



# Stormwater Management Studies

PDS

Engineering Services Division

ES Policy # 3-01

Revised Date: 10/12/2015

## INTRODUCTION

The City of Overland Park requires submission of a stormwater management study as part of the development plan application. This study is required for new development, and may also be required on redevelopment of existing property.

The goal of these studies is to identify existing and potential drainage problems and delineate required stormwater treatment facilities early in the development process so that positive steps can be taken to address the problems and to document the final decisions made.

In general, the process for stormwater management studies will include the following steps:

1. ***At Initial Rezoning, Preliminary Development Plan, or Preliminary Plat:*** Submit a preliminary stormwater management study. A flood study may also be required at this stage.
2. ***At final development plan or final plat:*** If significant changes to the plan have been made, staff may require an updated and/or more detailed preliminary stormwater management study.
3. ***During development of construction documents:*** A final stormwater management study will be required. The final study will document the actual proposed construction and stormwater design elements.

## RELATED DOCUMENTS

Engineering Services Division Policy # 3-02 - U.S. Army Corps of Engineers' 404 Permitting Requirements.

<http://www.opkansas.org/wp-content/uploads/downloads/US-Army-Corps-of-Engineers-404-Permitting-Requirements.pdf>

Engineering Services Division Policy # 3-07 – Stream Corridor Development Plan Requirements.

<http://www.opkansas.org/wp-content/uploads/downloads/Stream-Corridor-Development-Plan-Requirements.pdf>

## **GENERAL REQUIREMENTS FOR ALL STUDIES:**

### **Submittals:**

- A. Two (2) copies of all stormwater management studies will be required.
- B. All studies, both preliminary and final, must be prepared by or under the direct supervision of a Professional Engineer Registered in the State of Kansas, who must sign and seal the study.
- C. All studies must be bound, and should include a cover sheet indicating project name, location, City assigned project number (when available), date, and approval signature block for the City.
- D. The study shall include a narrative section and engineering calculations as outlined under specific study requirements.
- E. Printouts from various computer programs used in preparation of the study shall be included as an appendix.
- F. All mapping required shall be bound in the study, or placed in bound pockets within the study. Mapping shall not be submitted separate from the study.
- G. Determinations from other regulatory agencies, including the Corp of Engineers, Division of Water Resources, FEMA, etc, shall be incorporated as an appendix to the study.
- H. Data files (digital) – The submitted stormwater management study shall include all input and output files in a digital format for all computer programs used in preparing the stormwater management study/report. Two (2) copies of all data CD's are required.
- I. Related Studies, (e.g. wetlands determinations, stream bank stability studies, etc.) shall either be included as an appendix or separately bound. In either case, the narrative shall refer to these studies and their location.

### **Computational Methods:**

Engineering calculations for Stormwater Management Studies must conform to the following acceptable methods:

- A. ***Peak Runoff Computation for Storm Sewer Design:***
  - Rational Method, TR-55, or other approved methods.
- B. ***Storm Sewer Design:***
  - Capacity – Manning formula, inlet and outlet control.
  - Head water elevations – Bernoulli equation.
  - Design Storm for enclosed storm sewers – 10-year (10%) for storm sewers, 25-year (4%) for cross road pipes at thoroughfares & collectors.
  - Design Storm for combined open, enclosed and overflow systems: 100-year.
- C. ***Detention Design*** – When it is determined that stormwater detention is required, the applicant should consult with City staff and obtain approval for software packages prior to starting calculations.
- D. ***Open Channel Flow*** – All computations should be based on the EGL and not the water surface.
  - Mannings equation, broad crested weir formula, HEC-RAS computer model, as appropriate.
- E. ***Water Quality Event Peak Runoff and Volume Calculations*** – Utilize the methods outlined in Chapter 6 of the MARC/APWA BMP Manual.
- F. ***Overland Park Municipal Code References and Stormwater Criteria:***
  - OPMC 15.10 – Stormwater Management Program – Standards and Permitting  
<http://www.opkansas.org/wp-content/uploads/downloads/1510-Stormwater-Management-Program-Standards-and-Permitting.pdf>
  - OPMC 18.360 – Floodplain Management  
<http://www.opkansas.org/wp-content/uploads/downloads/18360-Floodplain-Zoning-Ordinance.pdf>
  - OPMC 18.365 – Stream Corridor Requirements

<http://www.opkansas.org/wp-content/uploads/downloads/18365-Stream-Corridor-Requirements.pdf>

- OPMC 16.210 – Stormwater Treatment  
<http://www.opkansas.org/wp-content/uploads/downloads/16210-Stormwater-Treatment.pdf>
- APWA Section 5600  
<http://kcmetro.apwa.net/chapters/kcmetro/specs/APWA5600.pdf>
- Design Criteria – Stormwater Conveyance Facilities  
<http://www.opkansas.org/wp-content/uploads/downloads/design-and-construction-standards-vol-1.pdf>
- Design Criteria – Stormwater Treatment Facilities  
<http://www.opkansas.org/wp-content/uploads/downloads/design-and-construction-standards-vol-1.pdf>

### **Waivers:**

Engineering Services may waive submission of a study/report, or any part of the study/report, where site conditions warrant. However, it is the applicant's responsibility to provide written documentation why a waiver is appropriate.

### **PRELIMINARY STORMWATER MANAGEMENT STUDY**

The goal of the preliminary stormwater management study is to ensure that stormwater runoff from the development will not have an adverse impact on existing development, to ensure that all existing and proposed structures shall be protected from flooding, and to ensure that there is adequate space on the site for required stormwater conveyance and treatment facilities.

### **Scope:**

The preliminary stormwater management study must include the following minimum items. For critical areas, staff may modify the scope as necessary to address individual site needs.

- A. ***Identification of Downstream Drainage Issues:*** Analyze the drainage system downstream from the development and determine system deficiencies. In most cases, the downstream analysis must extend to a point where the contributing drainage area from the project site is less than 10% of the total downstream drainage area. Previously identified problem areas further downstream should also be referenced in the report.

- B. **Preliminary Onsite Drainage System:** Prepare a plan showing the preliminary stormwater drainage system. The preliminary drainage system should show:
- Pipe system alignment (sizing not required).
  - Overflow system path (sizing may be required for large overflows). Include an evaluation of building/parking site layout with relation to overflow drainage. Overflow drainage must allow for 1 foot freeboard from Energy Grade Line (EGL) to structure low opening. Maximum flow depth in parking/driving areas shall be 7 inches.
  - Show building finish floor elevations for comparison with flood elevations.
  - How stormwater treatment facilities are integrated into the stormwater conveyance system. This shall include the routing of the 100-year storm peak flows through the stormwater treatment facilities.

*Note: Mannings “n” values for above-ground conveyance elements utilized as stormwater treatment facilities (bioswales, native vegetation swales) are typically greater than for turf swales. The Manning’s “n” values utilized in design shall be selected in accordance with the guidance provided in Table 4 and Figures 13-18 of the “Handbook of Channel Design for Soil and Water Conservation” (Natural Resources Conservation Service, SCS SP-61).*

- C. **Drainage Computations:** At a minimum, the following drainage computations will be required. In critical areas, staff may require additional drainage computations to help ensure that a project is viable as designed. In ALL cases, full upstream development should be assumed using the City’s land use map for determining estimated impervious areas. Upstream stormwater detention should be assumed to not be present for design flow purposes.
- Design flows (10 and 100-year) entering the site from all upstream tributary areas.
  - Design flow leaving the site at each downstream outfall.
  - Water Quality event flows and volumes for each proposed stormwater treatment facility. See Chapter 6 of the MARC/APWA BMP Manual.
- D. **Flood Control Detention:** The preliminary stormwater management study must investigate the need for detention on the proposed development site. Stormwater detention may be required if any of the following occur:
- The proposed development would cause or increase flooding of downstream buildings.

- The proposed development would cause or increase substantial roadway flooding.
- Other adverse impacts that could be mitigated by detention.
- In some instances, downstream improvements may be proposed in lieu of detention.

E. **Flood Control Detention Requirements:** If it is determined that stormwater detention is required for a site, the following information must be submitted:

- Preliminary detention volume and surface area computations\*.
  - Design Computations must analyze the existing and proposed site conditions for the 10-yr and 100-yr storms using the HEC-1 storm distribution for the 24hr storm duration.
  - The outflow from the proposed site must not exceed the outflow from the existing site in the 10-yr storm.
  - The Detention Basin must be sized to hold the volume of the 100-yr storm less discharge without utilizing the auxiliary spillway. The auxiliary spillway must be sized to convey the second 100-yr storm discharge assuming the basin is full.
- Site plan showing how the required detention area will be incorporated into the overall development.

\*For approval of Rezoning, Preliminary Development Plans, and Preliminary Plats, reserving an effective detention volume of 10,000 cubic feet per acre is acceptable in lieu of providing actual computations. If this method is used for determining rough area requirements for detention, a revised preliminary stormwater study including actual detention modeling must be completed and submitted prior to approval of a Final Development Plan or Final Plat. For detention facilities that will provide both flood control and extended detention of the Water Quality Volume (WQv), the WQv shall be added to the reserved effective detention volume to determine the total volume and surface area requirement for the facility.

F. **Stream Corridors:** OPMC requires the preservation of most natural streams and reservation of a stream corridor on each side of existing stream channels in accordance with OPMC Chapter 18.365.  
[http://www.opkansas.org/Assets/law/opmc/opmc\\_by\\_chapter/18-365.pdf](http://www.opkansas.org/Assets/law/opmc/opmc_by_chapter/18-365.pdf)

The size of the Stream Corridor is measured from the Ordinary High Water Mark (OHWM) in accordance with the following:

<b>Drainage Area (acres)</b>	<b>Distance Beyond OHWM (feet)</b>	<b>Stream Preservation Required</b>
< 25	15	No *
>=25 to 40	30	No *
>=40 to 160	60	Yes **
>=160 to 5000	100	Yes **
>=5000	120	Yes **

\* Stream Corridor reservation is at option of developer. See OPMC section 18.365.040 B and C for additional restrictions.  
 \*\*Exceptions available for short stream segments – see OPMC 18.365.040A for additional information.

Land disturbances in a stream corridor during construction is highly restricted. There are also use limitations. See OPMC 18.365

[http://www.opkansas.org/Assets/law/opmc/opmc\\_by\\_chapter/18-365.pdf](http://www.opkansas.org/Assets/law/opmc/opmc_by_chapter/18-365.pdf)

and Engineering Services Policy # 3-07 for additional information.

[http://www.opkansas.org/Documents\\_and\\_Forms/stream\\_corridor\\_requirements.pdf](http://www.opkansas.org/Documents_and_Forms/stream_corridor_requirements.pdf)

For purposes of the Preliminary Stormwater Management Study, the following information must be included on maps included in the study:

- Proposed limits of disturbance adjacent to the stream corridor.
- Tributary Area of stream entering and leaving the site.
- Breakpoints in tributary area along the stream as illustrated in the table above and at the confluence of significant side channels entering the stream corridor.
- Location of the OHWM on both sides of the stream. For very small streams, showing the stream centerline in lieu of the OHWM is acceptable.
- Offset distance from the OHWM and the edge of the stream corridor at each significant change in offset distances.
- Locations for any existing or proposed utility crossings or encroachments into the stream corridor.
- Identification of proposed uses and locations within the stream corridor.
- Location of significant stands of trees or other vegetation within the stream corridor.

G. ***Stormwater Treatment Requirements:***

The Preliminary Stormwater Management Study shall include sufficient information to evaluate the existing environmental characteristics of the site, the impacts on water quality as a result of the proposed development, and how these impacts will be controlled or managed. If stormwater treatment facilities will not be implemented on the site, evidence shall be provided indicating that the site meets the exception conditions described in OPMC 16.210.030. If a deviation for the site is requested, sufficient evidence shall be provided in support of the deviation in accordance with OPMC 16.210.060.

The Preliminary Stormwater Management Study must determine the required footprint for all stormwater treatment facilities proposed for the site. Adequate documentation shall be included to verify the required size, type, and location of all stormwater treatment facilities.

In order to meet the above three goals, the Preliminary Stormwater Management Study shall, at a minimum, include documentation of the following steps:

1. Written or graphic inventory of the natural resources on the site, including soil conditions, vegetative cover, topography, and other native vegetation areas on the site.
2. Identification of and a preliminary plan for control of any stormwater "hot spots" as indicated in the MARC/APWA BMP Manual Section 4.4.
3. Inventory map of existing soil types and land usage for determining a Curve Number for the existing site.
4. Summary of proposed or assumed site uses and impervious cover percentage.
5. Description of development impacts and Level of Service calculations on MARC/APWA Manual Section 4 Worksheet 1 for an undeveloped site or on Worksheet 1A with Tables 3 and 4 for a developed site that is to be redeveloped.
6. Proposed stormwater treatment facility types and locations in plan.
7. Maps and/or plans indicating the tributary drainage areas for each stormwater treatment facility proposed for the site and how the 100-year storm peak flow will be routed through each facility.

8. Identification of areas to be utilized for the Additional Treatment Credit for Stream Corridor Management Practices. Required information shall include:
  - a) A plan that shows a clear indication of those areas to be preserved (for “excellent”, Category 3 Quality Ratings) and those areas to be enhanced or restored (for “poor”, Category 1 or “fair”, Category 2 Quality Ratings) within the stream corridor and their associated value ratings (see City of Overland Park Stormwater Treatment Standards).
  - b) A completed “Overland Park Stream Riparian Corridor Quality Rating Form” with photos documenting existing stream conditions.
  - c) A sufficiently detailed clearing and planting plan for those areas to be enhanced or restored to verify that the proposed enhancement or restoration will meet an “excellent”, Category 3, Riparian Corridor Quality Rating when completed.
9. Mitigation Package Calculations, including completed Worksheet 2 from the MARC/APWA BMP Manual. For a redevelopment site, utilize Worksheet 1A and Tables 3 and 4 in lieu of Worksheet 1.
10. Proposed stormwater facility types and locations in plan.
11. Typical section for each proposed stormwater treatment facility type.
12. Water Quality Control Volume (WQv) and/or Peak Flow utilized in sizing design of the stormwater treatment facilities (see next item).
13. Summary of required surface area for each stormwater treatment facility, including the WQv, maximum ponded depth, and peak WQ discharge rate (as applicable). In general, preliminary sizing for stormwater treatment facilities can be determined using the guidelines provided in Chapter 8 of the MARC/APWA BMP Manual as follows for each category of stormwater treatment facilities:
  - a) Storage and/or infiltration type facilities (bioretention, extended detention, etc.): The footprint is typically found by dividing the WQv by the maximum ponded depth allowed for each stormwater treatment facility per Chapter 8 of the MARC/APWA BMP Manual.

- b) Swales: The footprint will require both a calculation of the WQv and the peak discharge rates indicated in Chapter 8 of the MARC/APWA BMP Manual for each swale type.
  - c) Porous Pavement and Media Filtration Practices: Sizing is dependent upon runoff volume and media filtration rates; refer to Sections 8.5 and 8.7 of the MARC/APWA BMP Manual for simplified volume and surface area sizing calculations.
  - d) Proprietary Systems: Sizing criteria will vary by manufacturer; provide product data and corresponding peak discharge rates and volumes and depths can be achieved within the constraints of the site.
- 14. Required easements, tracts, setbacks, and access routes for each proposed stormwater treatment facility, in accordance with the Stormwater Treatment Standards and Chapter 8 of the MARC/APWA BMP Manual. Easements shall be sized to include the total area required for construction and ongoing maintenance of each stormwater treatment facility. This shall be shown graphically on a site plan and summarized in the text.
  - 15. Preliminary grading plan, including retaining walls, to ensure required storage volumes and depths can be achieved within the constraints of the site.
  - 16. The party responsible for long-term maintenance of the stormwater treatment facility.
- H. ***Corps of Engineers Requirements***: Determine the Corps of Engineers requirements (See Related Document on Corp of Engineer's Section 404 submittal requirements).

[http://www.opkansas.org/Documents\\_and\\_Forms/404\\_permits.pdf](http://www.opkansas.org/Documents_and_Forms/404_permits.pdf)

A qualified expert in 404 permitting must prepare a technical study to determine the "waters of the U.S." Corps of Engineers jurisdiction, including identifying the limits of potential wetlands, and determine whether a Nationwide or Individual permit will be required. Include a narrative section that summarizes the requirements along with appropriate maps of all "waters of the U.S." and jurisdictional wetlands. Additionally, all correspondence from the Corps of Engineers should be included in an appendix.

- I. **FEMA/DWR Requirements:** In the event a developer wants to alter floodplain boundaries, a professional engineer must prepare a flood study as detailed below under FLOOD STUDY. A flood study may be required with submission of the preliminary development plan.
- J. **Maps:** The submitted preliminary stormwater management study shall include, at a minimum, the following maps:
  1. **Site Map:** A site map at a scale of 1" = 50 feet or greater, and a maximum contour interval of 2 feet. The site map must include existing topographical information of the site to be developed and adjoining land whose topography may affect the proposed layout or drainage patterns for the development. The source of the topographic information should be indicated on the map. The map shall show all existing streams, waterways, channels, the extent of both FEMA and non-FEMA floodplains, waters of the U.S. and jurisdictional wetlands.
  2. **Drainage Map:** A drainage area map at a scale of 1" = 200 feet or greater, and a maximum contour interval of 2 feet. In cases where there are large offsite areas draining to a site making 2 foot contours impractical, a larger contour interval may be allowed. The drainage area map should include all off-site drainage, including pipe network information, that drains to the site and all on-site drainage that leaves the site (to the next downstream storm drainage conveyance).

## FLOOD STUDY

In addition to the above information required for the preliminary stormwater management study, if the development plan includes a significant natural stream, drainageway, or open channel, a flood study may be required. The goal of the Flood Study may include any one or more of the following:

- Verification that any fill placed in the floodplain will result in no adverse impacts, including no rise in flood elevations (or Energy Grade Line) beyond the limits of the property
- Determination of the location of the FEMA Special Flood Hazard Area and/or Floodway
- Establishing minimum floor and/or low opening elevations for buildings
- Determining depth of flow in parking lots and streets

If the plan proposes fill in a federally regulated floodplain, refer to OPMC Chapter 18.360 [http://www.opkansas.org/ Assets/law/opmc/opmc\\_by\\_chapter/18-360.pdf](http://www.opkansas.org/Assets/law/opmc/opmc_by_chapter/18-360.pdf) for the City's floodplain management criteria. Often, the proposed change must be submitted to FEMA as a Letter of Map Revision (LOMR) or Letter of Map Revision based on fill (LOMR-F).

If either a LOMR or a Conditional Letter of Map Revision (CLOMR) for placement of fill in the floodplain is required, it is advisable to submit the LOMR or CLOMR application with the flood study since City approval of the application is required prior to submittal to FEMA. In addition, a Floodplain Development Permit from the Building Safety will be required at the time a building permit is issued.

In addition to the FEMA related documents, other State and Federal permits may be required prior to issuance of City permits, including but not limited to a Section 404 Permit from the Corps of Engineers, and a Stream Obstruction Permit from the Kansas Department of Agriculture, Division of Water Resources.

### **Scope:**

The Scope of a Flood Study must include the following minimum items. For critical areas, staff may modify the scope as necessary to address individual site needs.

#### **A. Modeled Conditions:**

***Attachment A*** summarizes required model conditions related to design storm, watershed development level, and physical site conditions.

#### **B. *Input and Output Data:***

Include HEC-RAS tabular output at each cross section showing the following data fields:

- Reach
- River Station
- Profile (Modeled Flow – i.e. 1% existing, 1% planning, 0.2% planning etc)
- Total Flow
- Minimum Channel Elev (Flowline)
- Water Surface Elev
- Critical Water Surface Elevation
- Energy Grade Line Elevation
- Energy Grade Slope
- Channel Velocity

Include cross section printout data (graphical) including water surface elevations for each modeled condition.

Include stream profile printouts (graphical) including water surface and energy grade line elevations for each modeled condition.

- C. **Summary Table of Results:** Include a table of results that includes the following information at pertinent cross sections for all modeled conditions.
- Q – Flow rates
  - WSEL - Water surface elevation
  - EGL – Energy grade line
  - Delta EGL and Delta WSEL – Show the change in the modeled EGL and WSEL during the design storm for all modeled physical conditions.
- D. **Floodplain Boundary Changes:** The report must include a discussion of proposed changes, if any, to the floodway or floodway fringe boundaries.
- E. **Effects on Adjoining Property:** The report must include a discussion of the possible effects that proposed development could have on area adjoining the development.
- F. **Cross Section Spacing:** In areas where adjacent lots are, or will be developed and the Flood Study is being utilized to establish Minimum Low Opening Elevations or Minimum Property Grades, cross section spacing shall be sufficient so that there is a maximum EGL differential of **1 foot** between cross sections. **Greater EGL differentials may be accepted in areas of very steep and uniform grade, where the potential errors introduced by interpolation are less, or where adjacent ground is well elevated and the possible errors less critical.**

### **Maps:**

The submitted Flood Study shall include, at a minimum, the following maps:

- A. **Site Map:** The site map should be at a scale of 1" = 50 feet or greater and include the following information:
- Existing and proposed contours at a maximum 2' contour interval
  - Source of the contour information (i.e. AIMS maps, field survey etc)
  - Plans must be referenced to State-Plane coordinate system.
  - Benchmark and datum (tied to 1988 NAVD (Johnson County Datum)
  - Stream centerline
  - Pre-construction and Post-construction 1% (100 year) floodplain for both existing and ultimate (planning) flows.

- Limits of the Floodway (if applicable)
  - Proposed site infrastructure
- B. **Drainage Area Map:** A drainage area map at a scale appropriate for the size of the watershed. The drainage area map should include all off-site drainage that drains to the site.
- C. **Cross-section Map:** An overall plan view map indicating the locations and river station of modeled cross sections in the vicinity of the project. The cross sections shown should extend upstream and downstream from the project beyond the distance that is affected by proposed fill in the floodplain.

**Updates to County Watershed Models:**

If the proposed project is in an area modeled by a County Watershed Model, and the proposed project alters grades in the floodplain, the City requires that the model data be provided in a format so that the County Watershed Model can be kept current. In those cases, Engineering Services Staff will request the following data in addition to the flood study report:

- A. **Two copies of Project Data as follows:**
1. HEC-RAS files containing:
    - Duplicate Effective Model (include date of model obtained from County – the project must start with the CURRENT model)
    - Existing Conditions Model
    - Post Development Model
  2. Plan Data Files in AutoCAD or Arcview GIS compatible format including the same mapping information shown in the flood study
- B. **AFTER construction of the improvements** and prior to a Final Certificate of Occupancy/Completion, submit a letter sealed by the design engineer stating that the Engineer certifies that the as-built cross section and contour data within the flood plain conforms with the previously submitted data disks (or if changes have been made, a replacement data disk with revised plan data and HEC-RAS runs must be submitted and approved).

## **FINAL STORMWATER MANAGEMENT STUDY**

The goal of the Final Stormwater Management Study is to document the final design of the proposed stormwater conveyance and treatment facilities. The study must document that stormwater runoff from the development will not have an adverse impact on existing development, that all proposed structures and parking areas are adequately protected from floods and stream bank erosion, and that there is adequate space on the site for required stormwater conveyance and treatment facilities,.

The Final Stormwater Management study should generally be a stand-alone document. It must reference and fully document all items addressed in the Preliminary Stormwater Management Study. If a flood study was required, it must reference the flood study and include a narrative synopsis of the study. In instances where the Preliminary Stormwater Management Study covers all items to the level of detail required for the Final Stormwater Management Study, and no significant changes were made during the design of the project, a Final Stormwater Management Study may be waived by the City. In these cases, a letter sealed by the design engineer stating that project substantially conforms to the approved Preliminary Stormwater Management Study is required.

### **Scope:**

The Scope of a Final Stormwater Management Study must include the following minimum items. For critical areas, staff may modify the scope as necessary to address individual site needs.

- A. ***Documentation of Downstream Drainage Issues:*** Document how stormwater drainage and flooding issues (including off-site drainage issues) were addressed. In most cases, the downstream analysis must extend to a point where the contributing drainage area from the project site is less than 10% of the total downstream drainage area. Previously identified problem areas further downstream should also be referenced in the report.
  
- B. ***Final Onsite Drainage System:*** Prepare a plan showing the final stormwater drainage system as it is to be constructed. The final drainage system should show:
  - Pipe system alignment and sizing.
  - Inlet locations and sizing.
  - Overflow system path, flowrate, and elevation. Include an evaluation of building/parking site layout with relation to overflow drainage. Overflow and open system drainage must allow for 1 foot freeboard from Energy Grade Line (EGL) to structure low opening. Maximum flow depth in parking/driving areas shall be 7 inches.

- Show building finish floor elevations for comparison with flood elevations.

C. **Drainage Computations:** At a minimum, the following drainage computations will be required. In ALL cases, full upstream development should be assumed using the City's land use map for determining estimated impervious areas. Upstream stormwater detention should be assumed to not be present for design flow purposes.

- Design flows (10 and 100-year) entering the site from all upstream tributary areas.
- Design flows (10 and 100-year) for all system components.
- Design flow leaving the site at each downstream outfall.
- Inlet capacity.
- Drainage area calculations.
- Gutter capacity/spread.
- Inlet intercept/bypass ratio.

D. **Stormwater Detention:** The Final Stormwater Management Study must document the basis for determining whether stormwater detention was required.

E. **Detention Requirements:** If it is determined that stormwater detention was required for a site, the following information must be submitted:

- Final stormwater detention calculations
- Final stormwater detention construction plans as a separate set of plans if not part of a private development.

F. **Stream Corridors:** Submit the same information as required for a Preliminary Stormwater Management Study with the following additional information:

Maps showing:

- Final utility locations and limits of disturbance if encroaching into the stream corridor.
- Restoration plan for any utility encroachments into the stream corridor.
- Distances and bearings for the perimeter of the stream corridor

Copy of the proposed Restrictive Covenants and Stream Corridor Maintenance Agreement.

[http://www.opkansas.org/Documents\\_and\\_Forms/stream\\_corridor\\_agreement.pdf](http://www.opkansas.org/Documents_and_Forms/stream_corridor_agreement.pdf)

- G. **Stormwater Treatment Requirements:** Submit the same information as required for a Preliminary Stormwater Management Study and include all design changes to the proposed stormwater treatment facilities.
- H. **Corps of Engineers Requirements:** Document the Corps of Engineers requirements (See Related Document on Corp of Engineer's Section 404 submittal requirements) [http://www.opkansas.org/Documents\\_and\\_Forms/404\\_permits.pdf](http://www.opkansas.org/Documents_and_Forms/404_permits.pdf) and how they have been satisfied (e.g. Jurisdictional Determination, Nationwide or Individual permit). Include a narrative section that summarizes the requirements along with appropriate maps of all "waters of the U.S." and jurisdictional wetlands. Additionally, all correspondence from the Corps of Engineers including permits should be included in an appendix.
- I. **FEMA/DWR Requirements:** The Final Stormwater Management Report must document how the FEMA/DWR requirements have or will be met. If a Flood Study was required, the report must reference and update (if needed) the Flood Study. Include all FEMA/DWR permits in the study.

**Maps:**

The submitted Final Stormwater Management Study shall include, at a minimum, the following maps:

- A. **Site Map:** A site map at a scale of 1" = 50 feet or greater, and a maximum contour interval of 2 feet. The site map must include both existing and proposed topographical information of the site to be developed and adjoining land whose topography may affect the proposed layout or drainage patterns for the development. The source of the topographic information should be indicated on the map. The site map must include the stormwater drainage system including the pipe system alignment and sizing as well as all inlet locations and sizes. The map shall show all existing streams, waterways, channels, the extent of both FEMA and non-FEMA floodplains, waters of the U.S. and jurisdictional wetlands.
- B. **Drainage Map:** A drainage area map at a scale of 1" = 200 feet or greater, and a maximum contour interval of 2 feet (both existing and proposed). In cases where there are large offsite areas draining to a site making 2 foot contours impractical, a larger contour interval may be allowed. The drainage area map should include all off-site drainage that drains to the site and all on-site drainage that leaves the site (to the next downstream storm drainage conveyance).

Stormwater Management Studies  
ES Policy # 3-01  
Updated on 10/12/2015

Engineering Services' staff is available to discuss storm water criteria with the design engineer at any stage of a project. If you do not know which engineer is assigned to your project, please call 895-6223.

**Attachment A** - Summary of Flood Study Model Requirements

**Attachment B** - Flood Control Detention Model Procedure

**Stormwater Management Studies - Attachment A  
 Summary of Flood Study Model Requirements**

Item	Category 1 No County Watershed Model Available (usually <160 acres)	Category 2 County Watershed Model Available (usually 160- 640 acres)	Category 3 FEMA Floodplain (4) (Usually 640+ acres)
<b>Peak Flow Computations</b>	Rational Method OR TR-55, HEC-1, HEC-HMS using APWA 5600 "Kansas Modified" calibration inputs	County Watershed Model Flows (1)	County Watershed Model Flows AND the FEMA models (if different)
<b>Open Channel Flow Computations:</b>	HEC-RAS	HEC-RAS	HEC-RAS
<b>Modeled Storm Frequencies (3):</b>	1% (100 year)	1% (100-year)	1% (100-yr)
<b>Governing Storm Frequency</b>	1% (100 year)	1% (100-year)	1% (100-year)
<b>Modeled Watershed Development Conditions (7):</b>	Existing Conditions	Existing Conditions	Existing Conditions
	Planning (Ultimate) Condition	Planning (Ultimate) Condition	Planning (Ultimate) Condition
<b>Physical Conditions (Cross Sections)</b>	Pre-Development	Duplicate Effective	Duplicate Effective
	-	Corrected Effective (5)	Corrected Effective (5)
	-	Existing Conditions (6)	Existing Conditions (6)
	Post-Development	Post-Development	Post-Development
<b>Downstream Model Boundary</b>	Determined by Design Engineer (2)	First downstream modeled X-section	First downstream modeled X-section
<b>Fill in floodplain requires post project certification (8)?</b>	No	Yes	Yes
<b>Submit HEC-RAS Data files to City?</b>	Yes	Yes	Yes
<b>Submit plan data files (Grading and improvements) to City?</b>	No	Yes	Yes

**Notes:**

- 1 - If watershed is "between" flow injection points, flows may need to be adjusted proportional to the size of the watershed at the next downstream flow point.
- 2 - Design Engineer should extend model downstream to either County Watershed Model (preferred), major structure, or to a point where variations in the flow depth at the boundary have negligible effects at the point of interest.
- 3 - The City may require additional design storm frequencies to be modeled for specific circumstances.
- 4 - If fill is placed in the FEMA Special Flood Hazard Area, a Letter of Map Change may be required. Contact the Plan Review Engineer for additional information on submittal requirements.
- 5 - Corrected Effective model is optional. It is needed only if errors or additional information (such as additional cross sections at the project site) are included in the model. It must not include any man-made physical changes to the floodplain since the effective date of the model. Man-made changes are included in the "Existing Conditions" model.
- 6 - Existing Conditions model is optional. It is needed only if physical changes to the floodplain have occurred after the date of the current effective model. Otherwise this model would be identical to the corrected effective or duplicate effective model.
- 7 - The City may require additional watershed development conditions to be modeled for specific circumstances (such as when there is an increase in the hydraulic intensity of the proposed use compared with the "planning" condition).
- 8 - See requirements for Post Project Certification of as-built grades. These requirements are in this memo under the section entitled "Updates to County Watershed Models".