5.4.1 Recreate Natural Flow Patterns

Description

Each site has an inherent geometry that reflects the natural, historic water patterns within a regional system. In many urban and suburban areas, these flow paths have been constricted, rerouted, buried, paved, or built over until the original drainage patterns were obscured and the stormwater management benefits lost. Natural flow patterns are comprised of a number of familiar components that, when combined, create a dispersed, multi-scale drainage network. Such a network includes conveyance and detention as well as other components.

Figure 5.4.1-1. Lawn area that used to be a wet meadow with ephemeral pond and swale. Notice remnant swale in middle ground of picture.

Where possible, natural drainage functions should be reestablished as site constraints allow. Retrofitting sites with small, varied, and connected stormwater management measures following historic patterns provides greater security from flooding and can create redundancy within natural and structural systems.

Figure 5.4.1-2. Lawn area during construction of restoration.

Some diverse, multi-scale, hydrologic features include:

- Bioswales
- Intermittent/ephemeral and perennial water courses
- Check dams, weirs, and baffles
- Depressions
- Basins, wetlands, or pools
- Floodplain terraces
- Wet meadows

Restoration of these features may include:

- Changing channel (cross-sectional) configuration by:
  - Widening buffers and/or creating benches that mimic floodplains.
  - Reestablishing the natural meander of a channel.

Figure 5.4.1-3. Restoration of wet meadow with ephemeral pond and swale complete.

Figure 5.4.1-4. Hickory Valley CC (now "First Tee") restored stream channel (before and after).

- Regrading the site.
- Day-lighting drainage flow from pipes.
- Enhancing vegetated cover with flood- and drought-tolerant, densely planted, deep-rooted species.
- Optimizing opportunities for infiltration and storage at points along the original flow path through the creation of depressions and bioswales. (This conversion may include the reuse of storm sewers for storage and/or overflow.)

BMP Functions Table

BMP	Applicability	Volume Reduction	Water Quality	Peak Rate Reduction	Recharge	Runoff Temperature Mitigation	Heat Island	Habitat Creation	Maintenance Burden	Cost
Recreate Flow Patterns	U/S/R	M	M/H	M	M	M	L	H	M	L/M/H

KEY: U = Urban; S = Suburban; R = Rural; H = High; M = Medium; L = Low

Key Design Guidelines

- Identify drainage patterns in site context.
- Identify and map historic natural drainage features (swales, channels, ephemeral streams, depressions, etc.).
- Minimize filling, clearing, or other disturbance of existing drainage features.

- Utilize natural drainage features instead of engineered systems whenever possible.
- Provide erosion protection or energy dissipation measures if the flow into the channel or swale can reach an erosive velocity.
- Plant native vegetative buffers around drainage features.

Advantages

- Dispersed, small-scale storage.
- Increased flood storage.
- Reduced water velocity.
- Reduced suspended sediment load.
- Increased pollutant and nutrient removal.
- Aeration/oxygenation of water depending on channel morphology.
- Surficial drainage pathways and devices can replace or adapt existing structural drainage measures as storage and/or overflow.
- Drainage can become a site-organizing feature and/or a site amenity.

Disadvantages

- May require other smaller BMPs over a larger portion of the site.
- Requires interconnected design of BMPs and may be subject to site program constraints.

Applications

- Strategies can be applied at multiple scales and with varying levels of formality.
- Restoration of natural flow patterns is particularly suited to large development properties such as residential, institutional, and corporate campuses in less urban areas. However, restoration can be useful at multiple scales.
- In denser urban areas, natural drainage functions can be mimicked with varying levels of formal, constructed (but vegetated) channels, basins, etc. This is referred to as reinterpreting the natural drainage patterns.

Applicable Protocols and Specifications

Protocol 2 Coordination with Other Site Utilities
Protocol 3 Soil Testing

Protocol 5 Planting and Mulching Guidelines
Protocol 6 Bioretention Soil Specifications

Design Considerations

This BMP is eligible for SOV credits as defined in Chapter 7. A Criteria Checklist is provided at the end of this section as a summary of design and establishment considerations.

Site Analysis

Where possible, identify and use the site's existing and historic hydrologic patterns in the proposed design. Look for opportunities to reconnect to remnants of the existing natural drainage features and reestablish natural drainage functions that serve to slow and/or retain runoff, maximize recharge, remove sediment and pollutants, oxygenate water, etc.

- Understand the site context—its location within the watershed and its hydrologic connectivity.
  - Identify and map existing, and where possible, historic drainage features. Note: USGS has an online Historical Topographic Map Collection showing the drainage and landforms of Chattanooga from 1936 to 1969 (http://nationalmap.gov/historical/index.html). Use the smallest map scale possible for the best detail, typically 1:24,000.
    - Historic aerial photographs can also provide other important information.
    - Storm sewers can provide clues to historic hydrologic patterns.
  - Identify the site's location within the larger watershed.
    - Placement in the watershed provides insight to hydrologic performance. For example, areas located within drainage areas close to headwaters or zero order streams will perform differently than sites along the banks of the Tennessee River. Stormwater systems should correspond to the inherent demands of the site. In headwater areas, infiltration should usually be maximized, whereas in broad floodplain areas, the focus should be on cleaning and dispersing stormwater.
    - Headwater stream drainage areas are critical to overall watershed health and should be given special consideration.
  - Identify healthy, stable references for channel/basin configurations appropriate to the site's position in the watershed, slope, and geology. For example, a drainage channel on a steep slope in eastern Tennessee will, most likely, look like a mountain stream. This is very different from the sluggish, braided watercourse with many meanders found on flat areas and in the valleys.
- Identify and map stormwater flow into and out of the site, including overland flow as well as underground flow (where possible). Use current topographic maps to calculate the size and location of drainage areas tributary to and within the project site.
  - Calculate current volume and velocity from the drainage areas for the given design storm.

- Current stormwater volumes will differ from historic volumes due to urbanization and must be accounted for when sizing new stormwater features that mimic historic patterns.
- Identify any existing storm sewers or other structural conveyances (paved ditches, culverts, etc.).
- Reassess stormwater management plan as the site plan develops.

Design Strategies

Compare the historical drainage configuration with present drainage along with site program requirements and determine what is feasible given spatial and budget constraints. What can be reused? What will provide the best performance in terms of water quality or volume reduction?

Create a dispersed, multi-scale drainage network with many varied and **connected** stormwater management measures based on historic drainage patterns. In denser urban areas, mimic natural drainage functions with varying levels of formal, constructed (but vegetated) channels, basins, etc. This is referred to as “reinterpreting” the natural drainage patterns. The following are several strategies for accomplishing this:

- Repair Structural Damage
  Although preserving or restoring healthy soils and vegetation is a key component in restoring site stormwater management performance, it may be critical to first address structural damage to the site. This includes restoring site topography and drainage damaged by previous grading, slumping, or erosion.
  - Remove, where feasible, historic fill and reshape leveled ground to direct water toward the drainage feature to be preserved as appropriate.
  - Reestablish stormwater management components such as bioswales, intermittent/ephemeral and perennial water courses, depressions, basins, pools, wetlands, floodplain terraces, and wet meadows in a choreographed, connected system.
  - Flow Path − Channel Design
    Conventional trapezoidal swale channels with 3:1 side slopes and flat bottoms are primarily to convey water. While these conventional designs are easier to calculate and engineer, they do not mimic natural conditions. Additional stormwater management benefits can be achieved with adjustments to the design. See Section 5.4.1.1, Naturalize Swales and Drainage Ditches in this manual for more detailed information.

    While modifying the channel design typically requires more space, it incorporates the following benefits: infiltration and filtration, pollutant removal, and increased storage opportunities. Other BMPs such as check dams or ponds can be used to supplement the functions of revised channel design. In addition, these areas can provide amenities if incorporated into the site design.

- Create a meandering channel with adjacent flood storage. Where appropriate, recreate natural stream meanders. Use rocks and logs or other materials to create deflectors to manipulate flow.
- Design the two sides of the channel so that they are different in section—one side steep and terraced and the other graded into a bowl-shaped floodplain.

Figure 5.4.1-5. Recreating a meander within a channel, note boulders and curves, and that the right side is higher than the left, which has area for overflow if the water "jumps" the channel banks.

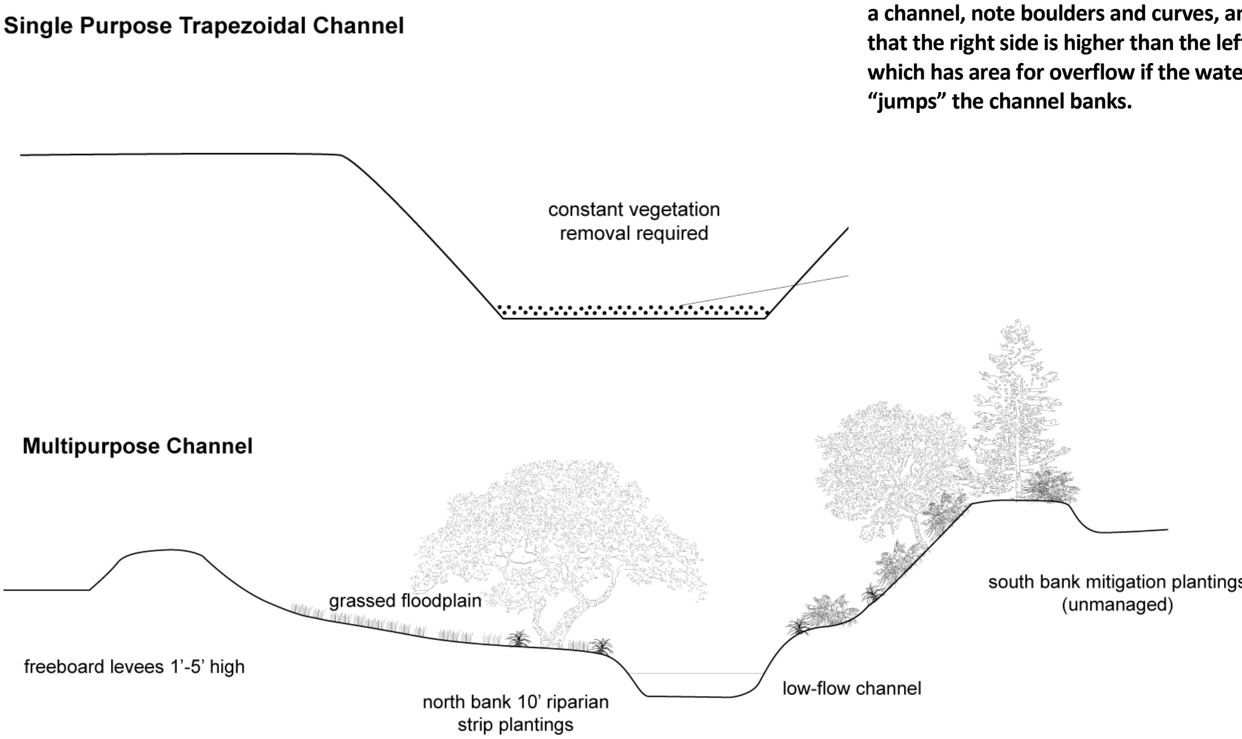

Figure 5.4.1-6. Two channel sections – Engineered vs. Naturalistic.

- Plan for Increased Volume – Sizing
  If the historic drainage patterns are being used as the basis for the current stormwater management plan, present stormwater volumes must be taken into consideration. Development/redevelopment on the site as well as within the areas draining to the site will most likely increase stormwater volumes.
  - Where the velocity and volume are high:
    - Create extra storage/infiltration capacity where applicable.
    - Stabilize swale slopes with bioengineering techniques.

○ Use check dams with low weirs and small pools. Check dams are recommended for any vegetated swales with longitudinal slopes greater than 3 percent.

Figure 5.4.1-7. Log check dam installed.

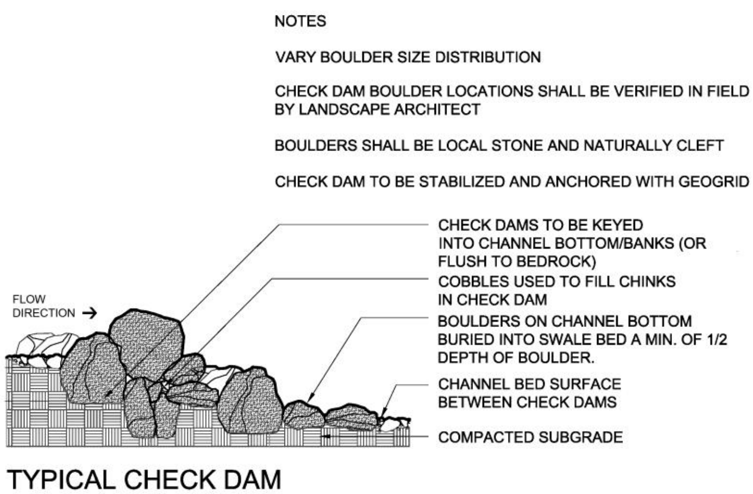

Figure 5.4.1-8. Stone check dam installed.

○ Swales with check dams more effectively reduce runoff quantity and quality than those without. Check dams create a series of small pools along the length of the swale. The frequency/number of small-dammed pools depends on the length and slope of the swale, as well as the desired amount of storage/treatment volume. These pools help to decrease energy in the water and enhance aeration, decrease runoff volume and velocity, and promote additional filtering and settling of nutrients and other pollutants. Care must be taken to avoid erosion around the ends of the check dams.

○ Pools must drain within a maximum of 72 hours to prevent mosquito breeding.

- Design small wetlands as storage basins adjacent to the channel to store floodwaters and promote groundwater recharge where appropriate.
- Plant vegetative buffers around recreated drainage features and re-vegetate all cleared or disturbed areas to trap sediment. Use deep-rooted plants suitable to alternating flood and drought conditions (i.e., floodplain vegetation). Selected vegetation must be able to thrive at the specific site and should be chosen carefully. No invasive plant species may be used. See Protocol 5 Planting and Mulching Guidelines.

Figure 5.4.1-9. Avoid straight, uniform cross-section grass swales where possible.

Figure 5.4.1-10. Vegetated swale – note meanders, rocks, grasses, etc. More pleasing to the eye than a straight swale, but still conveys stormwater and has more water quality functions.

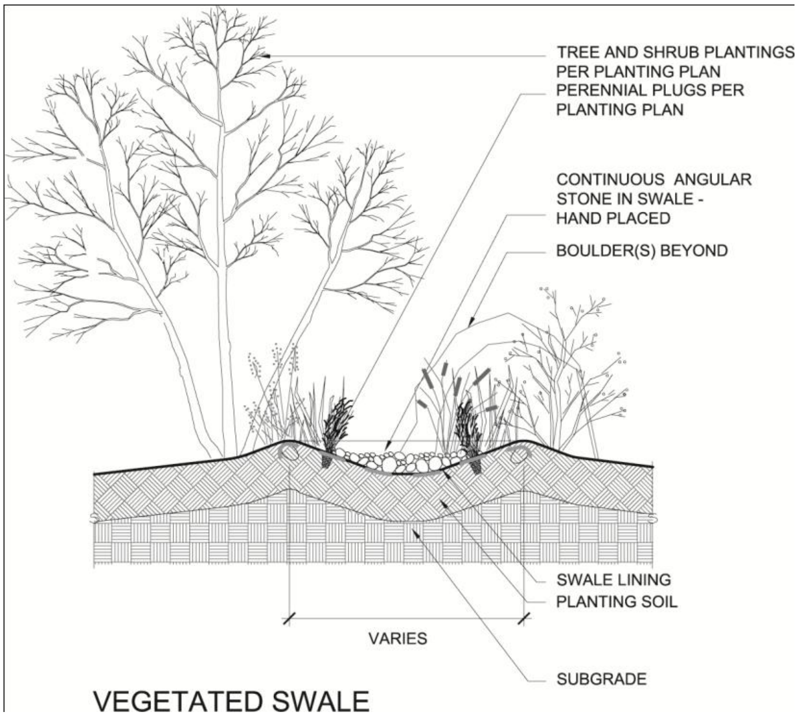

Figure 5.4.1-11. Vegetated swale detail.

Construction Sequence

- Identify proposed natural drainage features on the construction drawings and stake out these features in the field at the start of construction.
- Strictly delineate and enforce protection areas and minimal disturbance areas.
- Protect recreated drainage features from sediment and stormwater loads during construction.
- Use smaller machinery in these areas and avoid working soil when wet to protect soil structure and infiltration rates.

Operations and Maintenance

Naturalized drainage features that are protected and integrated as part of a site's development require monitoring and targeted maintenance and inspections, especially after large rain events. Inspections can assess variables such as erosion, bank stability, sediment/debris accumulation, plant condition, and the presence of invasive species. Problems should be corrected in as timely a manner as possible to avoid compounding effects.

When vegetation is being established, efforts such as watering, weeding, mulching, replanting, etc. may be required regularly during the first few years. Undesirable species should be removed and desirable replacements planted if necessary.

Protected drainage features on private property should consider an easement, deed restriction, or other legal measure to discourage future disturbance or neglect. These measures can be tailored to protect not only the channel but also associated basins. In some cases, depending on the location, the City may require these legal measures.

References

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Riley, Ann L. 1998. *Restoring Streams in Cities: A Guide for Planners, Policymakers and Citizens*, Island Press.

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Criteria Checklist BMP 5.4.1

ITEM DESCRIPTION	YES	N/A
The following checklist provides a summary of design guidance for the owner/applicant for successful implementation.		
• Identify existing remnant and historic natural flow pathways on the site inventory plan.	☐	☐
• Delineate and label historic flow patterns on the existing conditions and site protection plan.	☐	☐
• Identify and map stormwater flow into and out of the site, including overland flow as well as underground flow (where possible). Use current topographic maps to calculate the size and location of drainage area flowing to and within the project site.	☐	☐
• Delineate and label current conceptual design on the appropriate plans as outlined in Chapter 4, General Design and Review Process for New Development and Redevelopment. Note relationship to historic flow patterns.	☐	☐
• Where possible, identify and use the site's existing and historic hydrologic patterns in the proposed design. Look for opportunities to reconnect to remnants of the existing natural drainage features and reestablish natural drainage functions.	☐	☐
• Highlight recreated/reinterpreted natural flow pathways that are integrated into stormwater management.	☐	☐
• Have measures been taken to guarantee that natural pathways will not be negatively impacted by stormwater flows? Have they been sized appropriately?	☐	☐
• Proposed natural drainage features should be identified on the construction drawings and staked out in the field at the start of construction. Protection and minimal disturbance areas should be delineated and enforced.	☐	☐
• Provide written description of any work that may need to be performed within the protected areas and areas of minimal disturbance.	☐	☐
• Utilize natural drainage features instead of engineered systems whenever possible.	☐	☐
• Plant native vegetative buffers around drainage features.	☐	☐