BMP 6.7.4: Floodplain Restoration

Floodplain restoration tries to mimic the interaction of groundwater, stream base flow, and root systems – key components of a stream corridor under pre-settlement (pre-1600s) conditions. Under pre-settlement conditions, typically the roots of the riparian vegetation on the floodplain were directly linked to the base flow elevation of the stream. Groundwater frequently interacted with the root zones and the stream's base flow. Where the groundwater was lower than the stream's base flow, the gravel-lined streams and permeable floodplains frequently reduced surface flows through infiltration. The interaction among the stream's base flow, groundwater, permeable floodplain soils, and riparian root zones provides multiple benefits, including the filtering of sediments and nutrients through retention of frequent high flows onto the floodplain, removal of nitrates from groundwater, reduction of peak flow rates, groundwater recharge/infiltration, and increase of storage and reduction of flood elevations during higher flows. As a result of historical and recent human impacts, many stream networks have little interaction among the groundwater, stream base flow, and the root systems of floodplain vegetation. Frequently, recently deposited floodplain soils are cohesive, separating the root zones from base flow and allowing only minimal infiltration from the surface flow through the porous pre-settlement soils and gravels. Floodplain restoration as a BMP should be considered where there is minimal interaction among the key components. Other benefits of this BMP include thermal cooling of the stream base-flow, improved benthic community species diversity and habitat, re-establishment and significant increases of wetland areas and native plant species on the floodplain, reduction of invasive plant species, and increased aquatic habitat and riparian areas.

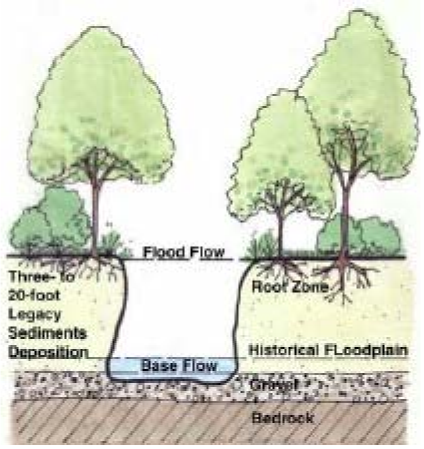
Key Design Elements	Potential Applications / Functions
▪ A natural, system-based BMP that uses native vegetation, soils, and other natural elements ▪ Can be easily integrated into the initial site planning process Can prevent riparian problems from getting worse or can fix problems caused by historical practices ▪ Can address numerous problems, from the site level to the watershed level ▪ Provides multiple benefits of restoring a fluvial and riparian system to a fully functioning level of interaction ▪ Re-connection of stream channel to functional floodplain ▪ Incorporation of an aquatic and riparian system that interacts with the groundwater and/or stream base flow. ▪ Reattachment of root systems of floodplain vegetation/riparian areas connected to groundwater and/or base flow. ▪ Removal of "legacy sediments" and associated nutrients stored within the stream corridors prior to release through bank erosion.	**Potential Applications** Residential: Yes Commercial: Yes Ultra Urban: Yes Industrial: Yes Retrofit: N/A Highway/Road: Yes **Stormwater Functions** Volume Reduction: Low/High Recharge: Low/High Peak Rate Control: Medium Water Quality: Med/High **Water Quality Functions** TSS: 85% TP: 85% NO3: >30%

Description

Floodplain restoration as a BMP is an effective tool to meet water quality and quantity requirements, prevent riparian problems from getting worse, and fix current problems caused by historical practices. The interaction and connection of the groundwater, stream base flow, riparian vegetation root system, and permeable floodplain soils and gravels immediately reduce downstream sedimentation by stopping or greatly reducing stream bank and channel erosion. The “legacy sediments” stored in stream valleys create unnaturally high stream banks and floodplains that frequently contain massive amounts of nutrients, which are released during erosion. Additionally, high banks separate plant root zones from the nitrates in the stream base flow and groundwater. Thus, instead of nitrogen being removed by the plants, groundwater and base flow continue to transport nitrates to receiving waters. Floodplain restoration directly removes a significant source of phosphorus and sediments and creates a riparian/aquatic environment to provide effective denitrification. Additionally, a restored floodplain and stream may greatly enhance infiltration and storage of surface flow in the floodplain, which reduces flood flow stages, volumes, and peak discharges. Floodplain restoration is an effective technique to meet stormwater management initiatives. One of the great advantages of this technique is that it can address numerous problems, from the site-specific to the watershed-level. Floodplain restoration can prevent or substantially mitigate the full range of stormwater impacts in one BMP. It is a natural, system-based BMP that uses native vegetation, soil, and other natural features. Floodplain restoration reconnects a number of key components within a stream corridor so that their interaction protects the stability of the bed and channel while the system receives, holds, infiltrates, and filters sediment and nutrients from overland flow. These components include:

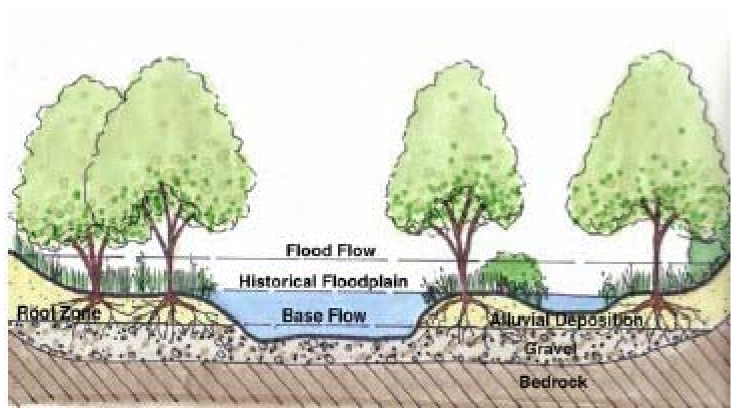
- a floodplain that receives more routine flows, thereby reducing erosive flow forces in the channel and allowing existing sediments and nutrients to remain in storage;
- a floodplain that allows vegetative root systems to interact with the base flow and/or groundwater, providing frequent removal of nitrates and effective stabilization of the stream banks and floodplain;
- a floodplain wide and flat along the valley bottom, consisting of the proper earthen materials to absorb surface flows and increase infiltration to groundwater;
- a plant community adapted to frequent inundation that will provide suitable habitat for riparian wildlife and whose root systems will provide nitrate and phosphate removal from surface and/or groundwater; and
- increased and improved habitat for aquatic resources.

Traditional on-site BMPs focus on the development site itself, while floodplain restoration can focus not only on the development site but also on the receiving streams. Adding floodplain restoration to the toolbox also increases the flexibility to address onsite BMP limitations such as steep slopes, shallow bedrock, or property limitations.



Existing Conditions: Stream channels are eroding or have eroded back down through sediments that collected behind mill dams, leaving their alluvial terraces high above the current base flow water elevation, and disconnecting riparian root systems from groundwater flows. The processes of frequent floodplain inundation, which relieves in-channel stresses; groundwater infiltration through porous floodplain material, and nitrogen removal from groundwater through root systems are lost under these conditions that are prevalent today throughout the Piedmont region of the United States.

Pre-settlement / Restored Conditions: Stable, pre-settlement stream and floodplain systems were characterized by: a low floodplain in close contact with surface water in the stream channel, allowing for frequent inundation of the floodplain during high flows; riparian vegetation with roots zones in contact with groundwater that enabled ground-water denitrification through root uptake; and a channel bed composed of cobble and gravel, which helped protect the underlying bedrock from erosive flow forces.



Santo Domingo Creek, Lititz Run Watershed, Lancaster County, Pa.
Top Left: Existing conditions.
Top Right: Restored conditions
Right: Riparian Wetland adjacent to channel.

Variations

When implementing a Floodplain Restoration BMP, existing site constraints can influence the opportunity or potential to achieve all the benefits. Impacts to natural channels often create streambeds that are perched above the historical bed that existed prior to the 1600s. This is especially the case when historical milldams, creating significant backwater influences upstream of the physical dam, caused natural channels to fill with fine alluvial sediments from hillside erosion during the widespread land-clearing of the post-settlement era. When current streambeds are perched, it is often the case that the groundwater elevation is below the streambed. In this case, base flow, whether intermittent or perennial, flows on the perched streambed and has little interaction with the groundwater elevation below the streambed. The fine alluvial sediments that washed from the hillsides often act as a barrier, keeping the in-channel base flow and groundwater separated.

As a ***first priority***, the design of a Floodplain Restoration BMP should attempt to establish the proposed streambed so that the base flow in the channel is connected to the pre-settlement streambed gravels and, typically, the groundwater elevation. This scenario provides the greatest benefit for nutrient uptake, because the newly established, active, vegetated root zone will be highly attached to the groundwater and base flows in the new active channel. Where cohesive soils or clays separate the top of the floodplain from the underlying porous material, these cohesive materials should be replaced with more porous soils. On sites where vertical constraints from existing infrastructure, such as roadway crossings, culverts, and utility crossings, prevent lowering the restored streambed to its historical pre-settlement elevation that would, in many cases, have been attached to the groundwater elevation, then a ***second priority*** to the Floodplain Restoration BMP should be utilized. The second priority shall be utilized where site constraints do not allow for the reconnection of the restored streambed to the groundwater elevation. In this case, the restored channel should be established such that the base flow or, in the case of an intermittent stream, the streambed is highly attached to the stream bank vegetated root zone, meaning that the established root zone extends down to the streambed elevation.

Applications

On-Site: When a stream is located within or immediately adjacent to a proposed development site, the Floodplain Restoration BMP can be directly tied into the site development stormwater management plan, given the stream is in need of restoration as a stand-alone BMP or as a supplemental BMP to other stormwater BMP needs. **Off-Site:** On development projects that do not have a stream on or adjacent to the site, the Floodplain Restoration BMP may be implemented on the downstream receiving stream or within the watershed. Existing watershed prioritization studies may be useful in identifying appropriate sites for off-site applications of this BMP. In areas where existing wetlands or mature riparian forests or vegetation exist, this practice may not be applicable. The benefits of the practice must be weighed against the impact to determine if this method is acceptable.

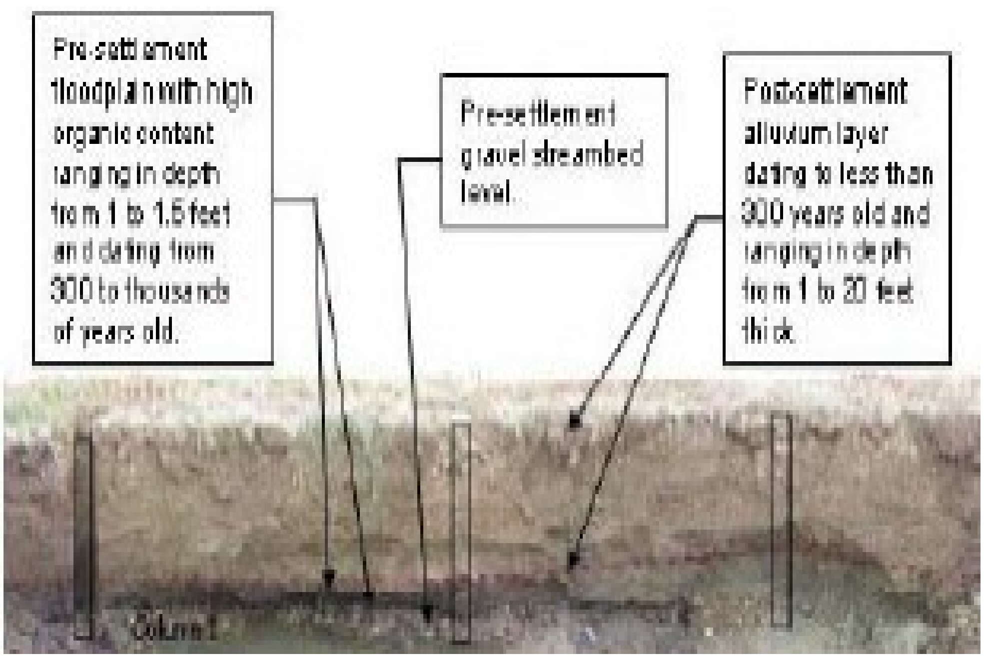
Design Considerations

The goal of floodplain restoration is to re-establish the natural interaction of a stream system, including surface flow; groundwater; porous, organic floodplain soils; and vegetative roots systems by re-establishing the stream channel and adjacent floodplain in their natural valley-flat location such that it functions similarly to the pre-settlement conditions. Any restoration required for the stream channel itself should follow the guidelines established by the Keystone Stream Team in *Guidelines For Natural Stream Channel Design for Pennsylvania Waterways*.

General design procedures:

1. Determine if the vegetative root zone is connected to the base flow and groundwater or, in the case of an ephemeral stream, the stream bed. A simplified way to determine root zone connection is to examine the root depth of the vegetation on the floodplain or out-of-bank level along the active stream banks. If the base of the active root zone extends into the base flow or channel bed region, then the floodplain is likely to be attached to the active stream channel.

2. Excavate a trench(es) or perform geo probes along the existing floodplain to determine pre-settlement floodplain and streambed elevations. Typically, the buried pre-settlement floodplain consists of dark peat and organic material.



Trench excavated across the existing floodplain reveals the pre-settlement streambed and floodplain levels currently buried under post-settlement alluvium and facilitates soil layer analyses, including various dating procedures.

3. Identify any vertical constraints or limitations that may prevent the floodplain restoration from providing the interconnection of the key components described above.

4. If the channel bed exists at the groundwater or pre-settlement bed elevation, then lower the floodplain and re-establish the appropriate vegetation where the rooting depth is connected to the base flow and/or groundwater.

5. If downstream constraints such as utility crossings or culverts will not allow lowering the floodplain and stream bed to its pre-settlement elevation, and floodplain soils are porous, excavate the existing

floodplain soils to an elevation that allows the floodplain vegetative root systems to be connected to the base flow elevation.

6. If downstream constraints such as utility crossings or culverts will not allow lowering the floodplain and stream bed to its pre-settlement elevation, and floodplain soils are cohesive and non-porous, remove the clays and replace with more porous materials to an elevation that allows the floodplain vegetative root systems to be connected to the base flow elevation.

7. Hydrologic/hydraulic studies may be necessary as required.

8. Obtain federal, state, and local permits and coordinate with local floodplain regulations.

9. Accommodate multiple uses, such as greenways, trails, and other stormwater BMPs as pre-treatment or energy dissipation measures.

10. Based on preceding design procedures, excavate floodplain to proper elevation and provide vegetative stabilization of the restored floodplain area. Vegetation establishment is an integral part of a floodplain restoration. Vegetation will help reduce flow velocities, promote settling, provide nutrient uptake, provide filtering, limit erosion along streambanks, and prevent active channel short-circuiting in the floodplain. Robust, non-invasive, perennial plants that establish quickly are ideal for floodplain restoration. The designer should select native species that are tolerant of a range of conditions, such as those accustomed to saturated conditions, emergent and upland areas.

Detailed Stormwater Functions

Volume Reduction Calculations: Floodplain restoration can achieve increased flood storage. Floodplain wetlands can attenuate smaller flows until the capacity of these wetlands is exceeded. The volume of soils removed as part of the floodplain restoration is now available for storage of flood flows and is capable of conveying flood flows at lower elevations, thus reducing water surface elevations and nuisance flooding.

Peak Rate Mitigation Calculations: Peak rate is primarily controlled through the infiltration of runoff and additional storage from runoff and receiving waters in the floodplain. Also, the shallow depth and high floodplain roughness can increase the travel time, reducing downstream peak rates.

Water Quality Improvements: Floodplain restoration will reduce the sediment load through the reduction of streambank erosion and the reconnection of the stream channel to a functional floodplain. A floodplain also promotes deposition of fine sediments and filtering of nutrients. Root zones attached to the base flow and groundwater remove nutrients during low flow or drought periods. The floodplain also acts as a riparian buffer or a vegetated filter strip filtering nutrients and sediment from overland runoff prior to waters entering the stream channel.

Recharge: The wide and flat area of the floodplain along the valley bottom should typically be porous, providing a large area for infiltration. In many “karst” or limestone areas, the channel bed may be significantly higher than the groundwater elevation. The channel and floodplain in these areas can provide significant groundwater recharge even during drought conditions. The floodplain/channel bed must consist of the proper earthen materials to absorb surface flows, increase infiltration to groundwater, and promote groundwater recharge.

Construction Sequence

The Pennsylvania Keystone Stream Team has developed *Guidelines For Natural Stream Channel Design for Pennsylvania Waterways*, and Construction Considerations are discussed specifically in Chapter 8.

Maintenance Issues

Floodplain restoration projects must have a maintenance plan that will address the condition of the channel and floodplain through the monitoring of the survivability of the riparian plan implemented with the restoration project. As discussed in the design considerations, vegetation establishment is paramount to the stability of streambanks and the floodplain. Vegetation established along the streambanks and within the floodplain should maintain a minimal 85 percent survival rate, which should be documented through the implementation of a monitoring plan.

Monitoring of the floodplain restoration should coincide with the regulatory requirements established by state and federal regulatory agencies. These monitoring requirements are typically established as a condition of the issuance of a permit to authorize the floodplain restoration activities.

Weed and Invasive Plant Control
Weeds and invasive plants limit buffer growth and survival of native plants; therefore, weeds and invasive plants should be controlled by either herbicides, mowing, or weed mats. These techniques may need to be implemented after the first growing season and may need to continue into the fourth year after the implementation of the floodplain restoration.

Herbicides
This is a short-term (two to three years) maintenance technique that is generally less expensive and more flexible than mowing and will result in a quicker establishment of the buffer. Herbicide use is regulated by the Pennsylvania Department of Agriculture. Proper care should be taken to ensure that proximity to water features is considered.

Mowing
Mowing controls the height of the existing grasses yet increases nutrient uptake; therefore, competition for nutrients will persist until the canopy closure shades out lower layers. Mowing could occur twice each growing season. Mower height should be set between eight and 12 inches.

Weed Mats
Weed mats are geo-textile fabrics that are used to suppress weed growth around newly planted vegetation by providing shade and preventing seed deposition. Weed mats are installed after planting, and should be removed once the trees have developed a canopy that will naturally shade out weeds. Once established, the floodplain restoration project should require little to no long-term maintenance.

Cost Issues

The Pennsylvania Keystone Stream Team has developed preliminary cost ranges associated with the assessment, design, permitting, and implementation of floodplain restoration projects. They can be found at the Keystone Stream Team website: http://www.keystonestreamteam.org/.

Specifications

Floodplain restoration designs need to accommodate the sediment loads of the watershed without aggrading or degrading. Guidelines for floodplain restoration projects can be found in the Keystone Stream Team's *Guidelines for Natural Stream Channel Design for Pennsylvania's Waterways* (March 2003).

References

Guidelines For Natural Stream Channel Design for Pennsylvania Waterways, Chapter 8, Keystone Stream Team, March 2003.

Cost Ranges Outline, Keystone Stream Team website: www.keystonestreamteam.org
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