

Chapter 2

SITE DEVELOPMENT REQUIREMENTS

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2.1 INTRODUCTION

Site development, for the context of this manual, is broken out into two categories: small site development and large site development. It is recognized that each development scenario is unique by nature and brings its own particularities. The purpose of this chapter is to provide clear direction on stormwater requirements for applicants as they navigate the development submittal and review process. Specific requirements related to development within the City of Raleigh (City) are discussed in detail throughout this chapter.

2.2 SMALL SITE DEVELOPMENT

Small site development is defined as lots identified in the City's Unified Development Ordinance (UDO) under [UDO Section 9.2.2.A.1 and 9.2.2.A.2](#). The intent of the small site development definition is to identify grandfathered and subdivided lots, along with use standards, that are granted an exemption for active stormwater controls.

Refer to the [Overall Small Site Development Checklist](#) for applicable requirements. During the submittal process, Stormwater Development Review staff may require additional information from the applicant to determine compliance with applicable regulations.

2.3 LARGE SITE DEVELOPMENT

Large site development is defined as a development that does not meet the small site development definition. These large site developments are subject to active stormwater controls (stormwater runoff and nitrogen) as well as stormwater requirements defined in this manual and detailed in the [Overall Large Site Development Checklist](#). During the submittal process, Stormwater Development Review staff may require additional information from the applicant to determine compliance with applicable regulations.

2.4 REQUIRED REFERENCE MATERIALS

The supplemental material shown below in **Table 2.4** shall be included with each submittal for site development regardless of the presence of streams or special flood hazard areas (SFHA) on the site.

1	A legible copy of the most recent United States Geological Survey (USGS) 7.5 Minute Quadrangle Map , including map reference, with site boundary clearly delineated and labeled. The map shall clearly show any streams. This map is required for surface water identification purposes.
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2	A legible copy of the Wake County or Durham County Soil Survey Map, including map reference, with the site boundary clearly delineated and labeled. The map shall clearly show streams. This map is required for surface water identification purposes and may be used for hydrologic soil group information.
3	A legible copy of the Web Soil Survey Map or a geotechnical exploration report, including map references, with the site boundary clearly delineated and labeled. The map may be used to show soil classification and shall include a reference table that describes the hydrologic soil group classification. This map shall not be used for surface water identification purposes.
4	A legible copy of the effective FEMA National Flood Insurance Program (NFIP) Flood Insurance Rate Map , including map number, map date and site boundary clearly shown and labeled. The effective and/or future FEMA 100-year floodplain, with base flood elevations, if applicable, shall be shown on the plans. The copy of the map can be pulled from the actual FEMA Flood map, a FEMA FIRMette or a map export from the North Carolina FRIS website .
5	Completed Stormwater Management Submittal Checklist(s) for the applicable submittal type. Checklist(s) shall be updated and provided with each submittal.
6	National Oceanic and Atmospheric Administration (NOAA) Atlas 14 Point Precipitation Frequency Estimates with hydrographs and any future rainfall intensity data adopted by the City. Design shall be based on whichever is more conservative. Data shall be specific to the site location. This shall be in the form of a printout of the Atlas 14 website or any future rainfall intensity data, with the site boundary clearly delineated and labeled. Hydrographs shall be downloaded and presented graphically. Atlas 14 works best when opened in Google Chrome or Firefox web browsers.

2.5 LOT GRADING PLAN (LGP)

An LGP serves as a visual summary of drainage information related to a development. The drainage patterns on the LGP shall be enforced by the City to ensure the approved drainage patterns are established and maintained by the property owner. If newly concentrated stormwater discharge locations are created by the proposed development, then stormwater flows from these new discharge locations shall be conveyed through an offsite drainage easement that has been secured and recorded between the developer and all downstream, impacted property owner(s). Such easements are required until the point where stormwater flow reaches a jurisdictional water body, a City right-of-way (ROW), or another public/private drainage easement. See Section 2.8 for more details on easement requirements.

2.5.1 LGP Applicability

2.5.1.1 Small Site Development

An LGP is required for small site developments and shall document drainage of an individual lot. Exclusions to the LGP requirements include, but are not limited to, any commercial interior alterations that do not include exterior work, and residential additions, decks, patios and other ~~small~~ accessory structures or improvements, as long as impervious limitations in [UDO Section 9.2.2.A.4](#) are not exceeded and drainage patterns are not altered leaving the property.

2.5.1.2 Large Site Development

An LGP is required for large site developments and shall document drainage for all lots. [For large site developments, the LGP will be required at Site Permit Review or Building Permits whichever comes first.](#) Exclusions to the LGP requirements include, but are not limited to, any commercial interior alterations that do not include exterior work, and residential additions, decks, patios and other small accessory structures or improvements, as long as drainage patterns are not altered leaving the property.

2.5.1.3 LGP Design Considerations and Requirements

After an LGP has been submitted and approved, any changes to the proposed development that may impact the lot grading and/or stormwater flow patterns will require a new LGP submittal for review and approval. Refer to the [Typical Lot Grading Plan Submittal Checklist](#) and [Sample Lot Grading Plans](#) for specific drawing requirements.

Below are the considerations and requirements that shall be taken into account during design of the LGP for both single-lot and multi-lot development:

- LGPs shall be submitted for site development projects unless the development falls within the exclusions listed in Sections 2.5.1.1 or 2.5.1.2.
- When placing fill on a single-lot development, existing flow patterns and concentrated stormwater discharge locations shall be maintained to the maximum extent practical. Where that is not possible and new concentrated flow discharge locations are created, the lot shall drain to an available drainage swale or system (with appropriate easement). Calculations shall be submitted to demonstrate adequate conveyance capacity of the swale or system. When existing swales are not available, a swale may be placed entirely on the applicant's property or along the property line of the adjacent property with the impacted property owner(s) approval and easement recordation, as appropriate.
- If placing earthen fill on a lot in a multi-lot development changes the drainage pattern, and a retaining wall is not proposed, the lot shall drain to a swale/yard drain system (with appropriate easement) designed per [Chapter 4 – Hydraulics](#).
- No flooding or impounding of water against an insurable structure shall be permitted during the 100-year storm event, except for properly floodproofed non-residential structures.
- No increased ponding or conveyance depth shall be permitted on adjacent properties for the 100-year event, unless located within a flood storage easement with impacted property owner(s) approval and easement recordation.
- Concentrated runoff [from stormwater pipes or swales](#) shall not flow across or onto sidewalks.
- When more than three cubic feet per second of discharge is flowing toward the street in a 10-year storm event, an inlet shall be installed to intercept flow.

- When roof drains are proposed as surface drainage, provisions shall be included to discharge roof drain flows away from the building foundation and to control erosion at the discharge point.
- Reverse slope driveways without associated engineered drainage design will not be allowed as they and other features that would likely fail to drain during major rainfall events. should be avoided.
- Any downspouts or other concentrated discharge shall be offset from the property line by a minimum of 10 feet (or at the building setback line, whichever is less) unless it discharges directly into a jurisdictional water body, a City right-of-way (ROW), or public/private drainage easement.
- Sheet flow can only occur for one lot, after which it is assumed to change to concentrated flow and a swale, channel or pipe conveyance system shall be provided.

2.5.2 Retaining Walls

Retaining walls included in the proposed small or large site development plan must adhere to the specifications and guidelines outlined in [UDO Section 7.2.8](#).

2.6 STORMWATER DEVELOPMENT ANALYSIS (SDA)

Prior to the approval of any preliminary or permitting submittal (whichever comes first) required by the UDO, the applicant shall submit an SDA that complies with the requirements set forth in the UDO and this Stormwater Management Design Manual. New developments or phased developments, where regulations have been changed, will be held to the new regulations unless all permits have been issued and remain active.

2.6.1 SDA Applicability

SDAs are required for the following scenarios:

- If existing or previously approved drainage patterns are proposed to be changed
- If an increase in previously permitted impervious area (over currently existing, or previously approved, impervious area in the SDA) is proposed
- If any existing conveyance system, as defined in [Chapter 4 – Hydraulics](#), is replaced or supplemented
- If any new conveyance system is proposed to meet current design criteria outlined in [Chapter 4 – Hydraulics](#)

Exclusions to the SDA requirements, include but are not limited to, any commercial interior alterations that do not include exterior work, and residential additions such as decks, patios and other small accessory structures or improvements, as long as any applicable impervious limitations in [UDO Section 9.2.2.A.4](#) are not exceeded and drainage patterns are not altered leaving the property.

A qualified small site development may be exempt from the following narrative reporting sections of the SDA (Section 2.6.2 of this document), assuming the development is below the maximum impervious area limits identified in the UDO for the zoning district, the proposed drainage patterns leaving the site are unaltered, and there is no documented downstream structural flooding, as stated in [UDO Section 9.2.2.E.3](#). Below are the potentially exempt, narrative sections:

- Section 7b – Applicable requirements for peak flow mitigation
- Section 8 – Applicable methodologies for peak flow
- Section 9 – Flood study requirements
- Section 10 – Downstream assessment
- Section 11b – Conclusions regarding peak flow mitigation

Small sites not located in Watershed Protection Overlay Districts are exempt from water quality reporting requirements listed below. Additionally, a qualified small site development in watershed protection overlay districts, if not increasing impervious area over approved existing conditions impervious area, can be exempt from water quality and nutrient loading requirements. Therefore, the development is also exempt from the following SDA narrative reporting requirements found in Section 2.6.2 of this document:

- Section 7c – Applicable requirements for water quality
- Section 8 – Applicable requirements for methodologies regarding water quality
- Section 11c – Conclusions on mitigation of water quality impact

2.6.2 SDA Narrative

A completed package, sealed by a North Carolina licensed design professional, shall be provided with each plan or permit submittal. Any packages that are incomplete will not be accepted for review. The SDA shall include a narrative report that describes the project, provides a discussion on the items outlined in this section and follows the requirements herein. If an item is not applicable, the narrative shall provide justification. The applicant shall also submit project-relevant, completed Stormwater Management Submittal Checklist(s). The checklist(s) shall note when items on the list may not be applicable to the submittal by writing "n/a" in the appropriate location. Stormwater Development Review staff will ultimately determine if items are required to demonstrate compliance with City stormwater regulations. The narrative shall include the following subsections:

1. **Project Data** – A list of the following project data shall be provided at the beginning of the narrative section:
 - a. Project name
 - b. Parcel Identification Numbers (PINs)
 - c. Parcel address or general site address if the site consists of more than one parcel
 - d. Current zoning district and any previous rezoning or plan/permit submittal case

numbers

- e. General site characteristics (e.g. topography, vegetation, soil type, land use, etc.)
 - f. Drainage basin (e.g. Crabtree Basin, Walnut Creek Basin, etc.)
 - g. Quantification of existing impervious area and proposed impervious area in both square feet and acres
 - h. Area of land disturbance in both square feet and acres
 - i. Any Total Maximum Daily Loads (TMDL) currently in effect for non-point sources if applicable in your watershed
 - j. Watershed Protection Areas (i.e. Urban Watershed Protection Overlay District, Falls Watershed Protection Overlay District and Swift Creek Watershed Protection Overlay District)
 - k. Any SFHAs, as defined in Chapter 7 – Floodplain Management, Section 7.2
2. **Brief Site History** – Using historical aerial photographs and/or existing permitting records, the paragraph shall describe the site’s history, including any changes in land cover taking place after May 1, 2001 and documentation of changes by date.
3. **Project Description** – The proposed project description shall include the following:
- a. Post-development land cover quantifying impervious area and type of development taking place (e.g. single-family homes, townhomes, condos, etc.)
 - b. Number of lots (existing and proposed) and whether the development is part of a shared stormwater solution for stormwater compliance
 - c. Parking areas
 - d. Building improvements
 - e. Changes in proposed land use and drainage patterns
 - f. Quantification and location of proposed land disturbance
 - g. Proposed slopes and drainage patterns
 - h. Downstream structural flooding
 - i. Any encroachment into an SFHA or stream/wetland/buffers
4. **Quantification of Limits of Disturbance and Change in Impervious Surface** – This will be a narrative that shall clearly identify and quantify the limits of land disturbance. Land disturbance, as defined below, shall provide an adequate work area and include an additional 20-foot offset or extend to the property line to allow for construction activities, which include staging, access, mobilization and storage.
- Activities that qualify may meet the definition of as land disturbance (UDO Section 12.2) include, but are not limited to, the following:
- a. Demolition

- b. Clearing and grubbing
- c. Grading
- d. Excavating
- e. Filling
- f. Dredging
- g. Change of land use (e.g. draining a pond, etc.)
- h. Construction
- i. Erosion and sediment control
- j. Construction access
- k. Earthen stockpiling
- l. Staging and storage
- m. Equipment parking

If there is no land disturbing activity, as defined in [UDO Section 12.2](#), state this in the narrative. Stormwater Development Review staff holds final authority to interpret the definition of land-disturbance areas.

Impervious areas, as defined in [UDO Section 12.2](#), as of the applicable baseline date, shall be clearly identified on the plans in accordance with [G.S. 143-214.7\(b3\)](#). The plans shall depict the boundaries and quantity of area that meets the definition of new impervious area. If there is no area that meets that definition, state this in the narrative. ~~Stormwater Development Review staff holds final authority to interpret the definition of what qualifies as new, and/or a change, in impervious area.~~

Projects located within the Falls or Swift Creek Watershed Protection Overlay Districts shall also identify all built areas, as defined by [UDO Section 12.2](#), on the plans. The plans shall depict the boundaries and quantity of area that meets the definition of new or existing built area. If there is no area that meets that definition, state this in the narrative. Stormwater Development Review staff holds final authority to interpret the definition of what qualifies as new, and/or a change, in built area.

Streams – Any streams on the property or within 150 feet of the property boundary, per the USGS 7.5 Minute Quadrangle Map or published Wake County Soil Survey Map (see [Table 2.3](#) for links to these maps), shall be described and the applicable Neuse Riparian stream buffer width(s) shall be stated. If a stream is not buffered (with respect to Neuse Riparian Buffer regulations), a buffer determination by North Carolina Department of Environmental Quality Division of Water Resources (NC DEQ DWR) is required. Within certain overlay districts (Falls, Swift Creek, and Urban Watershed Protection Overlay Protection Districts, Conservation Management Districts, and the Metro-Park Overlay District), watercourses on the property or within 150 feet of the property boundary shall be described and the applicable watercourse buffer widths shall be stated as per [UDO Section 9.2.3](#). Note that these buffers apply to all watercourses, not only those that may

appear on the USGS 7.5 Minute Quadrangle Map or published Wake County Soil Survey Map.

The narrative shall explain how diffuse flow, if applicable, is being maintained for stormwater discharge from the proposed project into a riparian or watercourse buffer. In addition, the narrative shall explain the purpose and extent of potential impact(s) to streams and/or buffers, and compliance with applicable provisions of this section.

5. **SFHAs** – Any SFHAs within four vertical feet or 20 horizontal feet (whichever is closer) of the property line or adjacent to the site shall be characterized in the narrative. SFHA requirements are further detailed in [Chapter 7 – Floodplain Management](#) and [UDO Article 9.3](#).
6. **Mitigation Strategies** – This section of the narrative shall discuss the following:
 - a. Applicable downstream assessment requirements
 - b. Applicable peak runoff and velocity requirements and plan to mitigate any peak flow or velocity impacts associated with the downstream assessment
 - c. Applicable water quality (i.e. nitrogen, phosphorus, TMDLs and total suspended solids [TSS]) requirements and strategy to achieve compliance with nutrient export and TSS removal requirements
 - d. Applicable impervious limitations as detailed in [UDO Section 9.2.2.A.4](#) or other impervious limitations including but not limited to those due to water supply watershed regulations or existing or proposed stormwater management plans for large sites which impose maximum impervious surface limitations for compliance with active stormwater control measure requirements
 - e. Documentation of all additional requirements (e.g. impervious area, built area, nutrient loading, buffer, retention, detention, etc.), as applicable, to the respective Watershed Protection Area overlay districts, as detailed in [UDO Article 9.5](#)
 - f. Applicable documentation of green stormwater infrastructure (GSI), including nutrient loading and stormwater control measures (SCM) sizing calculations
7. **Methodology** – A thorough description of all methodologies, procedures and data sources used in the calculations shall be included, as well as a detailed record of all assumptions. Note that the same methodology shall be used for both pre-development and post-development stormwater runoff calculations for purposes of meeting the requirements of this Design Manual.
8. **Flood Study Requirements** – Information shall be submitted as part of the Flood Study, including narrative discussions on existing and proposed conditions, work maps, calculations, methodologies, benchmarks, modeling parameter backup calculations, results/conclusions and North Carolina licensed professional engineer seal. More detailed information can be found in the [Flood Study Submittal Checklist](#).
9. **Downstream Assessment** – When downstream assessments are required, information submitted for the downstream assessment shall follow the analysis procedure detailed in

Section 2.8.4 of this document and shall include all requirements included in the [Downstream Assessment Submittal Checklist](#).

10. **Conclusions** – The conclusions shall state whether each applicable requirement is being met and how it is being met:

- a. Present the findings from the downstream assessment.
- b. For the peak runoff analysis, provide a table comparing the peak flow rates for pre-development, post-development without SCMs and post-development with SCMs scenarios. Also, include a summary of SCMs needed for compliance with peak flow requirements.
- c. For water quality compliance requirements, summarize the target nutrient loading rates for nitrogen and phosphorus and the SCMs required to achieve the required on-site nutrient reductions. Each SCM shall be specifically identified by type and shall detail why each SCM type was chosen. If compliance with the target nutrient loading rates cannot be fully met on-site, include details of the nutrient buydown credits that must be purchased from a private mitigation bank or from the North Carolina Department of Environmental Quality Division of Mitigation Services (NC DEQ DMS).

Projects which utilize GSI to meet nutrient loading requirements shall summarize the pre- and post-development volumes of runoff leaving the site for the 90th percentile storm event and the SCMs necessary to achieve the required volume matching. Each SCM shall be specifically identified by type and shall detail why each SCM type was chosen. These projects shall also include a summary of nutrient loading calculations for record keeping purposes per NCDEQ guidance provided in the May 13, 2014 memorandum "[Procedure for Meeting the Requirements for Nutrient Sensitive Waters Stormwater Management Programs by Implementing Low Impact Development](#)" or any future updates to that procedure as issued by NCDEQ.

- d. For TSS and applicable TMDLs, include how these applicable requirements are being met. For SCMs needed for compliance with TSS and TMDL requirements, identify by type and detail why each SCM was chosen.
- e. For riparian buffer compliance, all buffers and limits of disturbance shall be shown outside of buffer limits. Any proposed disturbance of riparian buffers must include federal or state approval documentation. For disturbance of any city-regulated riparian buffer, documentation of how the buffer disturbance complies with [UDO Section 9.2.3](#) must be provided.
- f. For impervious area compliance, clearly denote all impervious areas for the site. Provide a summary table comparing the impervious area for the pre-development and post-development project site showing compliance with impervious area limitations.
- g. For built area compliance (on projects within Falls or Swift Creek Watershed

Protection Overlay Districts), clearly denote all built areas for the site. A summary table comparing the built area for the pre-development and post-development project site showing compliance with built area limitations shall be provided.

2.7 DESIGNER'S LETTER

If the applicant's project meets one or more of the scenarios below, then the applicant shall submit a Designer's Letter signed and sealed by a North Carolina licensed professional engineer, landscape architect or land surveyor. The following list includes examples of projects where a Designer's Letter may be allowed in lieu of a full SDA as interpreted by the Stormwater Development Review staff:

- Project consists solely of co-location of a cell tower and tower equipment on top of an existing building, tower or pad.
- Project consists of a revised or amended site plan that preserves previously approved drainage patterns, does not increase impervious area within previously approved drainage patterns and does not include newly studied SFHA boundary on the developed property downstream of the site.
- Development of an outparcel(s), where a previously approved SDA or Stormwater Management Plan exists that accommodates the future development of the parcel(s). This applies only if the proposed development conforms to the previously approved SDA and still meets current stormwater regulations.

The Designer's Letter shall reference the following items:

- Project name
- Project description
- PINs
- Current zoning district and any previous rezoning or plan/permit submittal case numbers
- N-File number
- Drainage basin (e.g. Crabtree Basin, Walnut Creek Basin, etc.)
- Watershed Protection Areas (i.e. Urban Watershed Protection Overlay District, Falls Watershed Protection Overlay District and Swift Creek Watershed Protection Overlay District)
- Any SFHA as defined in [Chapter 7 – Floodplain Management, Section 7.2](#)

The Designer's Letter shall also provide a brief explanation of why a full SDA (either revised or new) is not warranted and shall include the following attachments:

- All previously approved signed and sealed SDAs for the site (if prepared for previous projects)

- Required materials as listed in items 1 – 5 of **Table 2.4**

FOR REVIEW ONLY

2.8 DOWNSTREAM ASSESSMENT

New development and redevelopment have downstream stormwater impacts that can be significant immediately downstream of the proposed development; however, those impacts lessen further downstream due to flow timing and attenuation. The area downstream of a new development or redevelopment where those impacts occur is known as the zone of influence. The zone of influence is identified using the 10% rule, which is described in Section 2.8.4 of this document.

The purpose of the downstream assessment is to ensure that the development has identified its zone of influence and has accounted for flow timing of the site with respect to the rest of the watershed. This is to protect downstream properties from increased flooding and downstream channels from increased erosion potential.

2.8.1 Downstream Assessment Applicability

A small or large site development is required to identify its zone of influence using the 10% rule and to coordinate with the City to determine if any existing structures are flooded within that zone of influence.

Proposed outfalls shall occur in a non-erosive manner.

General exclusions to the downstream assessment requirement include, but are not limited to:

- Any interior alterations that do not include exterior work
- ~~Small accessory~~ Accessory structures or improvements if drainage patterns leaving the property are not altered

At rezoning of any parcel, the zone of influence shall be identified within the rezoning submittal. If structural flooding is identified within the downstream zone of influence, then a condition shall be offered to include a downstream assessment at the time of preliminary or permitting review, whichever occurs first.

Refer to the [Overall Small Site Development Checklist](#) and [Overall Large Site Development Checklist](#) for applicable requirements. During the submittal process, Stormwater Development Review staff may require additional information from the applicant to determine compliance with applicable regulations.

2.8.1.1 Small Site Development

A downstream assessment is required for a small site development if one or more of the following conditions apply to the site:

- The proposed development exceeds the maximum impervious threshold for its zoning district, as specified in [UDO Section 9.2.2.A.4](#); and no onsite stormwater controls or green stormwater infrastructure mitigation measures are proposed;
- A structural flooding issue is identified by the City downstream of the site within the development's zone of influence;
- The site development changes flow type (i.e. changing sheet flow to concentrated flow)

or location leaving the property

2.8.1.2 Large Site Development

A downstream assessment is required for large site developments if one or more of the following conditions apply to the site:

- The site development changes flow type (i.e. changing sheet flow to concentrated flow) or location leaving the property
- A structural flooding issue is identified by the City downstream of the site within the development's zone of influence

The proposed development may voluntarily choose to perform the downstream assessment to potentially avoid on-site detention where it may not be required due to flow timing of the watershed per [UDO Section 9.2.2.E](#).

2.8.2 Structural Flooding – Additional Points of Analysis

As part of the downstream analysis, any documented instances of structural flooding within a project's zone of influence must be analyzed. The analysis shall include an analysis point at each instance of structural flooding, in addition to the other required analysis points as described in Section 2.8.4. Increases to documented structural flooding of greater than 0.04 feet in elevation will require additional runoff controls and will require notification to the affected property owners.

2.8.3 Evaluation of Potential Downstream Adverse Flow Conditions and Flooding Concerns

2.8.3.1 Flow Timing

If water quantity control (detention) measures are indiscriminately placed in a watershed and changes to the flow timing are not considered, the measures may increase the peak discharge downstream. This is demonstrated in **Figure 2.8.3.1**, where the peak flow from the site is reduced appropriately, but the timing of the flow is such that the combined detained peak flow (the larger dashed triangle) is higher than if no detention was required.

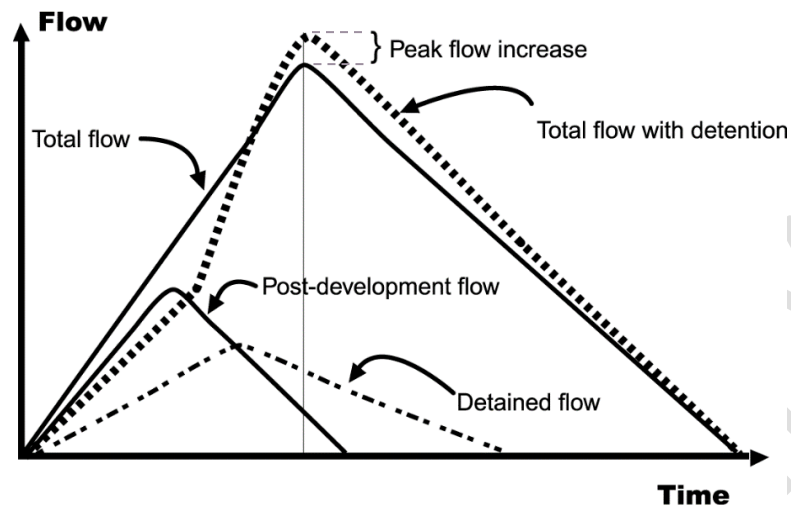


Figure 2.8.3.1 Detention Timing Example

In this case, the shifting of flows to a later time brought about by the detention measures makes the downstream flooding worse than if the post-development flows were not detained. This is most likely to happen if detention is placed on tributaries toward the bottom of the watershed, holding back peak flows and adding them as the peak from the upper reaches of the watershed arrives. In such instances, peak flow detention should not be implemented, and in consultation with Stormwater Development Review staff, appropriate mitigation measures shall be identified.

2.8.3.2 Increased Volume

An important impact of new development is an increase in the total runoff volume of flow. Thus, even if the peak flow is effectively attenuated, the longer duration of higher flows due to the increased volume may combine with downstream tributaries to increase the downstream peak flows.

Figure 2.8.3.2 illustrates this concept. The figure shows the pre- and post-development hydrographs from a development site (Tributary 1). The post-development runoff hydrograph meets the pre-development hydrograph criteria (i.e. the post-development peak flow is equal to the pre-development peak flow at the outlet from the site). However, the post-development combined flow at the first downstream tributary (Tributary 2) is higher than pre-development combined flow. This is because the increased volume and timing of runoff from the developed site increases the combined flow and flooding downstream. In this case, the detention volume would have to have been increased (and delayed, via extended detention) to account for the downstream timing of the combined hydrographs to mitigate the impact of the increased runoff volume. Such a design requirement would require significantly larger SCMs and, as such, would be entirely impractical. In such instances, peak flow detention should not be implemented.

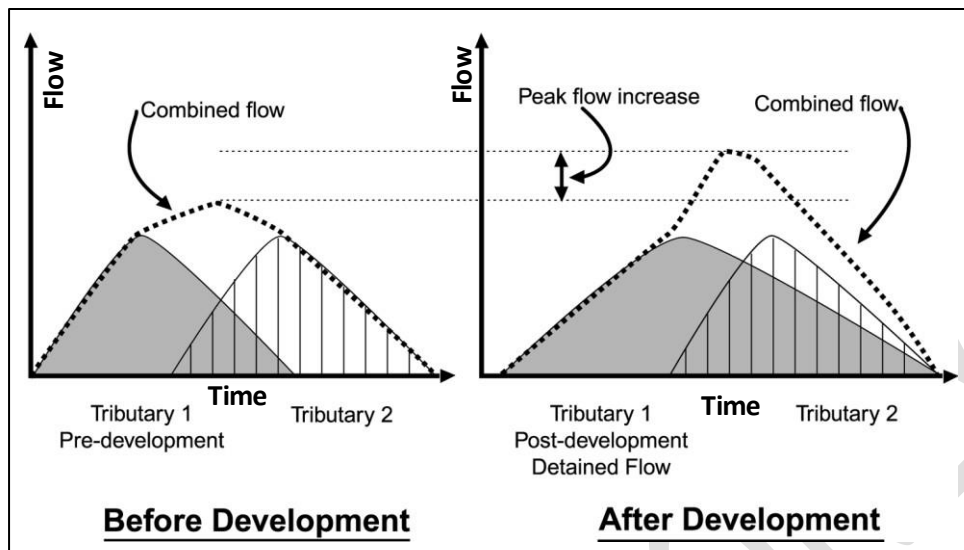


Figure 2.8.3.2 Effect of Increased Post-Development Runoff Volume with Detention on a Downstream Hydrograph

2.8.4 Analysis Procedure

The downstream assessment should extend from all outfall(s) of a proposed development to a point downstream determined by the 10% rule. Routing calculations must proceed downstream to a confluence point where the drainage area being analyzed represents 10% or less of the total drainage area. The development outfall(s) and all the confluence points with other systems or tributaries downstream are points of interest to compare increased discharges, along with existing structural flooding locations.

In situations where the cross section at the point of discharge is not clearly defined, the analysis must consider either shallow concentrated flow or channelized flow. Sheet flow for analysis purposes will not be accepted.

2.8.4.1 Example Demonstrating 10% Rule

Figure 2.8.4.1 illustrates the concept of the 10% rule for two sites in a drainage basin. Site A is a development of 10 acres, with the first point of analysis draining to a tributary. The 100-acre (10%) point is between the 80- and 120-acre tributary junction points. Looking downstream at each tributary in turn, it is determined that the analysis should end at the tributary labeled 120 acres as the nearest confluence point past the 10% location.

An accurate estimation of the time of concentration is important in the downstream assessment hydrologic analysis. Significant detention structures will impact the time of concentration estimate and should be accounted for in the analysis. Significant detention measures vary based on project scale and site-to-site characteristics. For a site that discharges directly into a FEMA studied stream, the hydrologic model used for that study already includes modeling of significant detention measures and is appropriate to use as the base model for your downstream assessment. For a site that discharges directly into a local

ditch, pipe system or roadway, it is appropriate to model other, smaller on-site SCMs, that are located on upstream and downstream properties within the analysis limits as significant detention measures. Best available information should be used to model these facilities such as aerial topography, field visits, survey or existing plans.

An approximate curve number is used because the actual peak flow is not key for initial analysis; only the increase or decrease is important. The accuracy in curve number determination is not as significant as an accurate estimate of the time of concentration.

Site B is located downstream at the point where the total drainage area of the receiving watershed is 190 acres. The site itself is only six acres. The first tributary junction downstream from the 10% point is the junction of the site outlet with the stream. The total 190 acres is modeled as one basin with care taken to estimate the time of concentration for input in to the model of the watershed.

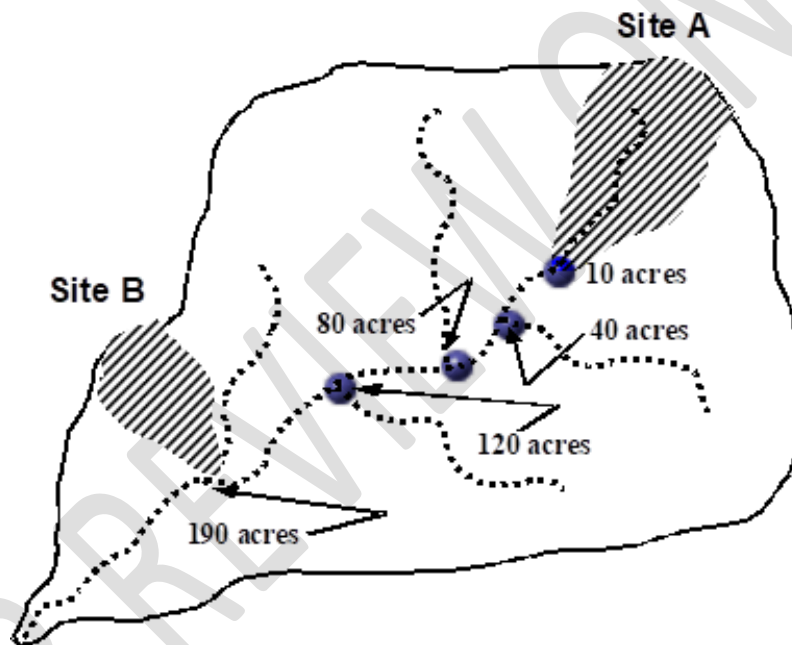


Figure 2.8.4.1 Example of the 10% Rule

2.8.4.2 Typical Steps in a Downstream Assessment

Hydrologic analyses to determine change in pre- versus post-development discharges must be developed throughout the extent of the zone of influence limits. Note that the same hydrologic analysis method shall be used for both pre- and post-development discharge calculations:

1. Determine the first point(s) of analysis where discharge leaves the property and identify the pre- and post-development site conditions.
2. Use a topographic map to determine the 10% point (zone of influence) for each outfall location and all analysis point locations.
3. Use a hydrologic model to determine the pre-development peak discharges at each analysis point within the zone of influence. Undeveloped off-site areas shall be

modeled as “full build-out” for both the pre- and post-development analyses. This model will include each of the following storm events:

- a. Erosion Protection Design Storm: 1-year, 24-hour
 - b. Conveyance Design Storm: 10-year, 24-hour
 - c. Flood Mitigation Design Storm: 100-year, 24-hour
4. Change the land use on the site to post-development conditions and rerun the hydrologic model, documenting peak discharges for each storm event at each of the analysis points within the zone of influence.
 5. Compare the pre- and post-development discharges at all analysis points within the zone of influence. If post-development discharges are higher than pre-development discharges for the same frequency storm event, then:
 - a. Perform hydraulic analysis to demonstrate the peak discharge increases do not increase water surface elevations by more than 0.04 feet at any analysis point.
 - b. Design on-site green stormwater infrastructure volume control device or an SCM such that the post-development discharges do not exceed the pre-development discharges at each analysis point.
 - c. With City approval, participate in off-site projects to mitigate impact of the development.

2.9 EASEMENTS

2.9.1 Easement Requirements

Requirements and locations for all easements, erosion hazard setbacks and development restrictions associated with the drainage of the property shall be shown and identified on the LGP. All easements, unless otherwise specified in the UDO, shall be recorded on a plat. This shall include, without limitation:

- Private drainage easements for conveyance or access
- Flood storage easements, where development results in an increase in flood levels
- Restrictions relating to streams and channels, including any buffers or erosion hazard setback zones
- Any other easements or restrictions that may apply to the subject property

Private drainage easements shall be provided for the following on any new development or redevelopment:

- If newly concentrated stormwater discharge locations are created by the proposed development, then stormwater flows from these new discharge locations shall be conveyed through an offsite drainage easement that has been secured and recorded

between the developer and all downstream, impacted property owner(s). Such easements are required until the point where stormwater flow reaches a jurisdictional water body, a City right-of-way (ROW), or another public/private drainage easement.

- Channel and pipe conveyance systems carrying runoff from two or more lots shall be in an easement.
- Swales, defined as small linear depressions conveying runoff between lots, shall be in an easement if they have two or more lots contributing runoff and runoff exceeds 3 cfs during the 10-year storm event.
- If the proposed development receives runoff from upstream properties in a system contained in an easement, then the proposed development shall be required to continue the system across their lot in an easement regardless of the number of lots contributing or runoff quantity.
- Primary and emergency dam spillways.
- Stormwater control measures and all means of transporting stormwater runoff to and from these measures.
- Other locations deemed appropriate by Stormwater Development Review staff.

2.9.2 Easement Widths

Adequate easements shall be provided to allow access of construction equipment, taking into consideration the limitations that may be imposed by embankment slopes or other obstacles. Easements containing only stormwater infrastructure shall be centered over the pipe or channel/swale. Minimum easement widths shall be based on **Tables 2.9.2.a and 2.9.2.b**.

TABLE 2.9.2.a EASEMENT WIDTHS FOR PIPES	
<i>Pipe Scenario</i>	<i>Easement Width</i>
Single Pipe	20 ft or 10 ft + pipe diameter + (2x invert depth), whichever is greater
Multiple Pipes	20 ft or 10 ft + outside pipe widths + (2x invert depth), whichever is greater

Where other utilities are involved, such as water and sewer, additional width shall be provided according to guidelines in the [Public Utilities Handbook](#), but in no case shall the easement widths be less than those listed above.

TABLE 2.9.2.b EASEMENT WIDTHS FOR OPEN CHANNELS OR SWALES	
<i>Drainage Area</i>	<i>Easement Width¹</i>
< 10 ac	10 ft on each side, from top of bank
10 - <25 ac	20 ft on each side, from top of bank
25 - <50 ac	30 ft on each side, from top of bank
50 - <100 ac	40 ft on each side, from top of bank
> 100 ac	The greater of the floodway width or 50 ft on each side, from top of bank
¹ Use the easement widths provided in this table or easement widths as defined by the erosion hazard setback defined in Chapter 4 – Hydraulics , whichever is greater	

Design exceptions for easement widths or off-center easement locations shall be reviewed by the City. In no circumstance will an easement width be approved that does not fully contain the limits of the 100-year storm event.

Refer to [Chapter 5 – Stormwater Management Design](#), specifically *Section 5.8.2 – Recorded Easement Requirements* and *5.8.4 – Small Site Considerations*, for easement requirements related to Stormwater Control Measures.