Special Hazards". Added in alluvial fans and distributary flow areas as special hazards and a requirement for engineering plans in these areas.

Section 6.3.2, Rational Method Criteria, Table 6.3. Revised Rational C coefficients for land use class 140. Values were incorrect due to typographical error.

Section 6.3.3. Unit Hydrograph Method Criteria. Verbiage was revised to clarify the description of Tables 6.5 and 6.6

Section 6.4. Stormwater Quality. The First Flush peak discharge equation was revised to reflect a more reasonable estimate of first flush rainfall intensity.

Standard 6.4.1 First Flush. Corrected a typographical error in equation 6.2. Vff should be Qff. Added the source reference for equation 6.2.

Standard 6.7.14. Floating Debris Allowance for Bridge Modeling and Design. Verbiage was revised and scope of criteria expanded per input from MCDOT.

Standard 6.8.2 Floodplain Encroachment Requirements. Added verbiage to clarify that the Drainage Regulations for Maricopa County must also be met.

Standard 6.8.3 Channel Lining Requirements. The standard was revised to agree with Arizona State Standard SSA 7-98 "Watercourse Bank Stabilization.

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Standard 6.8.5, Table 6.14 Criteria for Artificial Channels. Corrected a typographical error in the table. Changed the maximum side slope designation for Grass from “(16%)” to “(25%).” Changed the maximum side slope designation for Earth from “(25%)” to “(16.7%).”

Standard 6.8.6 and 6.8.7. Added additional guidance for supercritical flow conditions.

Standard 6.10.7 Within Parking Lots. The word “public” was added to the first sentence after “any” and before “parking lot location.”

Standard 6.10.9 Underground Storage. Added a requirement for a 75-year design life instead of the standard 50-year design life stated under Section 6.1. Added design concerns that should be addressed.

Standard 6.10.10 Basin Drain Time Requirement. Revisions to the text to clarify the standard. No changes in criteria.

Standard 6.10.12 Permeability Test Requirement for Retention Basins. A complete rewrite and expansion of this standard was done to address user concerns brought up since the release of the 1st edition. Criteria were revised.

Standard 6.10.13 Drywells. Revisions to the text to clarify the standard and to set an upper limit on the design percolation rate.

Corrected other miscellaneous typographical errors and formatting revisions.

3rd Edition Draft: January 7, 2013

All references for the Floodplain Regulations for Maricopa County were changed to reflect correct call out from the updated 2011 version, including verbiage on Figures 4-1 and 4-2.

All references to the Drainage Regulations were changed to reflect the placement of the regulations into the Maricopa County Zoning Ordinance.

Reference to Sand and Gravel Mining Application Guidelines (page 3-1) was removed.

Policy 3.11.12 Storage Requirement Variance. Variance was changed to Waiver to reflect correct term.

Section 5.6 the following was added: The Maricopa County Stormwater Management and Discharge Control Regulation can be found at: <http://www.maricopa.gov/EnvSvc/QC/StormWater/pdf/swregulation.pdf>

Corrected other miscellaneous typographical errors and formatting revisions.

4th Edition Draft: January 26, 2016

Removed Resolution of Adoption.

Corrected other miscellaneous typographical errors and formatting revisions.

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Information was added regarding Green Infrastructure/Low Impact Development and water harvesting.

The term County was changed to County/Community through the document.

Removed sections 2.68 Rules of Development and 2.69 Drainage Guidelines and renumbered sections 2.6.8 through 2.6.11.

Removed sections 4.3.5 Application Process and 4.3.8 Floodplain Requirements for Alluvial Fans and renumbered sections 4.3.5 through 4.3.9.

Section 4.3.12 was renumbered to 4.4 and Sections 4.4 through 4.8 were renumbered.

Section 5.2 was renamed and added provision for Communities.

Section 5.4 Maricopa County Zoning Ordinance and Section 5.5 Maricopa County Subdivision Regulations were combined into section 5.4. The rest of chapter 5 was renumbered.

Section 5.9 Contact Information was removed.

Chapter 7 Individual Lot Development Outside of Subdivisions was added.

References to Chapter 7, 8, 9 and the number of chapter were revised.

Chapter 7 Revision Process and Chapter 8 Glossary were renumbered to Chapter 8 and 9.

Figures 4.1 Generic FEMA Floodplain Encroachment Permit: Individual Lots and Figure 4.2 Generic FEMA Floodplain Encroachment Permit: Subdivision, were removed.

Tables 6.12 Maximum Permissible Velocities for Unlined Channels and 6.13 Maximum Permissible Velocities for Grass-Lined Channels were removed. The tables 6.14 through 6.19 were renumbered.

List of Acronyms and Abbreviations: GI/LID Green Infrastructure/Low Impact Development was added.

Reference to the Maricopa County Drainage Regulations was changed to Maricopa County Drainage Provisions (Section 1205 of the Maricopa County Zoning Ordinance) through the document.

Section 1.1, a sentence was added to the last paragraph.

Section 1.3 was changed to define when drainage portion of this manual applies to communities.

Section 1.4 revised 2nd paragraph, regarding the Uniform Drainage Policies and Standards being superseded.

Section 2.1, 1st paragraph was revised to reflect the District's Vision. Item 10 revised and item 14 and last paragraph were added.

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Section 2 was revised; GI/LID, water conservation, water harvesting were added.

Section 2.4.1 ARS 48-3602 was changed to ARS Title 48 Chapter 21. Erosion hazard zones reference was changed from ADWR (1996) to FCDMC (2013) Hydraulics.

Section 2.6.3, items (a), (b), (c) (1) (2) (3) (d) (e) (f) and (g) were removed.

Section 2.6.7 was revised the reference to City of Phoenix Flood Hazard and erosion management district replace.

Section 2.6.9 Other Hazard Considerations, the FCDMC methodology was added.

Section 2.6.10, was revised to add high velocities, and unwanted erosion.

Section 2.6.11 Cost, the last two sentences were removed.

Section 2.7.1 and 2.7.2 reworded clarified.

Section 2.7.3 last sentence changed.

Section 2.8 the 2nd sentence of first paragraph changed, added a sentence to last paragraph.

Section 2.9 references were updated.

Section 3.1 3rd and 4th sentences of the 1st paragraph were removed. Regulations and ordinances references were updated.

Policies 3.3.2 and 3.3.3 were removed. Policies 3.3.4 and 3.3.5 were renumbered. Policy 3.3.4 Watercourse master Plan Requirements the last sentence was modified.

Policy 3.3.5 Permits was modified.

Policy 3.4.1 reference was added.

Policy 3.5.1 #2 last two sentences were added.

Policy 3.6.6 the 4th sentence was revised. The last sentence was added.

Policy 3.7.1 last sentence to 1st paragraph was added. Item 3 everything after the 1st sentence was removed.

Policy 3.7.3 modified to add District, Community approval.

Policy 3.7.4 modified to reflect current permitting naming.

Policy 3.7.7 revised to clarify and to add ADWR (1996) reference.

Policy 3.8.1 added last sentence.

Policy 3.8.5 last sentence expanded.

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Policies 3.8.8, 3.8.9, 3.8.10 and 3.8.11 updated.

Section 3.9 revised to add pedestrians and cyclists and 2nd paragraph added.

Policy 3.9.1 pedestrians and cyclists added. Green infrastructure and low impact development verbage added.

Policy 3.9.2 pedestrians, cyclists were added.

Policy 3.9.5 without County/District approval was removed.

Policy 3.10.1 reworded.

Policy 3.10.5 last sentence added.

Policy 3.10.8 reworded.

Policy 3.10.9 last sentence added.

Policy 3.11.2 reworded, last sentence added.

Policy 3.11.3 revised and expanded.

Policy 3.11.4 last sentence added.

Policy 3.11.6 reworded.

Policy 3.11.8 reworded and last sentence added.

Policy 3.11.9 last sentence added.

Policy 3.11.12 reworded. Item 5 was added.

Section 3.12 changed to within jurisdictional watercourses.

Policy 3.13.2 change Minor Land Divisions to Lot Splits.

Section 3.14 the 1st sentence was added to the 1st paragraph.

Section 3.15 references were updated.

Section 4.2 contact list updated.

Section 4.3.3 updated where FIRM's are available.

Section 4.3.4 item 1 rainfall changed to runoff event. Item 2 reworded.

Section 4.3.5 Approval Actions Taken by FEMA, the paragraph between items 4 and 5 was revised to reference current form. Item 6 was revised to include over a relatively small area. Item 7 reworded. The paragraph after item 7 was revised to reference current form. The last paragraph was updated.

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Section 4.3.6 BFE changed to RFE, reworded, next to last paragraph the last sentence was added. The opening requirements were added.

4.3.8 Maricopa County was changed to the District.

Section 4.3.9 the link to FEMA was changed.

Section 4.4 link was removed, State Standards were updated.

Section 4.5 was updated.

Section 5.1 the 1st paragraph, the 3rd sentence was removed.

Section 5.2 links removed.

Section 5.3 link was generalized to the District's main website.

Section 5.4 the link was generalized to Planning and Development's main website.

Section 5.6 the first sentence was removed.

Section 5.7.1.2 was change to from Grading and Drainage Permit to Building Permit.

Section 6.1 removes reference to Minor Land Divisions.

Section 6.2 1st paragraph public safety was added to the 2nd sentence.

Standard 6.2.1 updated.

Standard 6.2.2 can was change to shall.

Standard 6.2.3 the last sentence was modified.

Standard 6.2.10 was added.

Section 6.3.2 last sentence of 1st paragraph changed.

Table 6.3 Kb Type was change for Class 2000 and 2001.

Section 6.3.3 1st paragraph was changed to add more information regarding the use of the values in Table 6.5 and 6.6.

Table 6.7 The 2-year through 50-year, Channel adjacent to Arterial/All-Weather Access streets and the Channel adjacent to Collector streets for flow parallel to street, with curb and gutter was changed to 10-year frequency.

Table 6.7 the text in the 100-year frequencies column for the Lowest floor elevation for dwellings within a delineated floodplain on District's Flood Management Maps was revised.

Table 6.7 the Lowest floor within a Non-FEMA Delineated Floodplain was modified to add and not on the District's Flood Management Map.

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Table 6.7 the column under the 100-year frequencies by the Lowest floor not within a FEMA or Non-FEMA Delineated Floodplain was modified.

Table 6.7 Retention Basin, the item in the Flood Event Return Interval was changed.

Standard 6.6.4 2nd sentence was added. The second to the last sentence was added.

Standard 6.7.16 revised and updated.

Section 6.8 1st paragraph was revised.

Standard 6.8.2 item 1 modify regarding nongovernmental levees.

Standard 6.8.3 updated.

Table 6.11a was added.

Standard 6.8.4 the last sentence was added.

Standard 6.8.5 Table 6.2 and 6.3 of the DDM were referenced. The last paragraph was added.

Table 6.12 was modified.

Standard 6.8.6 was revised and updated.

Standard 6.8.7 item 1 last paragraph was added. Item 2 was modified for sand-ben channels. Item 3 was modified for governmental agency project.

Standard 6.8.9 the last sentence was added.

Standard 6.9.4 was modified to add landscape character.

Standard 6.9.5 was modified for governmental agency project only.

Standard 6.10.2 modified for clarification and added water harvesting language.

Standard 6.10.3 was updated.

Standard 6.10.4 item 2 was removed.

Standard 6.10.5 was expanded to include Subdivisions.

Standard 6.10.6 item 3 the last sentence was added. Item 5 the last sentence was modified.

Standard 6.10.10 was updated.

Standard 6.10.12 was updated.

Standard 6.10.15 was modified for landscaping.

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Standard 6.12.2 item 2 was removed.

Section 6.13.1 was modified the 5th paragraph was added.

Section 6.13.3 item 1 was removed.

Standard 6.15.2 was updated to include the seal expiration date.

Standard 6.15.5 item 4.D was modified to add junction types and invert elevations. Item 11 was modified to include relate profile sheet to the hydraulic design model and the construction plan set. Clarified item G, H, I, and J.

Section 6.16 updated the References.

Section A.2 item 30 was added.

Index was updated.

5th Edition Draft: June 1, 2016

Added Earth/Grass to type of channel Lining in Table 6.12.

Added Section 6.13 Numerical Models, renumber Sections 6.13, 6.14, 6.15, 6.16.

6th Edition Draft: Month day, 2018

Revisions notes moved from front of document

Table of Contents was updated

Updated list of Acronyms

Changed Flood Control District to Flood Control District of Maricopa County and FCD to FCDMC throughout the document

Section 1.1 updated and expanded the second paragraph

Section 1.5 updated Regulation adopted date

Sections 1.5, 3.11 and 5.2 updated Drainage Regulation reference for Maricopa County

Section 2.6.3 revised

Section 2.1 revised items 7 and 10, and made last paragraph bullet item number 15

Section 2.2 revised items 7 and 9

Section 2.4.1 modified definition for WCMP

Sections 2.4.2.1 and 2.4.3 updated reference to section 6.14

Section 2.6.5 expanded item 8 and split item 8 into item 9

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Section 2.7.4 added

Section 2.9 updated FCDMC, 2013 to FCDMC, 2018

Section 3.1 added Street Drainage to bullet list

Section 3.6 added System to Sewer System operator

Section 3.7.1 revised policies 3.7.2, 3.7.3, 3.7.4 and 3.7.9; added/inserted policy 3.7.6 and 3.7.7; renumbered policies 3.7.6 to 3.7.8, 3.7.7 to 3.7.9 and 3.7.8 to 3.7.10.

Section 3.9 replace FCDMC with The County/Community/District

Section 3.9.1 deleted last two sentences

Section 3.12 reworded

Section 4.3.1 added “and the Communities”, corrected grammar

Section 4.3.3 expanded

Section 6.3.2 and Section 6.3.3 Added Bold to text

Section 6.13.2.2 added bullet item #2

Section 6.17 add reference to the FCDMC, 2018, Drainage Design Manual for Maricopa County, Hydrology; the FCDMC, 2018, Drainage Design Manual for Maricopa County, Hydraulics, and the FCDMC, 2015, Standard Details.

Policy 3.10.9 expanded

Policy 3.11.4 expanded

Standard 6.2.1 corrected spelling

Standards 6.5.1, 6.6.4, 6.7.2, 6.8.1, 6.9.1, 6.10.1, 6.11.1 and 6.12.1; the reference to Section 6.15 was changed to 6.16.

Standard 6.6.4.a was added

Standard 6.7.14 was revised

Standard 6.8.2 corrected grammar

Standard 6.8.7 split item 2 and renumbered

Standard 6.9.2 added clogging factor for structural analysis

Standard 6.9.4 expanded

Standard 6.10.6 Item 3 revised

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Standard 6.10.5 Hyperlinks added

Standard 6.10.15 expanded

Table 6.3 and Table 6.5 revised heading and foot notes

Table 6.7 hyperlinks repaired

Table 6.11 column heading revised

Table 6.12 Concrete Artificial Channels revised footnotes

Section 7.3 add Policy 3.7.6 and 3.7.7, renumbered 3.7.7 to 3.7.9 and 3.7.8 to 3.7.10

Figure 7.1 added note

Section 8 Revision Process was revised

Section 9 Added community to Minor Land Division and Subdivision glossary terms.

Index was updated.

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Flood Control District

of Maricopa County

MEMORANDUM

Summary of Changes for the 6th Edition Draft of the Maricopa County Drainage Policies and Standards Manual dated June 28, 2018

KEY TEXT CHANGES

- Section 1.1 – updated and added the following to the second paragraph:
- “These policies and standards support the District’s Mission reduces risk from flooding so that property damage and loss of life is minimized, economic development is supported in a safe and responsible manner, stormwater is recognized as a resource for the long-term benefit of the community and environment.”
- Section 2.6.3 – removed reference to Waters of the U.S. (WOTUS) Definition.
- Section 2.1 – added statements to items 7 and 10 regarding groundwater recharge and preservation/conservation, and made last paragraph bullet item number 15.
- Section 2.2 – added statements to items 7 and 9 to encourage integrated, multi-purpose strategies and water conservation.
- Section 2.6.5 – added the following text to item 8, and made last paragraph bullet item number 9. “such as increased recreational spaces, natural desert and riparian visual aesthetics, and preservation of natural, pervious landscapes to reduce heat island impacts. These provide economic benefit through higher home values and reduced up-front infrastructure costs.”
- Section 2.7.4 – added new section which states: “**2.7.4 Pervious Concrete** The Maricopa Association of Governments’ Uniform Standard Specifications and Details for Public Works Construction, Section 323 allows for the use of pervious concrete. Per Section 323 pervious concrete “is usually part of a water management system used to reduce runoff rates and volumes from on-grade surfaces such as patios, walkways, driveways, fire lanes, and parking spaces...intended for light traffic areas”. Refer to Table [6.3](#) & [6.5](#) for runoff C coefficients and developed condition parameters.”
- Section 3.1 added Street Drainage to bullet list
- Section 3.7.1 FEMA – revised policies 3.7.2 and 3.7.3 to match the Code of Federal Regulations and to clarify the FEMA approval date for LOMR is the effective date on the LOMR not when FEMA approves the LOMR. This gives FCD & P&D staff guidance and provides consistency when permitting development affected by a LOMR. This also lets the developers affected by a LOMR know the process upfront.; 3.7.4 and 3.7.9 to match the updated Floodplain Regulations; added policies 3.7.6 and 3.7.7 (These were added as a results of permit cases that had comments, questions and direction from the supervisor’s level. They were added to provide consistency in plan review and to provide direction to applicants for what is required for permits.); renumbered policies 3.7.6 to 3.7.8, 3.7.7 to 3.7.9 and 3.7.8 to 3.7.10.

- Section 3.9.1 – deleted last two sentences related to use of green infrastructure for street drainage.
- Policy 3.10.9 – the following text was added: “integrated drainage design, utilizing natural drainages and”
- Policy 3.11.4- the following text was added: “integrated storage design, utilizing natural approaches and”
- Section 4.3.3 – added the following language: “and used by the insurance industry to determine flood insurance rates. Areas considered within the SFHA includes the boundary line as shown on the FIRMs. If part of the structure is located within the SFHA the whole structure is considered in the SFHA.”
- Standard 6.6.4.a – the following new text was added: Utility Profiles
- “Vertical alignments of proposed utility, water and sewer lines must be carefully evaluated and designed when coming into contact with existing drainage infrastructure. Minimum separation between the proposed utility line and existing drainage infrastructure shall be four feet (4’) vertical as measured from the bottom of the existing structure and two feet (2’) as measured from the top of the existing infrastructure. The utility line shall be placed so that there is no change in grade as it crosses the existing infrastructure. Refer to Flood Control District of Maricopa County Standard Detail FCD404-1. In cases where a new utility line is installed at the same time as the new District drainage infrastructure, the separation should be two feet (2’) both top and bottom.”
- Section 6.13.2.2 – the following language was added as bullet item #2 and #3:
- USAACE HEC-RAS River Analysis System, version 5.0.3 or latest version.
- Other industry-common 2D software may be used with justification provided by the engineer of record that the software is appropriate for the use. This may include FEMA-approval and/or documentation illustrating that the software is appropriate to use in the given situation.
- Standard 6.7.14 – the following text was added: “For supercritical flows, see Standard 6.7.17 for additional freeboard requirements.”
- Standard 6.9.2 – the following text was added: “A clogging factor of 100 percent shall be used in the structural analysis of all trash racks.”
- Standard 6.9.4 – the following text was added: “mimic natural features in design. If space limits opportunities to include mimicked natural features, built structures should”
- Standard 6.10.6 – the following text was added to Item 3: “In Special Flood Hazard Areas or Special Flood Hazard Areas shown on the Flood Management Maps for Maricopa County, tThe”
- Standard 6.10.15 – the following text was added/amended: “support County-wide water conservation efforts by utilizing xeriscaping concepts with low-water, desert-tolerant plant materials in conjunction with rainwater harvesting and stormwater reuse features, when possible to reduce potable water use for outdoor irrigation. Designs should ~~show accommodation~~ allow”
- Section 8 Revision Process – revised to reflect change of procedure from Adoption by the Board of Directors to being a best practices Substantive Policy Statement, adding addition of communities to committee and routing process.

MINOR UPDATES OR FORMATTING CHANGES

- General Correction throughout of contact information or dates of documents/regulations as needed
- Revisions notes moved from front of document to back after appendices
- Table of Contents was updated
- Updated list of Acronyms
- Changed Flood Control District to Flood Control District of Maricopa County and FCD to FCDMC throughout the document
- Section 1.5 updated Floodplain Regulations adopted date
- Sections 1.5, 3.11 and 5.2 updated Drainage Regulation reference for Maricopa County
- Section 2.4.1 grammatical correction to definition for WCMP
- Sections 2.4.2.1 and 2.4.3 corrected reference to section 6.14
- Section 2.9 updated FCDMC, 2013 to FCDMC, 2018
- Section 3.6 added System to Sewer System operator
- Section 3.9 replace FCDMC with The County/Community/District
- Section 3.12 grammatical corrections to sentence
- Section 4.3.1 added “and the Communities”, corrected grammar
- Standard 6.2.1 corrected spelling
- Section 6.3.2 and Section 6.3.3 Added Bold to text
- Standards 6.5.1, 6.6.4, 6.7.2, 6.8.1, 6.9.1, 6.10.1, 6.11.1 and 6.12.1; the reference to Section 6.15 was changed to 6.16.
- Standard 6.8.2 corrected grammar
- Standard 6.8.7 split item 2 and renumbered
- Standard 6.10.5 Hyperlinks added
- Table 6.3 and Table 6.5 revised heading and foot notes
- Table 6.7 hyperlinks repaired
- Table 6.11 column heading revised
- Table 6.12 Concrete Artificial Channels revised footnotes
- Section 6.17 add reference to the FCDMC, 2018, Drainage Design Manual for Maricopa County, Hydrology; the FCDMC, 2018, Drainage Design Manual for Maricopa County, Hydraulics, and the FCDMC, 2015, Standard Details.
- Section 7.3 add Policy 3.7.6 and 3.7.7, renumbered 3.7.7 to 3.7.9 and 3.7.8 to 3.7.10
- Figure 7.1 added note
- Section 9 Added community to Minor Land Division and Subdivision glossary terms.
- Index was updated.