PENNINGTON GAP, VA

GREAT STONE FACE

NORTH FORK POWELL RIVER GREENWAY

Prepared for the Town of Pennington Gap, Virginia

October, 2004

C D A C COMMUNITY DESIGN ASSISTANCE CENTER

College of Architecture & Urban Studies . Virginia Polytechnic Institute & State University

The Community Design Assistance Center (CDAC) is an outreach of the College of Architecture and Urban Studies and Virginia Tech that assists communities, neighborhood groups and non-profit organizations in improving the natural and built environments through design, planning, and research. Through the integration of the learning and working environment, the Center will execute projects that link instruction and research and share its knowledge base with the general public.

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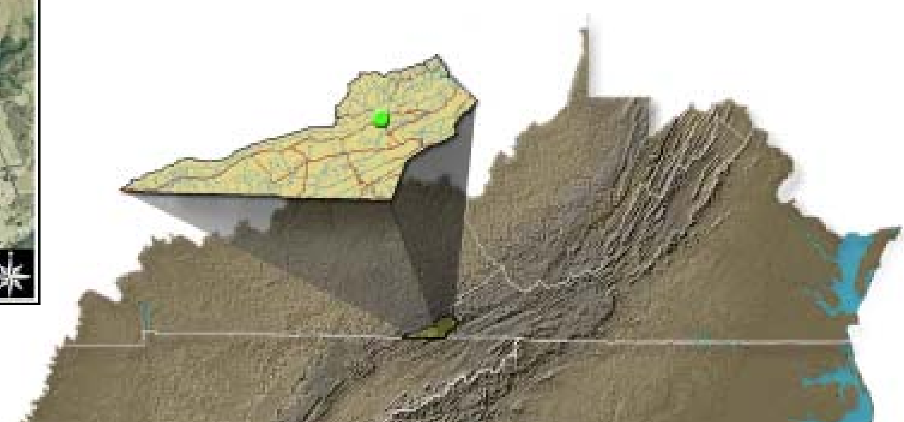
I. INTRODUCTION

Pennington Gap is a small town in northern Lee County, which is located in the coalfields of Southwestern Virginia. It has a population of 1,922 (approximately 931 families) and a land area of 1.5 square miles, making it the largest town in Lee County. With twelve outdoor recreational destinations within an hour of the town including Cumberland Gap and Wilderness Road State Park, Pennington Gap is the hub of the wheel of regional tourism opportunities branching out in every direction.

The Town of Pennington Gap enlisted the services of the Community Design Assistance Center (CDAC) to assist in designing a greenway trail that runs along the North Fork of the Powell River from Route 58, where it enters the town limits, to Leeman Field, the town-managed recreation area. The greenway will provide a pedestrian access corridor from Leeman Field into downtown. There are also hopes that this portion of trail may one day be tied into a larger regional trail system, further linking the Town of Pennington Gap to its regional neighbors.

The majority of the greenway corridor land is owned by either the Town of Pennington or Lee County. The section where the trailhead is located, adjacent to Route 58, is a privately owned commercial site that currently has stormwater quality issues. At present, there are no Best Management Practices (BMPs) that treat the stormwater sheet flow coming off the parking lot and entering the river. Through the initiatives of the Tennessee Valley Authority (TVA), an effort has begun to gain an easement along this 700′ of river frontage in order to implement a stormwater BMP, as well as provide enough land "canvas" in which to set the greenway trail. This report describes and documents the the design process and the final conceptual design for the North Fork Powell River Greenway and information regarding stormwater management and Low Impact Development.



Pennington Gap in Lee County. Lee County is the western-most county in Virginia and is centered in a five-state area including Kentucky, West Virginia, Virginia, Tennessee, and North Carolina.

II. HISTORY

Lee County was formed from Russell County in 1792 and was named for General Henry 'Light Horse Harry' Lee of Westmoreland. Pennington Gap was named for Edward Pennington who came to Lee County in 1790 and built a home two miles east of Dryden. He later married and moved to the south side of the gorge to what is now Pennington Gap.

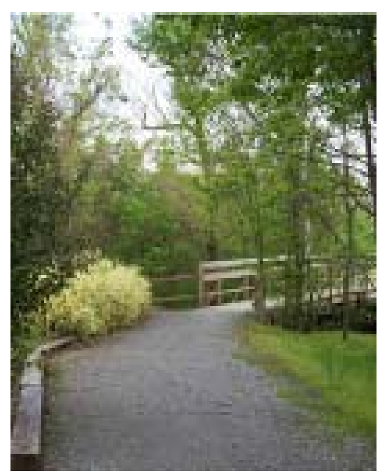

Coal miners exiting mine

Pennington Gap is located about six miles south of the town of St. Charles, where commercial coal mining began in about 1905. The town was mainly a shipping point for the northern portion of the county and was served by the Cumberland Valley division of the Louisville and Nashville Railroad and by Highway 421 and Route 58.


View from Cumberland Gap into Tennessee and Kentucky

III. GOALS

The primary aims of the greenway in its entirety are to improve the water quality of the North Fork of the Powell River adjacent to the Riverbend Shopping Center, to improve the quality of life for Pennington Gap residents by promoting healthy lifestyles and pedestrian connections to town amenities (i.e. downtown to Leeman Park), to create educational opportunities for residents and the adjacent school, to provide public access to the river in designated areas, and to increase the desirability of the town to both residents and tourists alike. CDAC's role was to provide the design and conceptual framework for realizing the aforementioned goals.


Greenway trail in Harrisonburg, VA

IV. POWELL RIVER


View of river north near the Industrial Park

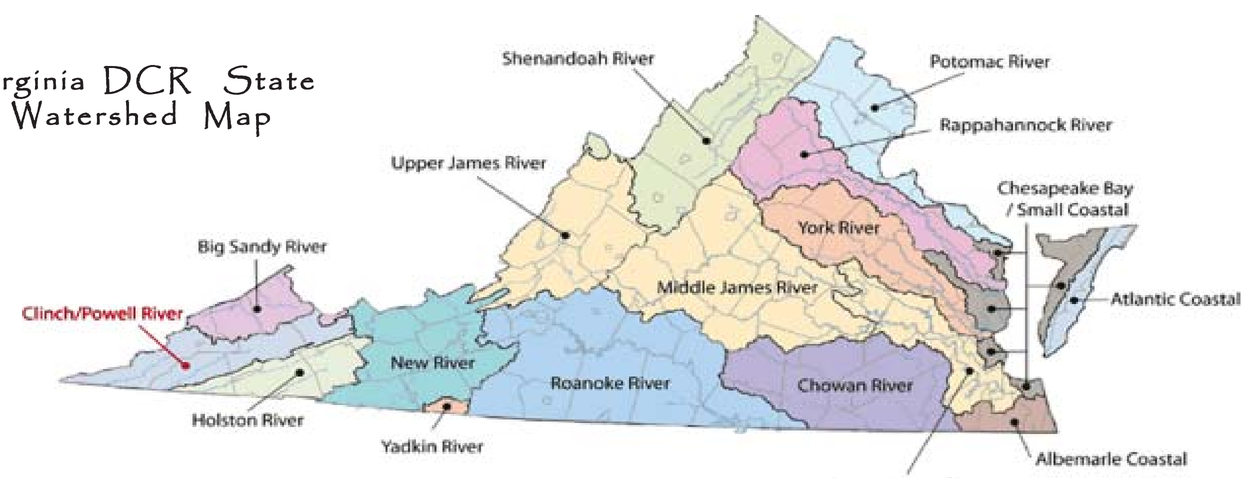
The Powell River flows 707 miles through predominately forested land in Lee and Wise Counties draining 353,221 acres. The Powell River, along with Powell Mountain and Powell Valley, is named for Ambrose Powell, one of the explorers who accompanied Dr. Thomas Walker through the area in 1750. The Powell River supports 330 species of wild animals, including 58 endangered or threatened species. Historically, coal mining has been the greatest contributor toward water quality degradation. Prior to 1977, the 'shoot and shove' methods of coal mining devastated the rural Appalachian Mountains in southwest Virginia and destroyed ground water supplies as well. Since that time, acid-mine drainage and sediment from abandoned mine lands still contribute significantly to nonpoint source pollution. Public drinking water, failing septic systems, lack of water quality education, and trash/litter are some of the top water quality issues.


View north upstream of the Shopping Center


Trash along riverbank at Shopping Center

The portion of the river directly affected by the greenway project is the approximate 700' of river frontage adjacent to the Riverbend shopping center parking lot. Currently, an estimated 84,000 gallons of untreated runoff from the parking lot enters the river for every inch of rainfall. With the average annual rainfall totals nearing 50", this portion of the river corridor is a hot spot for water quality. The proposed greenway easement will incorporate an infiltration trench that will cleanse the stormwater and allow for slow groundwater recharge. Since the town will take over maintenance responsibilities for the greenway, the level of trash and debris will be reduced and the overall aesthetics and health of the river corridor will be enhanced.

Virginia DCR State Watershed Map



The Powell River supports as many as 37 species of mussels, including six species that the U.S. Fish and Wildlife Service lists as endangered. Freshwater mussels are only found in Virginia in those rivers that drain into Tennessee, such as the Powell, Clinch, and Holston. Freshwater mussels are an essential component of our rivers and streams. By their siphoning actions, mussels filter bacteria, algae, and other small particles, which make them one of the few animals that actually improve water quality. Mussels also serve as a food source for many species of fish, reptiles, birds, and mammals. Their shell is home to many aquatic insects, algae, and plants, and is an egg-laying site for many fish.


Freshwater Mussels


Freshwater Mussels

V. WHY IS WATER QUALITY IMPORTANT?

The Environmental Protection Agency comments that our water resources are of major environmental, social, and economic value, and if water quality becomes degraded this resource will lose its value. Water quality is important not only to protect public health, but it also provides ecosystem habitats, is used for farming, fishing, and mining, and contributes to recreation and tourism. If water quality is not maintained, it is not just the environment that suffers - the commercial and recreational value of our water resources will also diminish. It is important that the citizens of Pennington Gap see the North Fork of the Powell River as a great resource. The Pennington Gap Greenway will begin to provide residents access to the river, to enjoy this resource, to learn about our natural resources, and to become more aware of the benefits healthy rivers and streams offer. (www.epa.gov).

Trash along riverbank adjacent to the Riverbend Shopping Center parking lot

More trash and debris along riverbank

VI. STORMWATER RUNOFF

The changes to natural land surfaces and drainage patterns which accompany urban development can result in natural watercourses becoming turbid, silted, littered, and undesirably enriched with nutrients. When turbid water restricts sunlight filtration, photosynthesis is reduced and productivity of the aquatic ecosystem suffers. Watercourses are subject to increased flooding due to increased runoff caused by large impervious services. Subsequent flooding contributes to erosion and siltation problems downstream.

The edge of the parking lot at the Riverbend Shopping Center runs to within a few feet of the river.

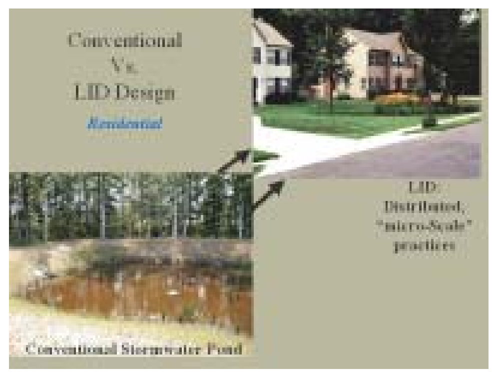
Toby Edwards & Elizabeth Gilboy discuss the Riverbend Shopping Center parking lot on a site visit.

View across the river to the bank below the Riverbend Shopping Center parking lot.

VII. LOW IMPACT DEVELOPMENT (LID)

The Virginia Department of Conservation & Recreation (DCR) in partnership with a number of private organizations has developed and published a guide to low impact development called *Low Impact Development: A Tutorial and Toolkit*. This guide deals directly with why and how planned and existing developments should address stormwater runoff issues with an environmental mindset. Low Impact Development is defined in this publication as: "an approach to site design and stormwater management that seeks to mimic the pre-development runoff characteristics on a development site."

As impervious surface increases, stormwater runoff increases. In the past, this issue was dealt with by developing stormwater ponds or detention basins. However, this practice was seen as unsightly and aesthetically unpleasing, despite the fact that it did cleanse the stormwater. Today, stormwater is dealt with by using micro-scale practices and implementing plant material to bring back a more "natural" look to treatment areas. Practices such as infiltration trenches in parking lots can be planted with species which help to cleanse the water while providing shade and a visual break in a landscape dominated by asphalt. These practices can be applied across the scale, from residential to commercial to institutional to municipal, and not only do they enhance the appearance of the developed landscape, they actually cost less than conventional practices.



** all images taken from DCR LID Powerpoint presentation

VIII. DESIGN PROCESS

The deisgn process included making an initial site visit to meet with town officials and interested governmental agencies to gain insight into the plans and aspirations of the greenway. There was also an interim meeting to recieve feedback on proposals from both officials and the landowners of the Riverbend shopping center. The team then responded to the feedback, and presented their final concepts to the Town Council on October 18, 2004.


Meeting at Pennington Gap Town Hall

The CDAC team made its initial site visit to Pennington Gap on June 10th, 2004. The team met with the client, partnering agencies, and interested parties to establish goals and objectives, to obtain base map information for the study area, as well as, maps showing regional existing and proposed trail systems. In attendance at this meeting were Pennington Gap Town Manager Mark Smith, engineering consultant to Pennington Gap Andy Miles, VISTA intern Amanda Wood, Tennessee Valley Authority Watershed Representative Toby Edwards, Conservation Specialist for the Daniel Boone Soil and Water Conservation District Shawn Morris, and the CDAC team members Kim Watson, Nathan Brown, and Ryan Millard. Following the meeting, the group walked and photographed the proposed greenway route.


Walking the proposed greenway path


Team members Ryan and Nathan analyzing

The group identified the current stormwater runoff problems from the Riverbend Shopping Center parking lot into the North Fork of the Powell River as one of the major issues to be addressed by the greenway. The parking lot was identified as a design priority, and upon returning to Blacksburg, the team focused their work on addressing the parking lot, reducing runoff, and improving water quality through design.

After the appropriate design and drawings had been completed, a second trip to Southwest Virginia was scheduled for July 1st, 2004 to meet with Riverbend Shopping Center owners Sutton and Randy Rigg in Wise, Virginia to discuss the design proposals.


Pre-meeting session preparing to meet with Riverbend Shopping Center owners

The objectives of this meeting were to present the stormwater BMP concepts to the landowners and to propose the possibility of obtaining an easement along the river for siting the BMP and the greenway trail. Attending this meeting were the landowners Randy and Sutton Rigg, the Pennington Gap Town Manager Mark Smith, VISTA Intern Jenny Wampler, TVA Watershed Representative Toby Edwards, and CDAC team members Kim Watson, Nathan Brown, and Ryan Millard.


CDAC team member Ryan Millard presenting

The landowners expressed enthusiastic support of the overall concept. They gave the CDAC team permission to proceed with the proposed route with two contingencies: first, that any parking spaces taken away by the easement would be replaced adjacent to the existing parking lot, and second, that tenants of the Riverbend Shopping Center would be willing to sign an addendum to their lease that would allow changes to be done to the parking lot.


CDAC team member Nathan Brown and Town Manager Mark Smith respond to questions

A meeting was scheduled for July 21, 2004 in Pennington Gap to meet with each of the tenants to describe the changes to the parking lot and ask for their approval. However, scheduling was a problem and many of the tenants could not meet. Tenants preferred to receive a packet of information showing the proposed changes (see Appendix). Thus packets were prepared and sent to all tenants. Follow up calls were made to receive tenants' feedback and an additional letter was sent, requesting tenants to sign and send a letter of project support.


CDAC team presenting ideas at the August 11 meeting

The CDAC team returned to Pennington Gap on August 11, 2004 to present the greenway concept to Mark Smith, Pennington Gap Town Manager, and members of the Lee County School Board.

Also present at this meeting were area representatives from TVA, the Virginia Department of Forestry, VDOT, and the Daniel Boone Soil and Water Conservation District. All those present at the meeting expressed enthusiasm and support for the concept.


Members of the School Board and VDOT at the August 11 meeting

The VDOT representative pointed out a few conflicts with the proposed Route 58 bypass corridor overpass, while the School Board identified an issue with the proposed auxiliary parking next to the Riverbend Shopping Center. The School Board is proposing a new baseball field that will replace the existing one, which will be removed to make way for the proposed Route 58 bypass corridor. The design team was provided a copy of the plans for the field and was able to rework the axillary parking so that it would not conflict with the proposed baseball field.

Proposed baseball field

Another issue brought to the design team's attention at this meeting was that the proposed outdoor classroom needed to be redesigned in order to accommodate the town's desire to have land available to expand Leeman Field.


Original outdoor classroom concept

The final public meeting was scheduled for October 18, 2004 in Pennington Gap. The design team presented final concepts to interested community members and related governmental agencies.

"Following a presentation and public hearing concercning the Green Belt Trail Conceptual Plan, members of the Pennington Gap Town Council unanimously approved a motion to proceed with seeking funding for the project."[1]

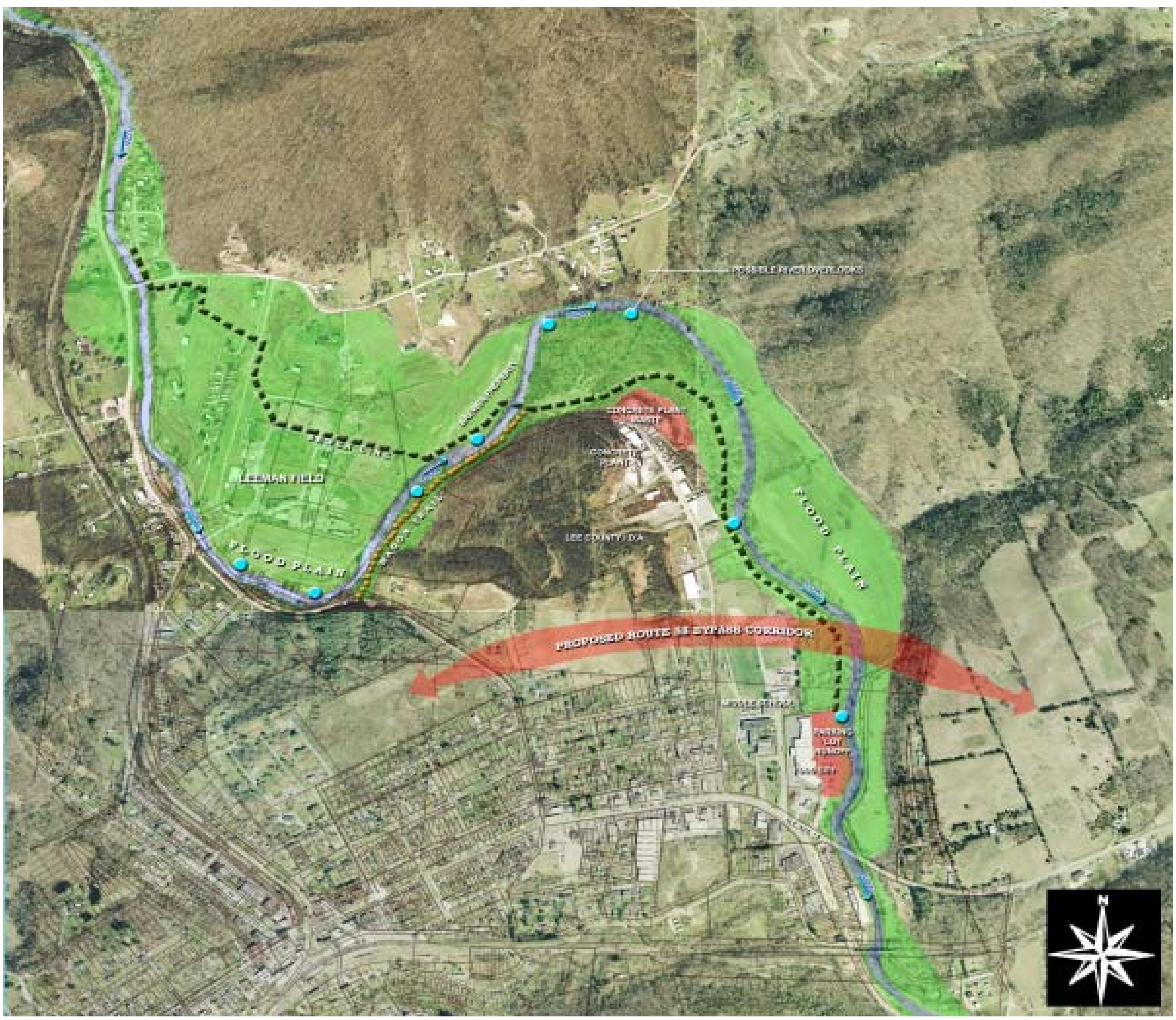

Revised outdoor classroom design.


Final presentation to Town Council on October 18, 2004

[1] *Powell Valley News* Wednesday, October 20, 2004

IX. SITE ANALYSIS

The entire proposed corridor for the trail lies within the floodplain of the North Fork Powell River. There are two areas that are of major concern. The first is the stormwater runoff issue at the Riverbend Shopping Center. The second is the waste fill from the concrete plant located at about the midpoint along the corridor. Recently, there has been a sewer line extension constructed from the town to St. Charles. This should not affect any trail construction, but rather, the trail should seek to follow, where possible, the already cleared right-of-way from sewer line construction. The proposed Route 58 bypass corridor will create some issues with trail placement and parking, and will force the county to relocate the baseball field that will consequently be removed. There are a number of opportunities along the corridor, namely, an historic wagon trail that runs parallel to the river. This could allow for historic interpretation or education. Another opportunity is the placement of river overlooks along the corridor. These overlooks could be educational in nature or purely recreational, allowing users to fish or sight-see from their elevated position.



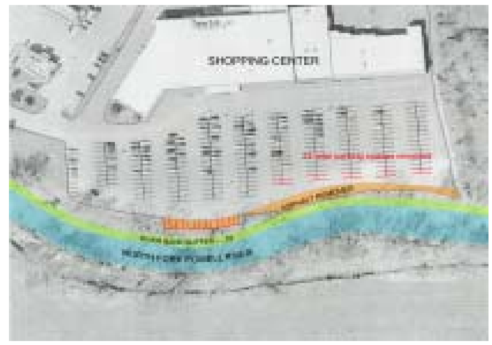
X. DESIGN CONCEPTS

This section provides a detailed explanation of the concepts dealing with the Riverbend shopping center and the greenway as a whole.

A. RIVERBEND SHOPPING CENTER

The Riverbend Shopping Center's parking lot has great potential to go from the current state of having untreated stormwater running into the river to a state of having LID practices implemented to treat the stormwater runoff, as well as, bordering a greenway.

Plan view of buffer zone extending into the parking lot.

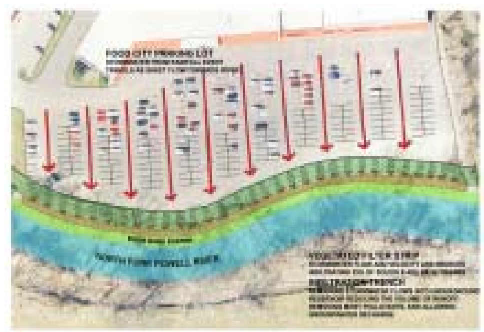


Parking spaces and asphalt removed as a result of buffer zone.

1. Buffer Zone Concept:

Because of the stormwater runoff water quality issue, a buffer zone of 40 feet was proposed from the river's edge stretching into the parking lot. This size buffer zone was proposed in order to implement stormwater management practices, as well as provide a setting for the trail to run through. As a result of the buffer zone, 23 parking spaces would be lost and a total of approximately 13,000 square feet of asphalt would be removed.

Set within the upper 15 feet of the buffer zone is the filter strip, which is a vegetated strip that removes 35% of solids and 40% of nutrients within the stormwater runoff. This also slows down the velocity of the runoff, allowing some water to infiltrate back into the soil. The middle 10 feet of the buffer zone is reserved for the actual greenway trail and infiltration trench.

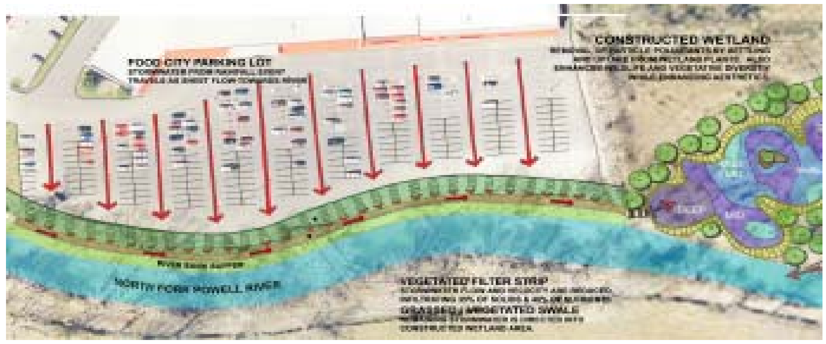

Infiltration trench concept

2. Infiltration Trench Concepts:

The infiltration trench is a gravel-filled trench that runs lengthwise parallel to the trail bed and intercepts the remaining volume of runoff coming through the filter strip. The gravel within the trench further cleanses the water and allows a slow, steady infiltration back into the water table. The trench is sized in proportion to the area of the parking lot and is designed to hold the "first flush volume" of runoff that will come off the lot during a rain event. The "first flush volume" is the volume of the first inch of rainfall on an area. This is the volume that is the most contaminated and requires the most cleansing. This trench, combined with the filter strip should cleanse and greatly improve the quality of the estimated 80,000 gallons of runoff produced in the "first flush." The remaining 15 feet of the buffer zone is located immediately adjacent to the river's edge and is meant to simply be a buffer between the stormwater BMPs and trail and the river. Trail material in this section could be hard-packed gravel or paved surface.

Trail concept at the shopping center.

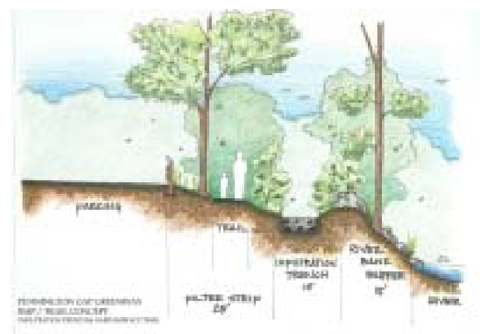
3. Wetland Concept:
Another proposed method of treating the stormwater runoff was to use a constructed wetland. This would still require a 40 foot buffer zone from the edge of the river in which a filter strip would take the top 15 feet and the middle 10 feet would be occupied by a grassed swale and the trail. The swale would funnel water parallel to the river's course to a wetland located just North of the parking lot. The water would then flow through the wetland, settling out some contaminated particles while others are taken up through the plants roots. The wetland approach would also increase the aesthetics of the system and provide for more wildlife and biodiverstiy.



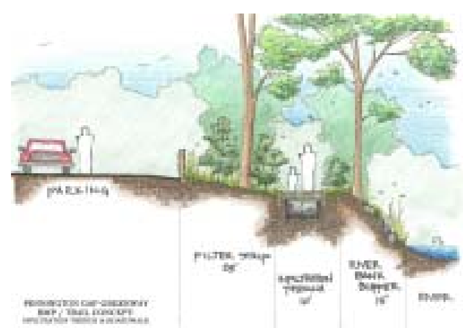
Wetland concept

The design team conceptualized a number of ways in which to set the trail and stormwater BMP in the buffer zone. The cross-section drawings to the right show these three different ideas on how to make these two important entities coexist. The scenarios are dependant upon which type of BMP is being proposed. The grassed swale/wetland approach lends the least amount of difficulty in siting the trail, as it would be set to one side of the swale. Also, the same approach could be utilized with the infiltration trench, as the trail could be set to the side; however, this posed an aesthetic problem. A third scenario was proposed in which the trail was actually a boardwalk above the trench. This would in effect hide the trench, but also would be at a considerably higher cost to construct.

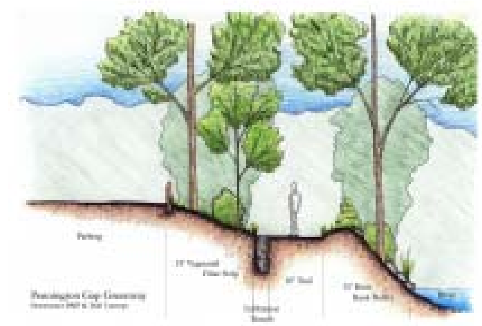

Grassed swale concept section


Infiltration trench with trail to the side

4. Final Concept:
The design team decided that an infiltration trench would be best suited for the parking lot for reasons that the wetlands would be expensive to build, would be upstream from the parking lot, and would take up a larger amount of land area versus the trench. Thus, calculations were done to accurately size the infiltration trench and to give each entity within the buffer zone an actual space. The result was a trench that was 18" wide, 5 feet deep, and approximately 700' in length. This allowed more surface area that could be utilized for the trail and made the issue of aesthetics minimal, as the trench would be located just off the trail on the uphill side. By locating the trench on the uphill side of the trail, it will intercept a majority of the overland flow coming through the filter strip, thus cleansing the water and returning it to the water table via infiltration. This is a much better situation in terms of water quality and erosion for the river bank along this section of the greenway.


Infiltration trench with boardwalk

Stormwater management was at the forefront of the design initiatives for this section of the greenway; however, it was not the only initiative. The design team, after corresponding with a local resident who liked to fish from the parking lot, decided to incorporate river overlooks, not only in this section, but all along the greenway in strategic points. The purpose for doing this is to allow users to observe the river at a vantage point that is unique and relays a sort of "bird's eye" sense. Another reason for these overlooks is to provide educational opportunities along the corridor. The overlook at the shopping center would be primarily for fishing, with informative signs educating the users about stormwater management, water quality, and biodiverstiy.



Final trail / BMP design

At the initial site visit, the design team quickly identified the caboose at the entrance to the middle school as being a prime spot to have an informational kiosk about the greenway. This area could also foster parking and possibly some sort of venue working out of the caboose, such as concessions or historical photo gallery. In order for users to get from the caboose to the trailhead, the town would need to extend their sidewalk from the caboose to the Riverbend shopping center. This would be the final link in the Town's sidewalk system and would help to complete the proposed pedestrian link from Main Street to Leeman Field.

Cross-section of river overlook

Perspective of information kiosk at caboose

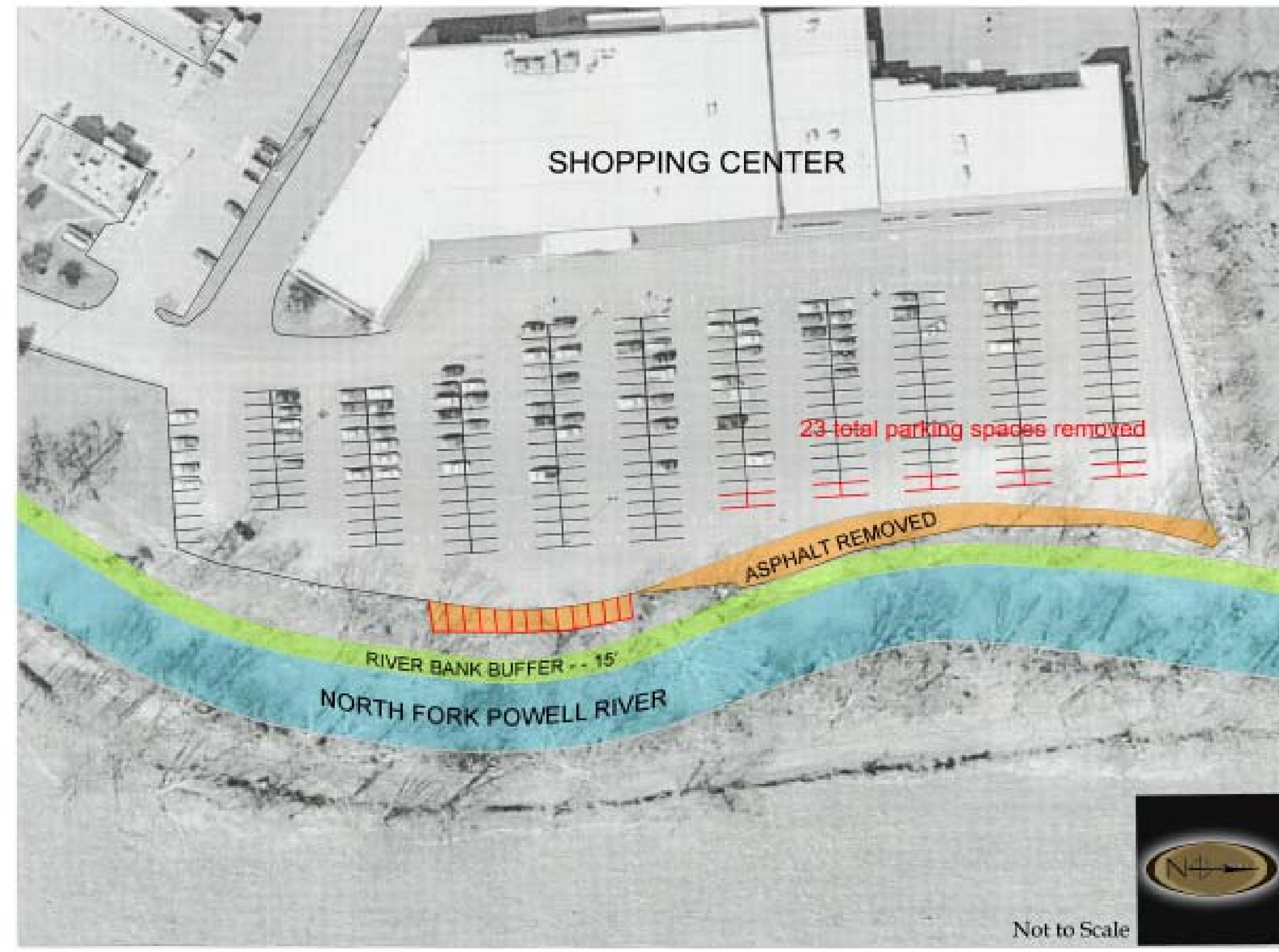
The trailhead of the greenway is proposed at the Southeast corner of the shopping center's parking lot. The design team has proposed that a gazebo be constructed for two reasons. First, the trailhead needs some sort of structure to ground it and to let users know that this point is the beginning. Secondly, there are a number of food venues in the shopping center, as well as, restaurant chain businesses, which are located only a short walking distance from the proposed trailhead. The gazebo structure could serve as a dining facility, allowing users to sit and eat a meal while overlooking the river. It could also be utilized for small gatherings and for informational purposes.

Perspective of trailhead gazebo

Note: the drawings on the following 2 pages show the final concept for the buffer zone, the parking lot implications, and the final concept for the infiltration trench and river overlook.

40' buffer zone for final design

Parking spaces and asphalt to be removed in final design



North Fork Powell River Greenway - Riverbend Shopping Center
Buffer Zone & Parking / Asphalt Implications

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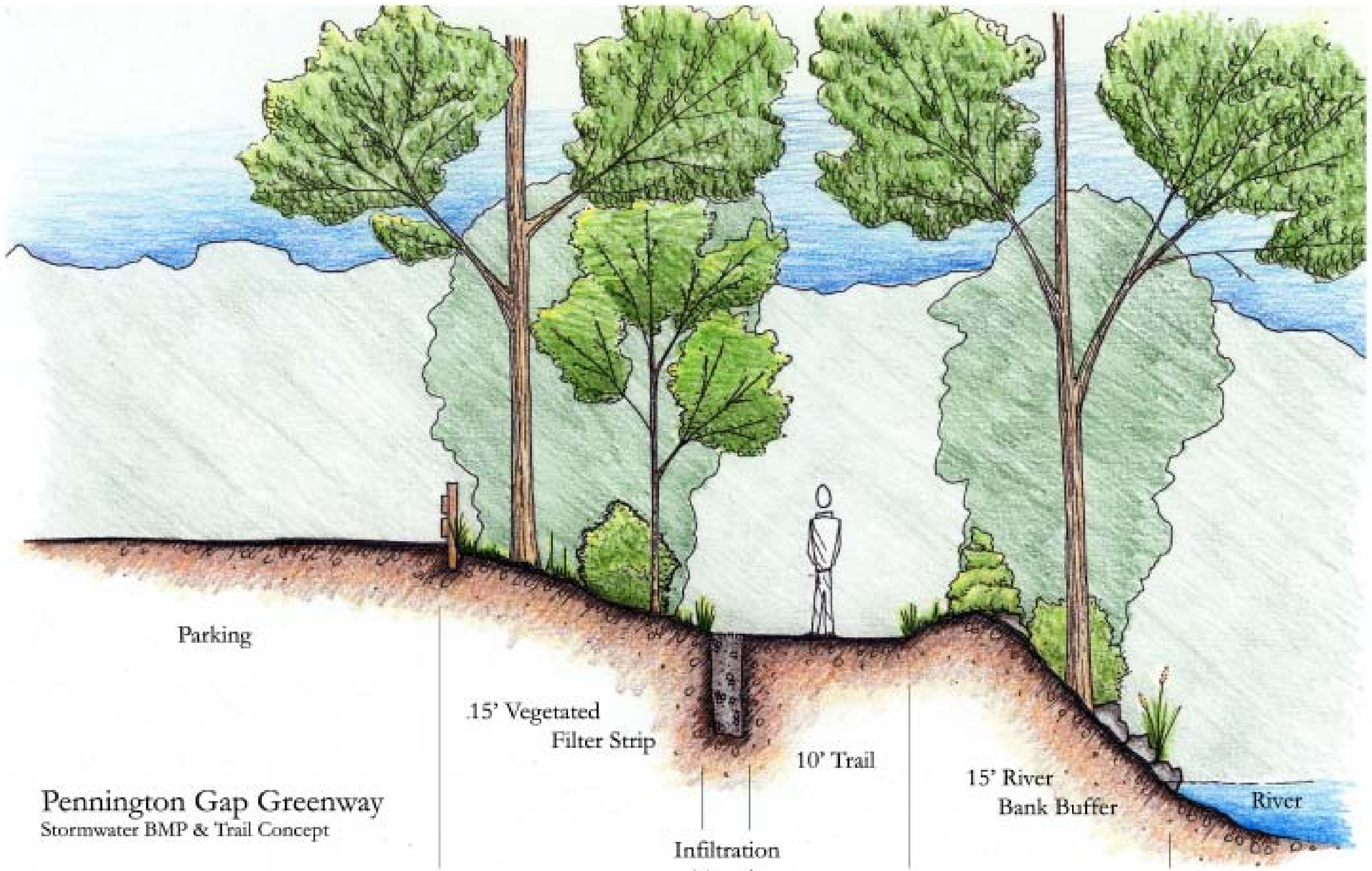

Pennington Gap Greenway
Stormwater BMP & Trail Concept

PENNINGTON GAP GREENWAY
OBSERVATION DECK

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North Fork Powell River Greenway - Riverbend Shopping Center
Stormwater BMP - Final Design Concept

community design assistance center
College of Architecture and Urban Studies
Virginia Polytechnic Institute and State University

B. NORTH FORK POWELL RIVER GREENWAY TRAIL CONCEPTUAL DESIGN

The proposed North Fork Powell River Greenway trail has the potential to be a wonderful asset to the Town of Pennington Gap and surrounding communities. The trail will provide a pedestrian link from the town to Leeman Field, an already popular recreation area for the town. The trail will host numerous recreational opportunities for users, providing such amenities as river overlooks, boat launches, and fishing opportunities, along with walking, jogging, biking, and possibly horseback riding. It is the dream of many involved in this project that this section of trail can be the first leg in a regional trail system where Pennington Gap serves as a regional trail head.

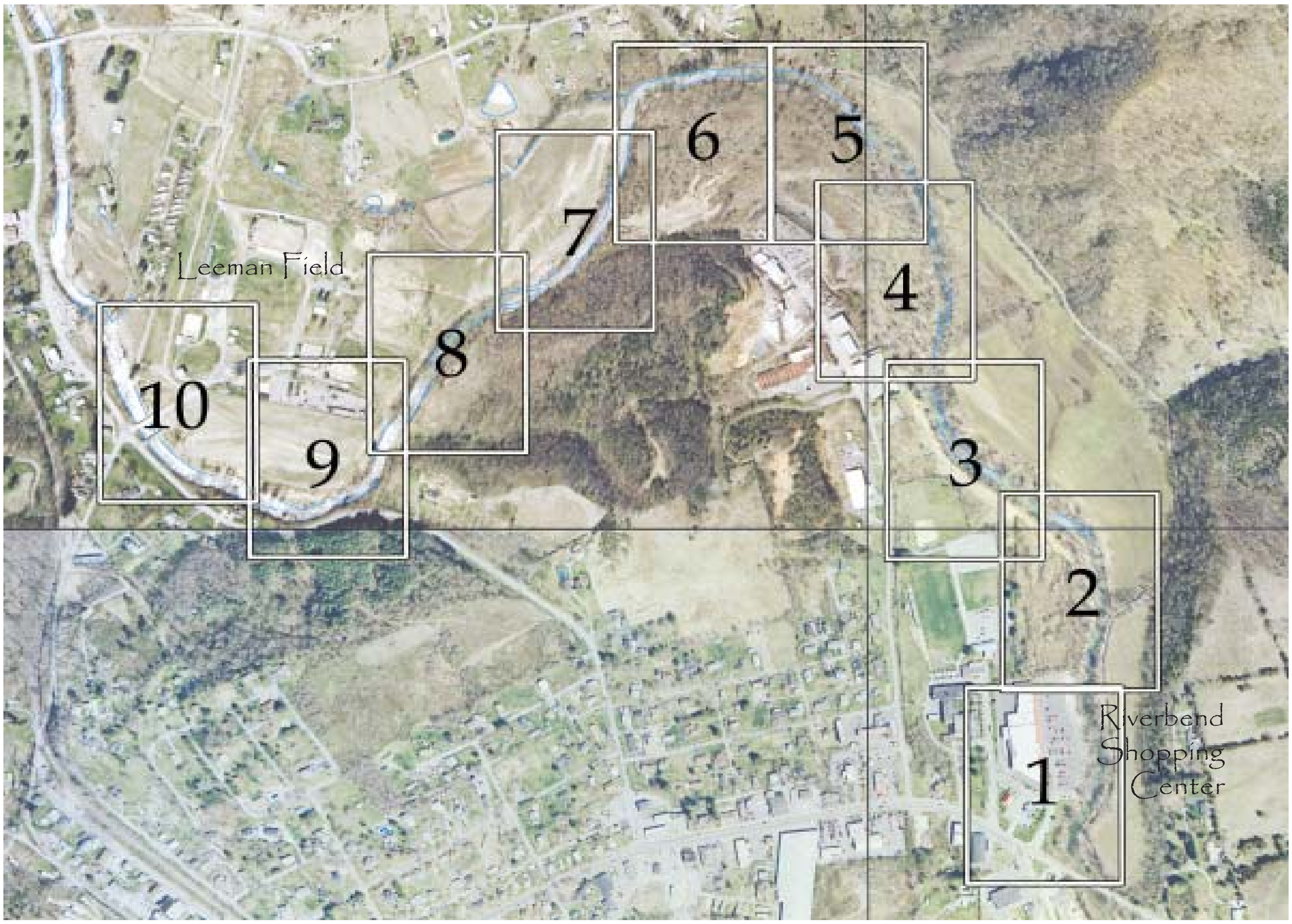
A major objective for the greenway, as stated in the goals, is to connect downtown Pennington Gap to the town's fairgrounds and recreation facility, Leeman Field. Built in 1933, the 20 acre facility hosts little league baseball, horse shows and events, and provides residents with a community swimming pool, a playground, picnic pavilions, an amphitheater, tennis courts, horseshoe pits, volleyball courts, restrooms, and one of Virginia's longest running county fairs. There is a horse arena where every month, March through October, the Cumberland Horse Association sponsors events for children, teens, and adults. Activities include team penning, exhibition classes, rodeos and speed shows, with barrel racing, pole bending, rescues, and speed races. The newly constructed amphitheater hosts special events such as karaoke sing-alongs and concerts. The walking/running trail that encircles the entire facility will serve as a terminus for the Pennington Gap Greenway.

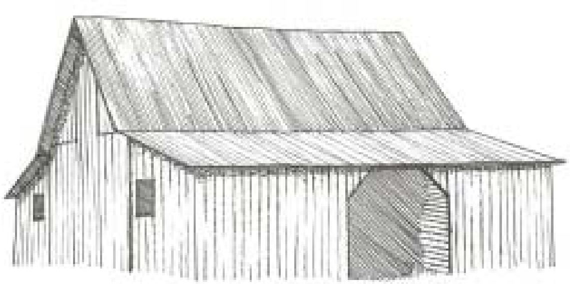
Entrance sign to Leeman Field


Jogger using the walking trail that encircles Leeman Field. The Pennington Gap Greenway will connect to this trail creating pedestrian access to Leeman from downtown.

There are also a number of educational opportunities along the trail, all of which are anchored by the outdoor classroom (sheets 4&5). At the river overlooks, informational signage will be placed to educate users about issues such as water quality, biodiversity, and stormwater management. The outdoor classroom is programmed to be utilized by the Lee County School System as an educational venue in which middle and high school students can learn about such things as agricultural and horticultural practices.

The following pages provide an up close view of each of the individually numbered sheets shown in the overall context map below. A description of what is going on in each sheet will be located at the bottom of each page.

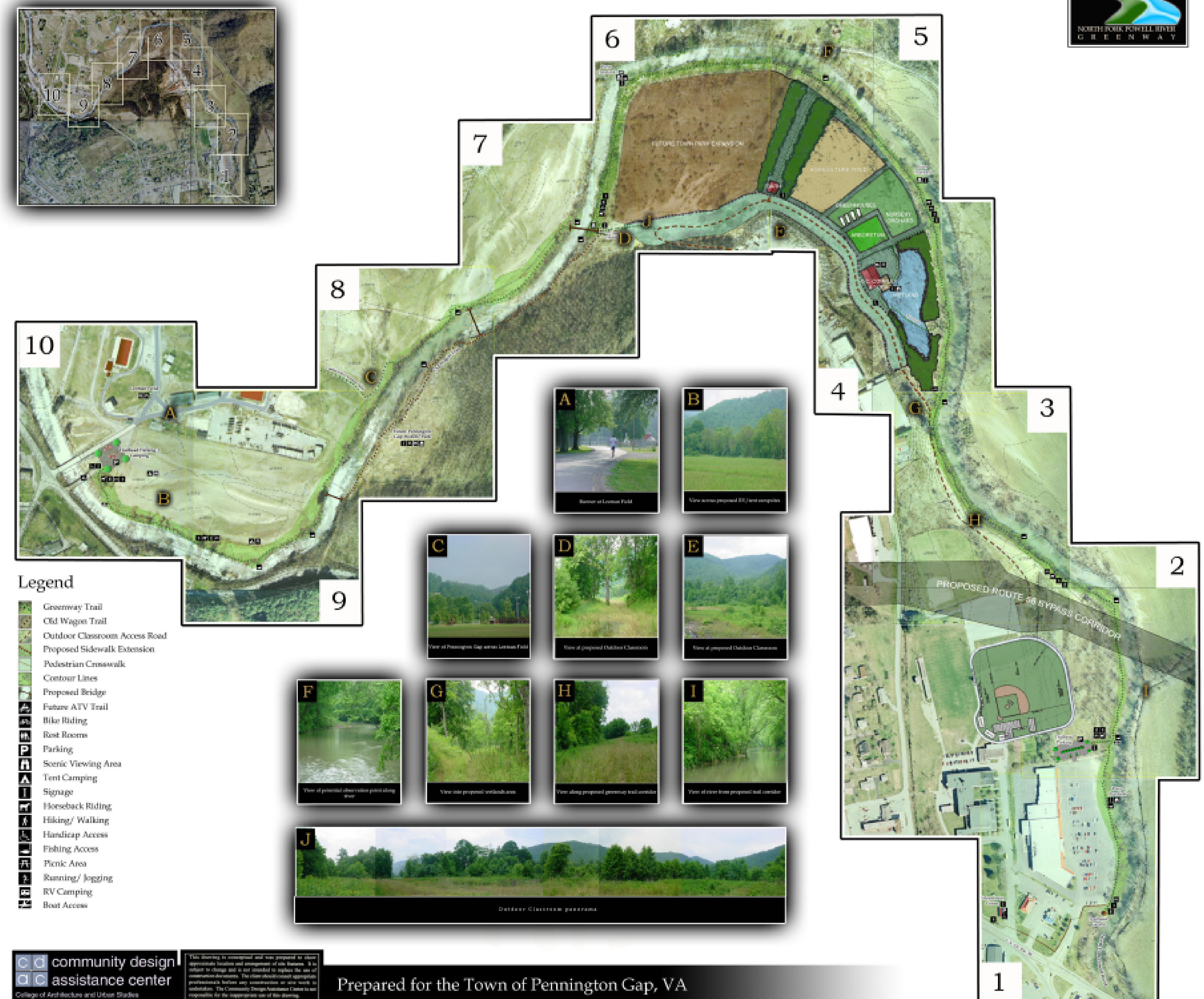




Perspective of historic Appalachian crib barn at the outdoor classroom

Perspective of the boardwalk through the irrigation wetland at the outdoor classroom

Conceptual Greenway Masterplan



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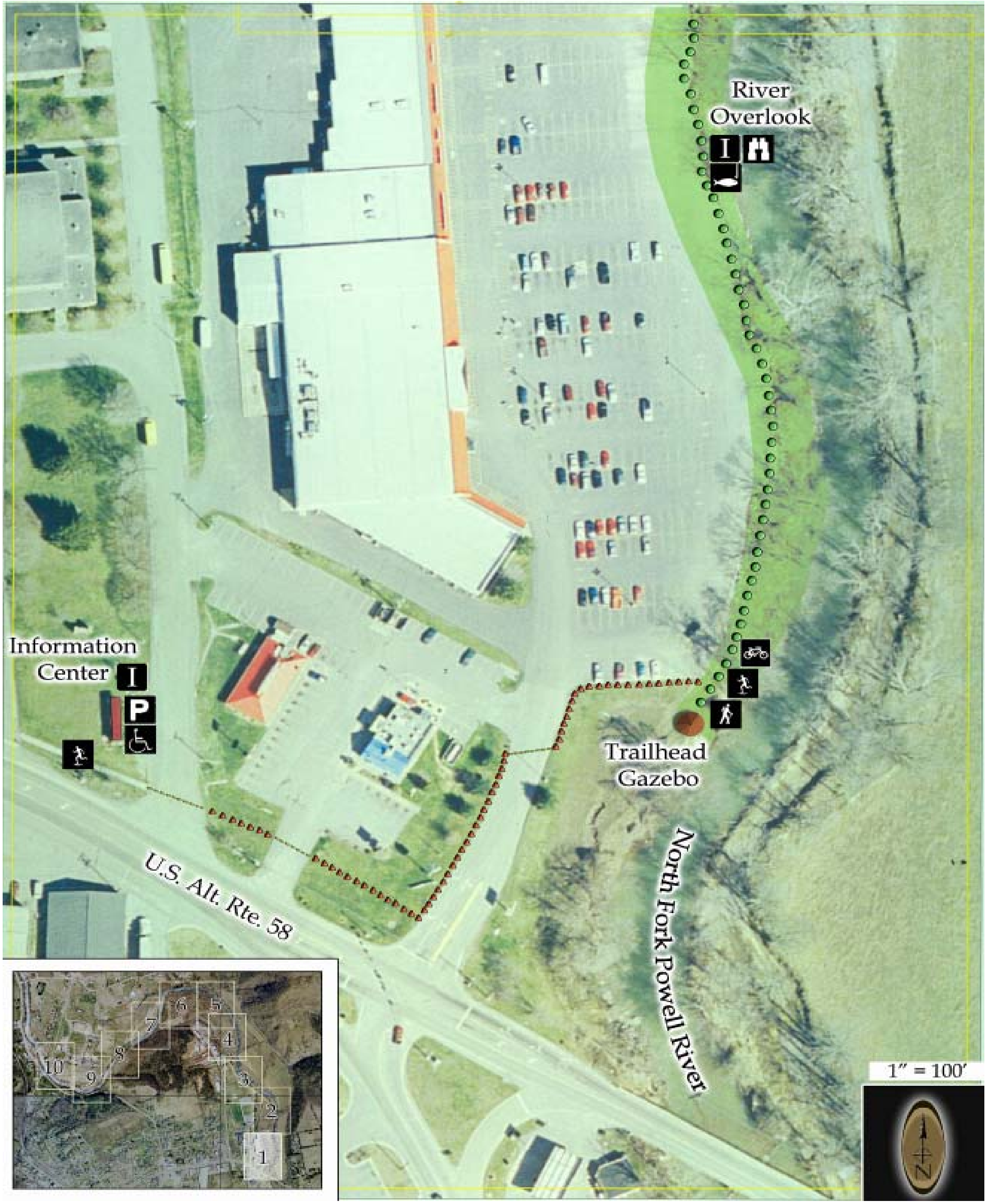
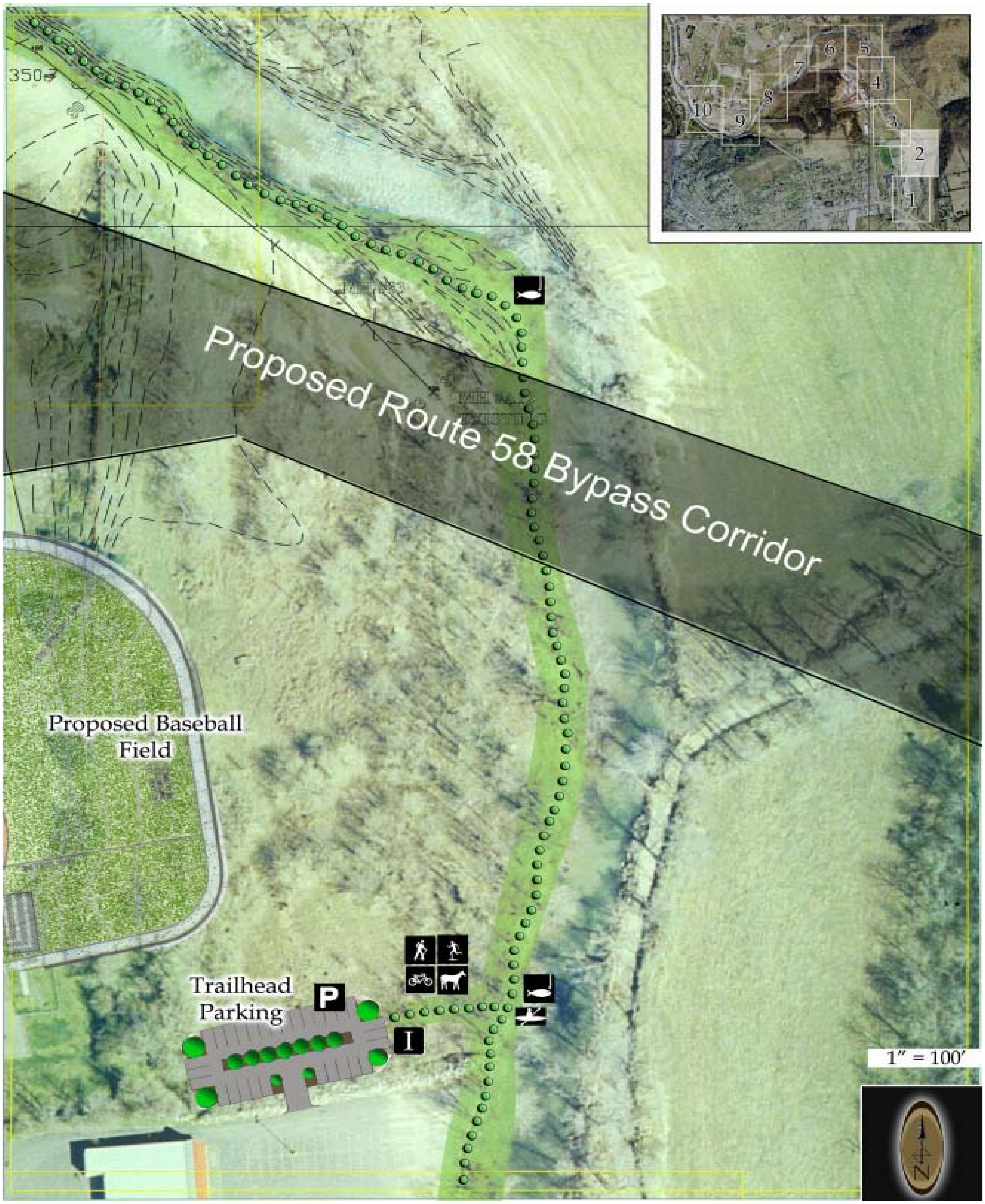
This drawing is conceptual and was prepared to show approximate location and arrangement of site features. It is subject to change and is not intended to replace the use of construction documents. The client should consult appropriate professionals before any construction or site work is undertaken. The Community Design Assistance Center is not responsible for the inappropriate use of this drawing.

Prepared for the Town of Pennington Gap, VA



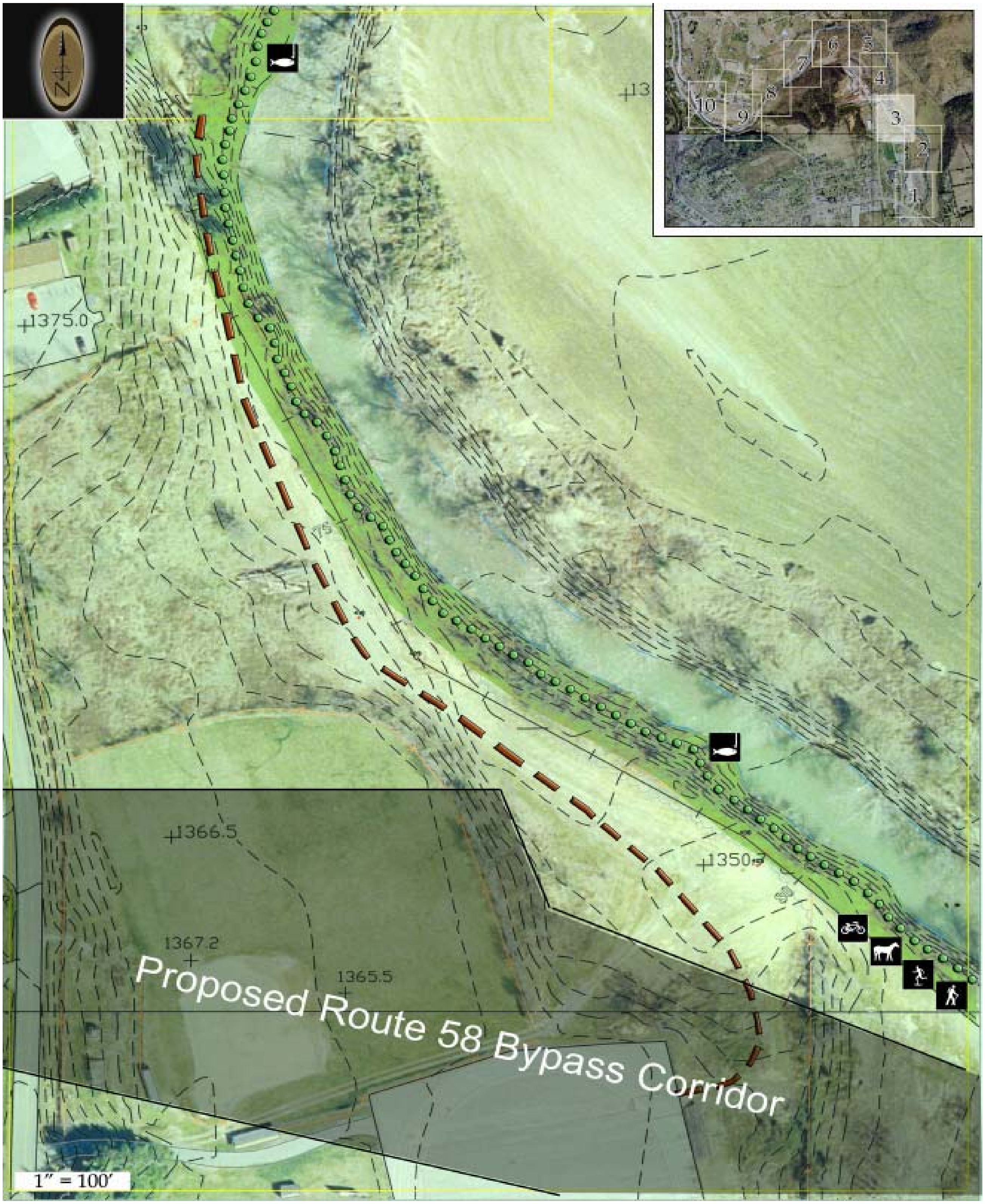
SHEET 1 of 10

This sheet shows the traihead, information center, and trail section along the Riverbend Shopping Center property. There is one proposed river overlook along this section that will allow fishing and will have informational signage regarding water quality and stormwater management. The trailhead gazebo will provide for leisure activity while the existing caboose will become the information center for the trail.



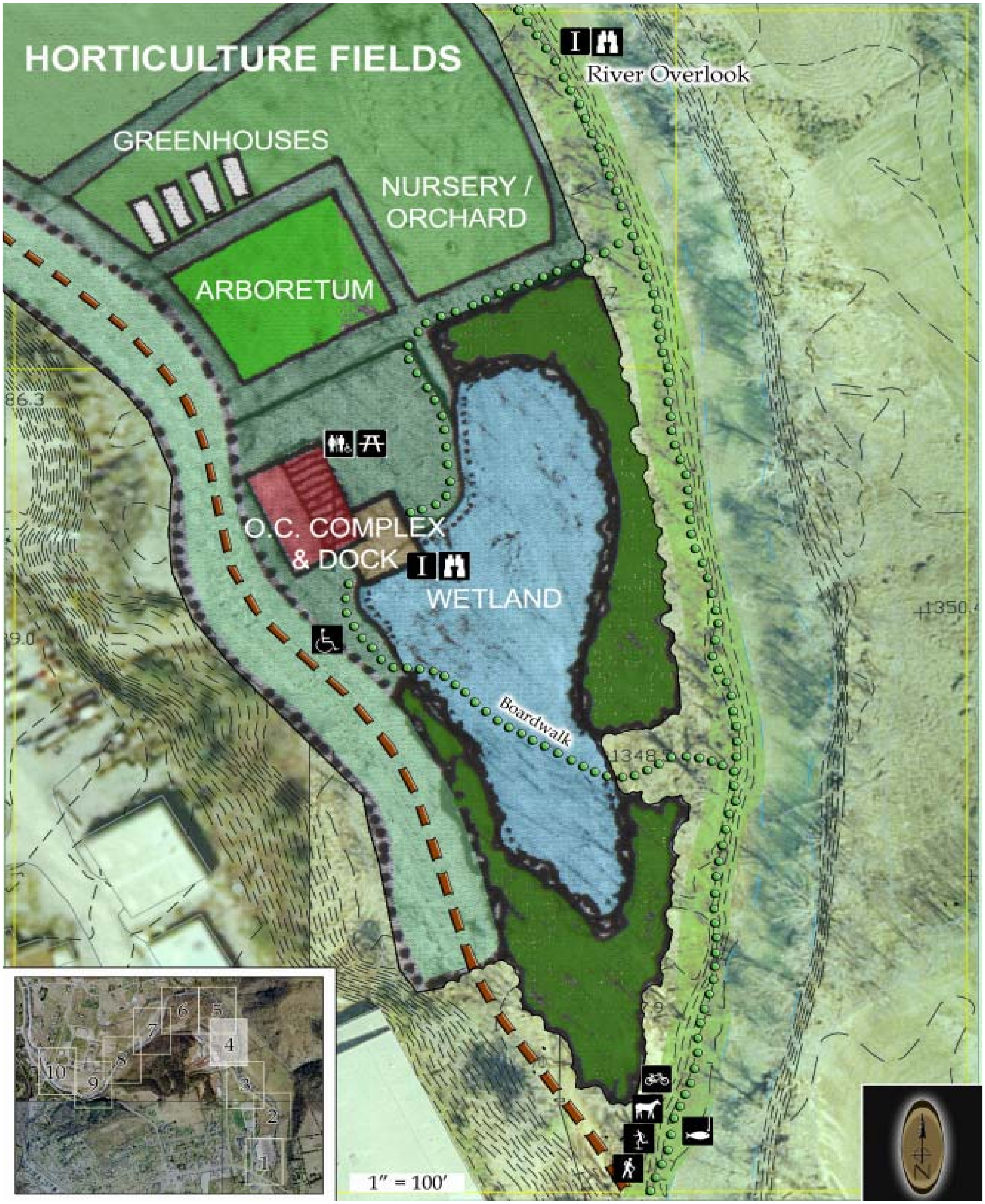
SHEET 2 of 10

This sheet shows the auxiliary parking lot that replaces the spaces removed due to the buffer zone for the trail and stormwater BMPs and provides trail parking. There will be a boat launch along this section, as well as, a fishing access just north of the proposed Route 58 bypass corridor. The proposed baseball field and the greenway trail could complement each other very nicely and provide further recreational opportunities.



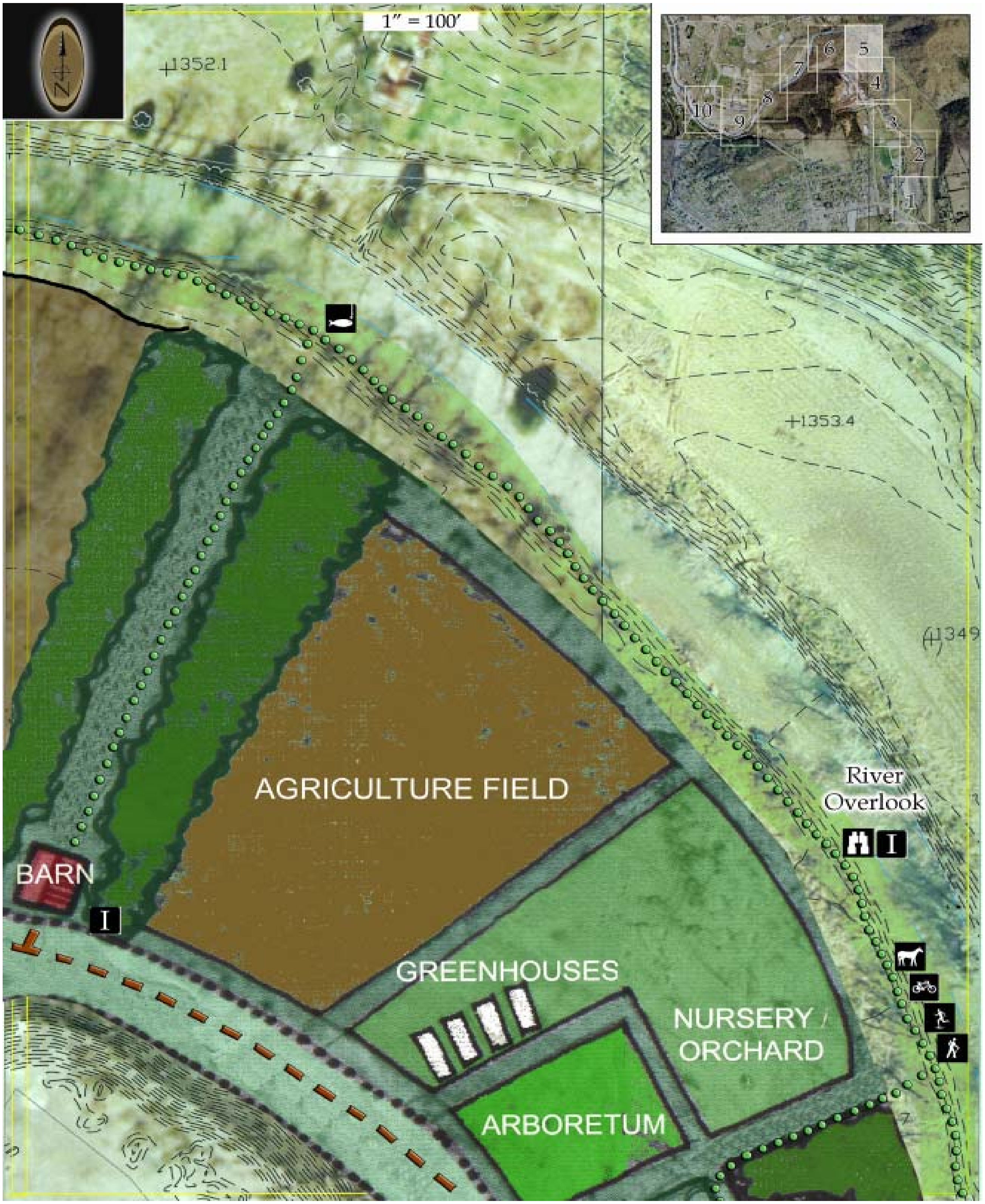
SHEET 3 of 10

This sheet shows the continuance of the greenway trail north of the Route 58 bypass corridor. The brown dashed line is the access road to the outdoor classroom area. There are two fishing access points in this section.



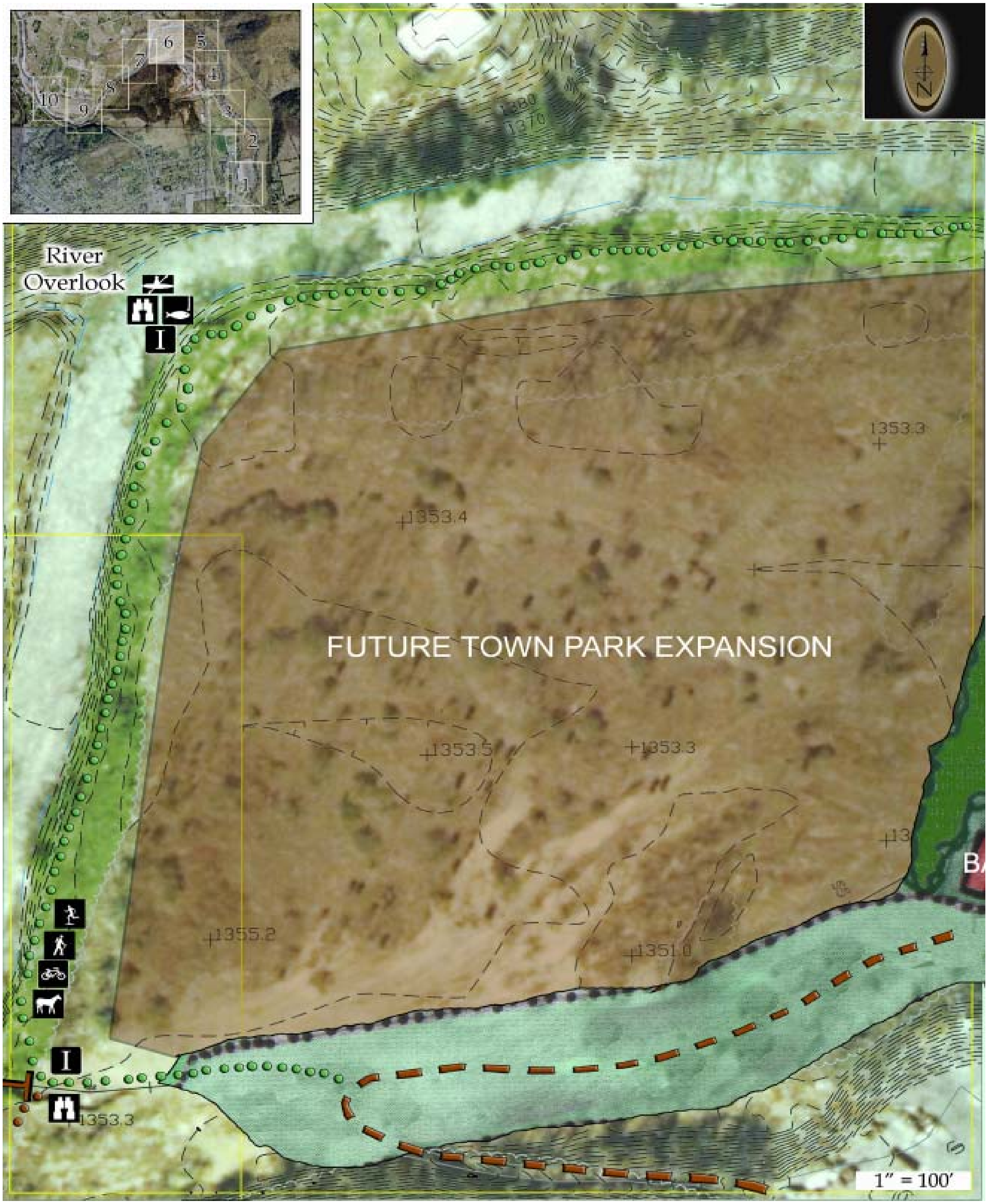
SHEET 4 of 10

This sheet shows the majority of the outdoor classroom area, including the horticulture fields, greenhouses, and arboretum. Also, the classroom building and dock will provide indoor and outdoor classroom settings. The wetland will be an irrigation BMP as the irrigation runoff will be routed here to be cleansed. There is an informational river overlook along this section that will educate users and students about the biodiversity of the Powell River.

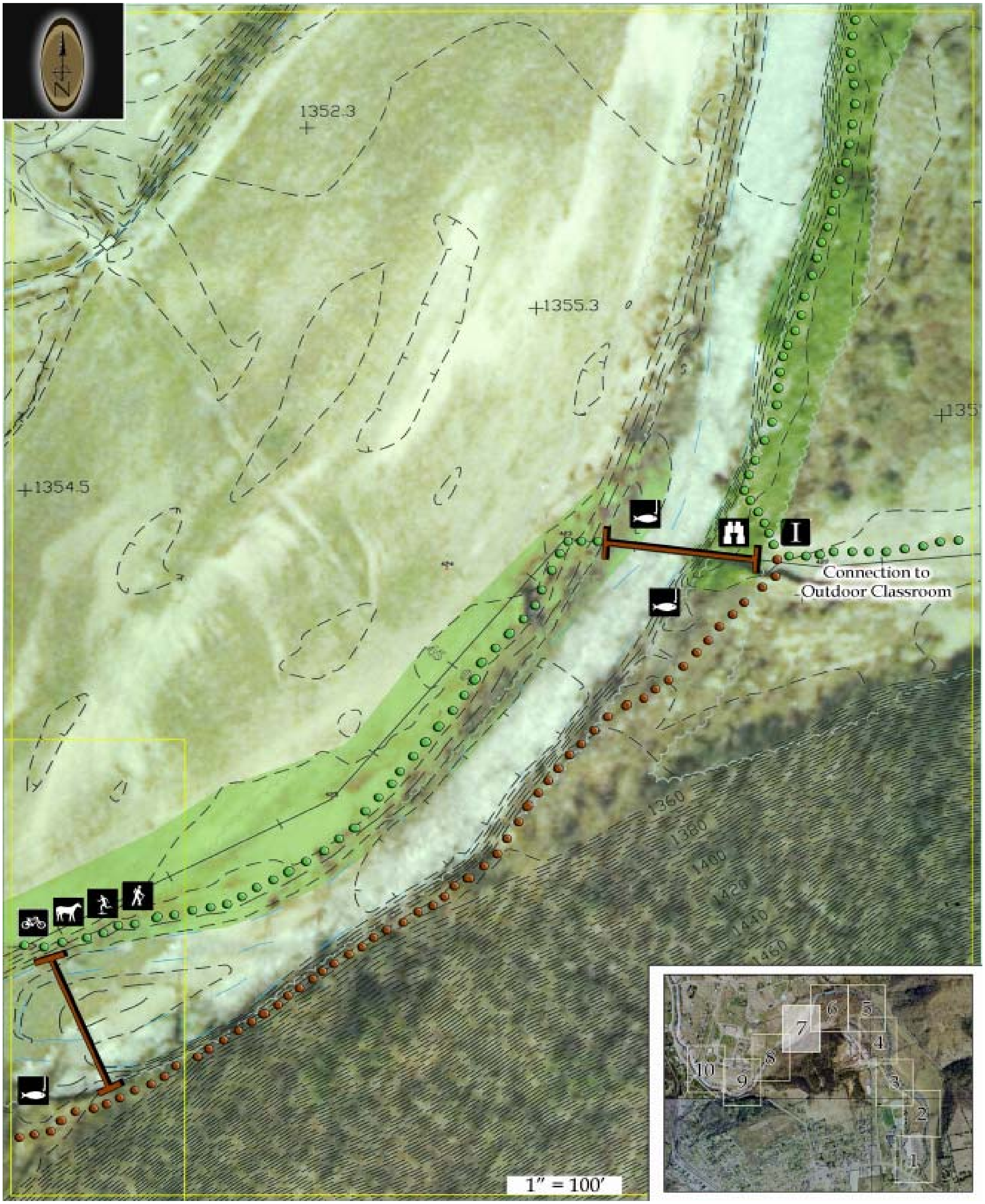


SHEET 5 of 10

This sheet shows the remainder of the outdoor classroom area. The barn is meant to be used for equipment storage, but also as a historical information point, as the architecture will reflect the barns of the area in the early frontier days.

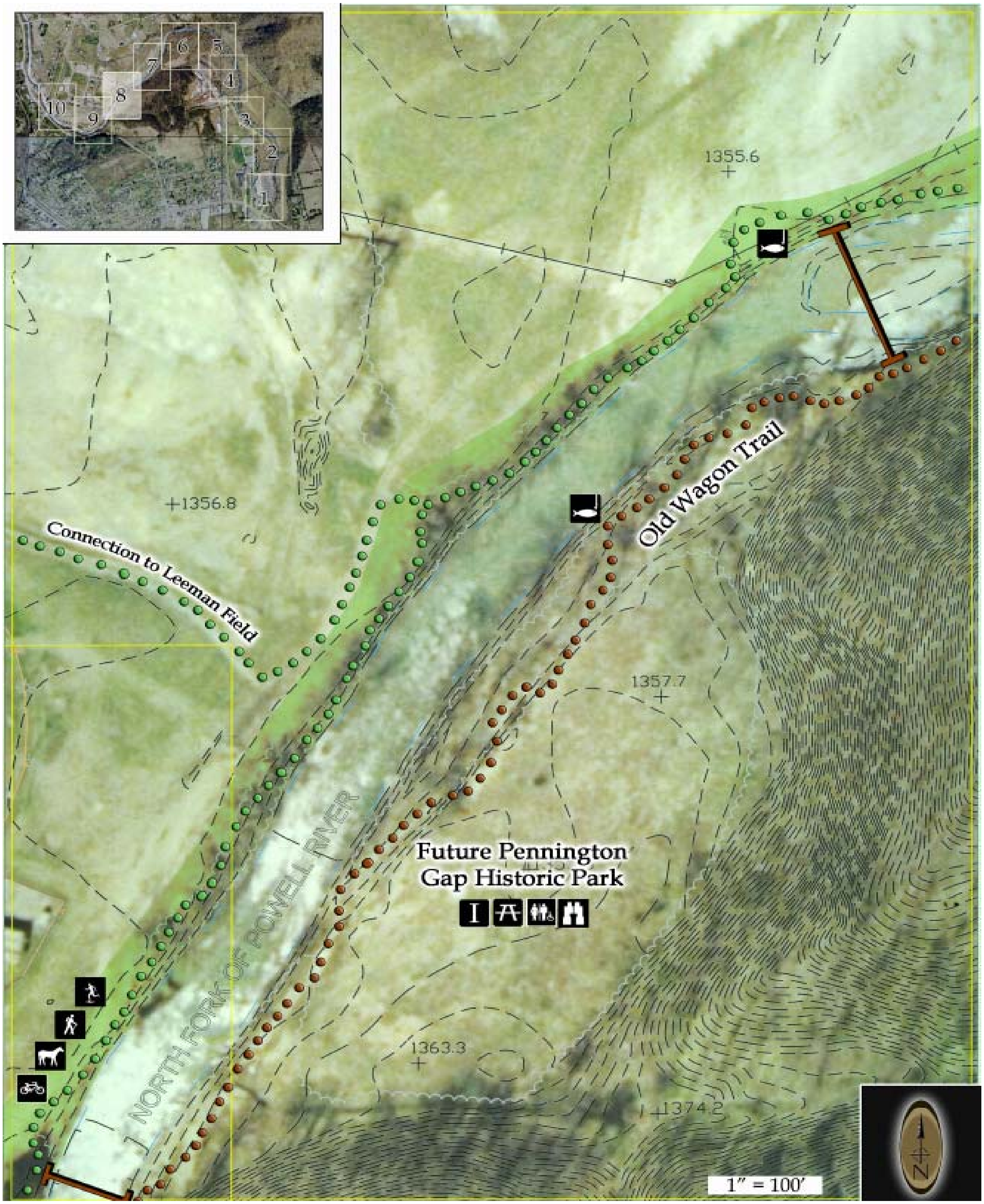


SHEET 6 of 10
This sheet shows the area for the Town's future park expansion. There is a river overlook that highlights the history of Pennington Gap, as the actual gap in Stone Mountain is visible from this point.



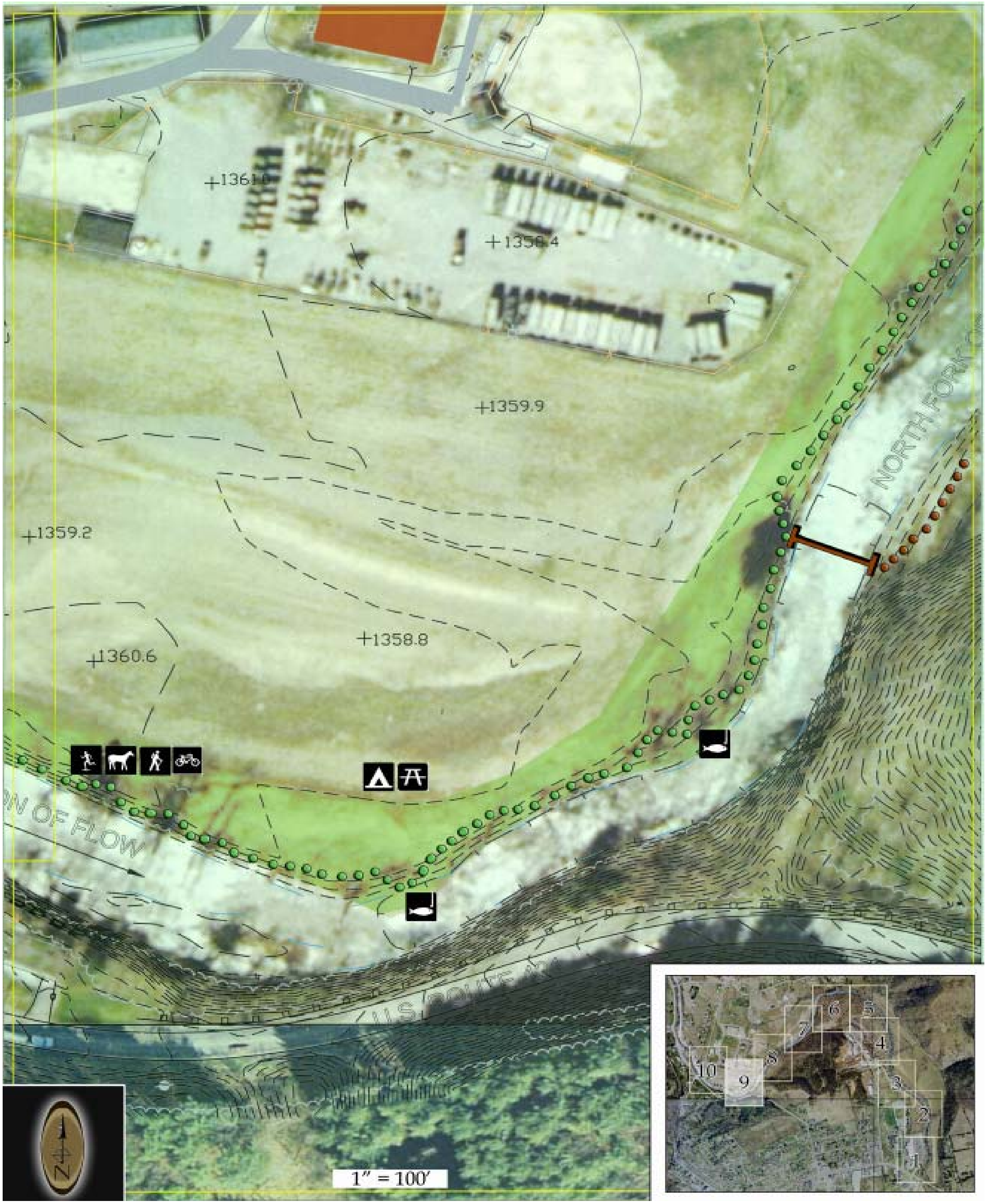
SHEET 7 of 10

This sheet shows 2 of the 3 proposed river crossings. The northern crossing, providing a connection to the outdoor classroom area, is the preferred crossing, as the bridge structure would visibly hide the exposed sewer line and provide protection to the line during a flood event. The historic wagon trail is also shown here and could, with the other river crossings, provide an excellent trail loop from Leeman Field.

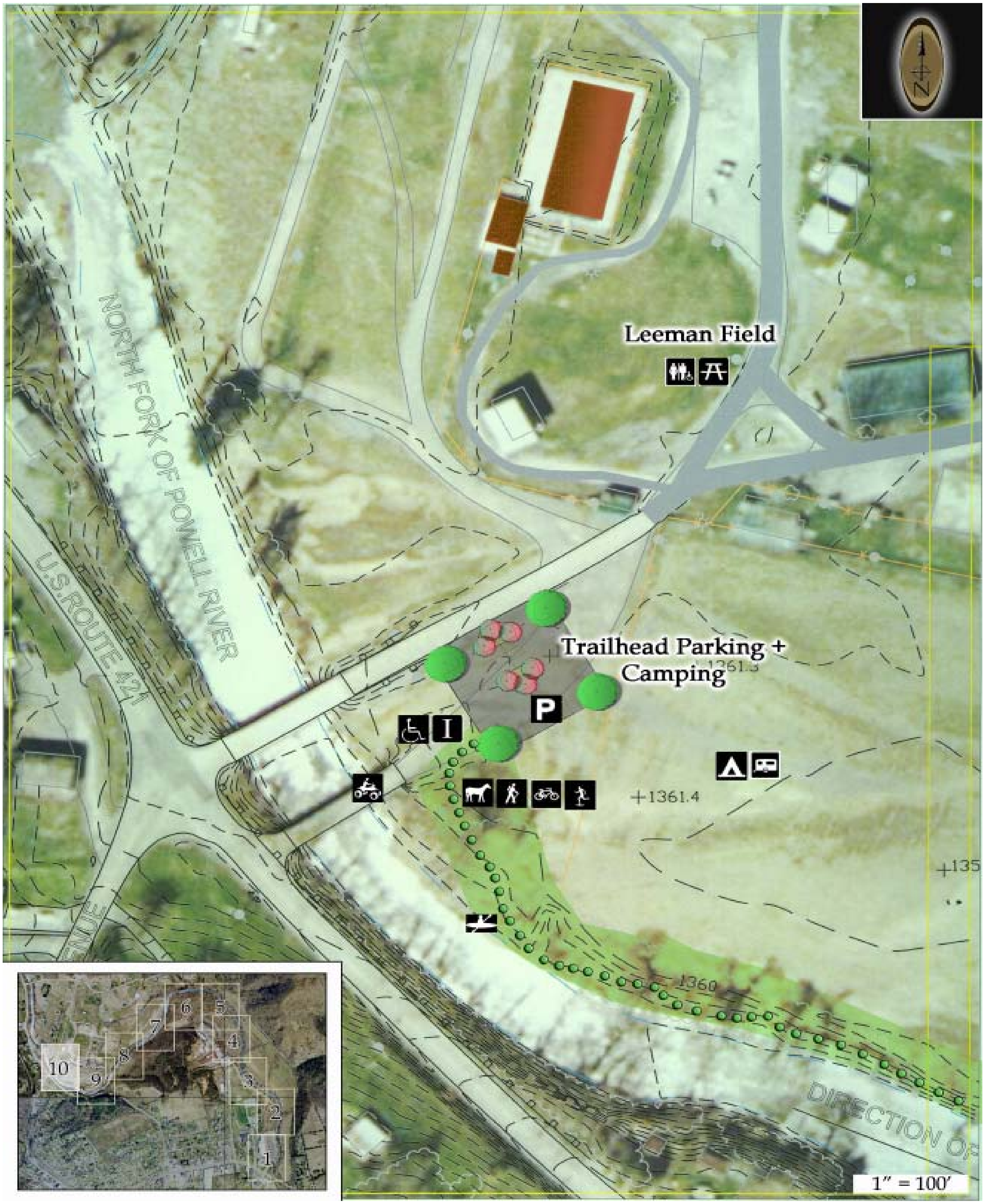


SHEET 8 of 10

This sheet shows the third river crossing point along with the area proposed for the future Pennington Gap Historical Park. This area for the historical park would be ideal because of its location along the wagon trail and its proximity to Leeman Field.



SHEET 9 of 10
This sheet shows where the proposed camping facilities will be located for users of the regional trail system. There are also a couple of fishing access points along this section.



SHEET 10 of 10
This sheet shows the proposed parking lot for trail users and Leeman Field. There is a boat launch next to the old bridge as well as RV hookups in the campground. This area will be the trailhead for the regional trail system, where ATV riders can come, camp, and be located within walking distance of town via the greenway.

XI. CONCLUSION

Upon completion, the North Fork Powell Greenway will be a wonderful community asset, as it will be a great start to the regional trail vision and will provide a wonderful recreational opportunity. The multiuse trail coupled with fishing access points, wildlife and scenic viewing overlooks, educational signage, and the outdoor classroom will provide a wide range of activites for both residents of the town and surrounding communities. The stormwater management along the edge of the Riverbend Shopping Center's parking lot will greatly improve the water quality along this stretch of river and will be an excellent educational model for other businesses and landowners along any waterway.

XII. APPENDIX

A. Recreational Planning: Trails, In General (DCR)

B. Greenway Information: Greenways (DCR)

C. Virginia Creeper Trail Powerpoint (selected slides)

D. Introduction to BMPs

E. Selecting BMPs

F. Preliminary Stormwater BMP -Infiltration Trench

G. Preliminary Stormwater BMP - Wetlands

H. Agricultural Management Practices for Water Quality Protection

I. Filter Strips

J. Infiltration Trenches

K. Stormwater Wetlands

L. Riverbend Shopping Center
   - Tenant Contact Information
   - Information Packet Sent to Tenants & Initial Letter to Tenants
   - Follow up Letter Sent to Tenant
   - Support letter

M. Conceptual Regional Trails Map

A. Recreational planning, Trails in general

Quick links

Recreational Planning

Trails, in general . . .

Specific trail resources and needs | From rails to trails | Bicycling and bikeways | Equestrian trails | Water and river trails | Motorized trails | Trail opportunities | Trail recommendations | Download *Virginia Greenways and Trails Toolbox* (PDF - 19 MB)

The ***Virginia Outdoors Plan*** defines a trail as a linear corridor, on land or water, with protected status and public access for recreation or transportation (excluding scenic byways and highways). This definition is adopted from *Trails for All Americans*, a report developed by the National Park Service and American Trails, a private, non-profit, broad-based trails coalition.

Trails for All Americans examined trails issues from a national perspective to develop broad policies and the following goals for implementing a nationwide system of trails. These goals are also applicable in Virginia:

- Trail opportunities should exist within 15 minutes of most Americans' homes.
- A nationwide system of trails should comprise federal, state, local, and private trails, with all the entities working together for an interconnected system.
- In addition to their recreational value, trail corridors should be recognized as important resource conservation mechanisms and as routes for alternative transportation.
- Trails should be planned as part of the infrastructure, as are highways and utilities.
- Planning for trail corridors and networks should be a grassroots effort to gain adequate support for their development, long-term maintenance, and protection.
- In response to the growing awareness and need for accessible trails, the Virginia Department of Conservation and Recreation offers technical assistance to various groups, facilitating the development of partnerships, and providing educational materials to share with public officials and landowners.

Specific trail resources and needs: Nearly all Virginia's long distance hiking and horseback riding trails are in the George Washington and Jefferson National Forests, and Shenandoah National Park. These two resources provide more than 2,000 miles of back country trails preferred by backpackers, hikers, and horseback riders. Also, hundreds of miles of multipurpose, primitive roads accommodate foot and equestrian travelers.

In the eastern part of the state, Assateague Island National Seashore, the Dismal Swamp National Wildlife Refuge, Back Bay National Wildlife Refuge and the larger national battlefield parks all offer opportunities for trail users. Virginia's state parks have more than 350 miles of trails, many of which combine with extensive trail and gated roads in adjacent state and national forests. New River Trail State Park is a 57-mile rail-trail stretching from Pulaski to Galax in southwest Virginia, which is used by hikers, bicyclists, and equestrians. Virginia's Department of Game and Inland Fisheries, within its Wildlife Management Area system, maintains numerous access trails for hunting, fishing, hiking, horseback riding, and other wildlife-related outdoor recreation. The Virginia Department of Forestry also maintains many trails -- several in Zoar State Forest, the Willis River hiking and canoe trails in Cumberland State Forest and the connectors between the Cumberland and Appomattox-Buckingham State Forests. Most state forests contain hiking trails and an infrastructure of forest roads and trails, totaling approximately 260 miles which are available for controlled forms of outdoor recreation.

Many local and regional parks have established lengthy multi-use trails, some of which take advantage of unique corridors in densely populated areas. The W&OD Railroad Regional Park follows the bed of the abandoned Washington and Old Dominion Railroad. Administered by the Northern Virginia Regional Park Authority, it extends 45 miles from Alexandria to Purcellville in Loudoun County. The Virginia Creeper Trail, of National Recreation Trail status, is a multi-purpose trail constructed on an abandoned railroad right-of-way between the towns of Abingdon and Whitetop. Two Virginia Beach parks eventually will be linked by a trail following portions of a utility easement. In Fairfax County, many trails have been developed along stream valleys in designated environmental quality corridors. Short foot trails, such as interpretive and walking trails five miles or shorter, are found in nearly all major recreational areas and in many local parks throughout the Commonwealth.

A particularly significant trail resource in Virginia is the Appalachian National Scenic Trail. Entering the state from the north near Harpers Ferry, this 2,100 mile Maine-to-Georgia foot trail winds its way down the crest of the Blue Ridge Mountains and then southwest through the George Washington and Jefferson National Forests before leaving the state near Damascus. The majority of the 540 miles of Appalachian Trail in Virginia is on public land and is consequently protected to some degree. Several stretches of the trail which cross private land, however, are experiencing incompatible encroachments and increasing conflicts regarding use. Even where the trail seems secure on public land, activities adjacent to or within this land may adversely affect the scenic and physical character of the trail. Efforts should be made to seek the voluntary cooperation of landowners and stakeholders to resolve these issues. State and local government may consider these issues in planning and zoning decisions that may affect lands in the vicinity of the trail.

The Appalachian Trail is unique because of its history of cooperative management. For more than 50 years the many representatives of the Appalachian Trail Conference (ATC) have worked voluntarily with federal, state, and local governments, as well as numerous individual landowners, to solve problems associated with the acquisition, development, administration, management, and maintenance of the trail. The Appalachian Trail Conference and its member clubs manage the trail. Recognizing its importance, the Virginia General Assembly in the *Code of Virginia*, Chapter 10.1-203, as amended, designated the Department of Conservation and Recreation (DCR) as responsible for acquisition, administration, and management of the trail in Virginia. DCR has agreed to:

- review the trail's location on state-owned lands.
- ensure widespread understanding of the significance of the trail and the components of good stewardship.
- acquire lands or interests in lands to conserve trail values.
- delegate to the ATC and trail-maintaining clubs responsibility for developing, maintaining and monitoring state-owned trail corridor lands.
- be a liaison between the ATC and other state agencies.
- meet annually with representatives of the ATC to discuss management and concerns.

Visit these sites for more useful information on trail resources and needs: **American Trails**, **Rails to Trails Conservancy's Trails and Greenways Clearinghouse**, **Virginia Trails**.

From rails to trails: The recreational potential of rail rights-of-way has long been recognized. Congress enacted the National Trails System Act to establish a nationwide network of trails. But after 15 years the number of established trails was quite small, as most railroads don't own all the land where their tracks lie. Instead, the railroads often have legal rights, or easements, to use the land of adjoining property owners. When the railroad abandons the rail line, these easements often are revoked, and the property reverts to the adjoining landowners. Establishing a trail under these circumstances would require an agreement with the railroad and all adjacent landowners.

Congress addressed this problem in the Trail Act Amendments of 1983. Those amendments prevent a railroad's easement from lapsing if the right-of-way is used as a recreational trail. As a result, trail use proponents now only must have a formal agreement with the railroad. Before the Interstate Commerce Commission (ICC) grants an abandonment to a railroad, posted notices tell the public and all potentially affected persons of the request, so that comments and appeals can be solicited. Trail users should notify the ICC and the railroad of their interest in the right-of-way as a trail.

Crisscrossing Virginia is an extensive system of more than 3,000 miles of operating railroads. Over the last 25 years, a substantial amount of this railroad mileage has been abandoned. While a few have been acquired for trail use and become very popular recreation resources, the majority of these corridors weren't acquired for recreational use because property ownership reverted to adjacent landowners.

Many miles of railroad rights-of-way in Virginia are either available or may soon become available for acquisition. Several of these pass through more than one locality, which complicates ownership and management. In such cases, it's better to establish a separate entity to manage the trail. A park authority is a good mechanism for crossing jurisdictional lines equitably. Another idea is a public/private partnership or a private, non-profit organization that works with local governments while building support for the trail.

The Virginia Outdoors Plan's Greenways system map identifies many rail lines that have been abandoned, as well as some operating lines that could be important components of a state greenways network. Many of the lines still in service operate only on low tonnage and may soon become the subjects of abandonment applications. Localities should evaluate railroads in their jurisdictions and could plan to obtain and manage abandoned rights-of-way for trails or other public uses.

Visit this site for more useful information on rails to trails: **Rails to Trails Conservancy**.

Bicycling and bikeways: More and more people are riding bikes recreationally and as a viable mode of transportation. The 1992 *Virginia Outdoors Survey* ranks bicycling as the seventh-most popular recreational activity, with 31 percent of households participating. Bicycle facility planning in Virginia is still evolving. The Virginia Department of Transportation, with its Bicycle Advisory Committee, published *A Virginia Guide for Bicycle Facility Planning* in 1994. The guide, primarily about paved-surface riding, combined with *Mountain Bikes on Public Lands* (The Bicycle Federation of America), provides planners and managers with a solid framework for meeting a wide variety of bicycling needs.

Bicycle projects must be included in comprehensive or transportation plans for funding consideration through most Intermodal Surface Transportation Efficiency Act (ISTEA) programs.

A bicycle accommodation needs to be in an adopted plan in order for the Virginia Department of Transportation (VDOT) to participate in its design and construction. VDOT is mandated to develop a state bicycle plan for areas not located in a Metropolitan Planning Organization (MPO). Biking and walking are addressed as elements in the statewide intermodal plan prepared by VDOT's Transportation Planning Division.

As with any trail planning, the most important aspect of bicycle planning involves obtaining input from the bicycling public. Many areas in Virginia have organized bicycling clubs that can help gather and provide information. However, not all community bicycling needs will be represented by clubs.

Bicycle plans should be compatible with 1) local comprehensive plans; 2) transportation plans developed at the local, regional (Metropolitan Planning Organization - MPO), or state levels; 3) transit plans; and 4) parks and recreation plans. Where appropriate, plans should follow American Association of State Highway and Transportation Officials (AASHTO) design guidelines.

Following the planning, design criteria should be established. Then performance criteria should be established, possibly including: accessibility, directness, continuity, route attractiveness, low conflict, cost, ease of implementation, and multi-modal coordination. An analysis should be made -- compiling an inventory of significant origins and destinations, projected and current bicycle use, existing bicycle facilities, planned highways improvements, and local comprehensive plans. Next, desired routes should be developed and evaluated and types of facilities designated. This should be followed by bicycle education, safety, law enforcement and encouragement programs. After development and adoption, the final step is implementation.

Existing Interstate Bike Routes

Interstate Bicycle Route 1 stretches from the Virginia/North Carolina state line at Palner Springs near Occoneechee State Park to Boston, Massachusetts. This route crosses the Potomac River in Arlington County and passes through Fredericksburg and Richmond.

Interstate Bicycle Route 76, crossing the United States to Asrotia, Oregon, begins in Yorktown, travels through Williamsburg, Richmond, Charlottesville and over the Blue Ridge Mountains to Waynesboro. From there, the route goes south to southwest and exits Virginia at Breaks Interstate Park on the Virginia/Kentucky state line in Buchanan County.

Mountain bikes

Although the majority of bicycles sold today are designed for off-road use, the number of trails designated for such use has not kept pace in Virginia. The lack of mountain bike trails often causes these cyclists to ride on trails not designed for bicycles or to ride off of trails, leading to environmental degradation. In addition, lack of education about proper multi-use trail etiquette has caused conflict between users, particularly equestrians, and mountain bikers. These situations can all be mitigated through careful planning and management. The Bicycle Federation of America recommends the following:

Signage:

- Post multiple-use trail signs at trailheads, illustrating yield hierarchy.
- Post safety and trail etiquette signs at trailheads.
- Use signs to advise riders to reduce speed to avoid skidding.
- Post other types of signs as needed.

User cooperation:

- Emphasize user input at all phases, from trails planning, to policy development and implementation to trail maintenance.
- Ask representatives of all trail user groups to walk or ride trails and to identify potential safety hazards and areas of environmental impact, and to discuss suitability of trail for multiple-use designation.
- Encourage representatives of trail user groups to discuss concerns with trail managers.
- Convene a local trails advisory council involving all user groups.

Partnership development:

- Work in partnership with local bicycle shops and/or mountain bike clubs to develop brochures about safety, etiquette, and environmentally sound riding techniques, raise money for signs, conduct desensitization clinics for horses, build new trails, and establish a volunteer mountain bike trail patrol to provide trail information to all trail users.

User education:

- Educate all trail users to "tread lightly."
- Use volunteer mountain bike trail patrols to educate trail users.
- Educate users through interpretive rides.
- Emphasize trail preparedness.

Trail maintenance:

- Organize volunteer trail maintenance teams to erect fencing on switchbacks, repair existing erosion, maintain waterbars, and use a *rolling dip* method rather than a rock or log waterbar when building new trails.

Trail regulations enforcement:

- Issue citations for trail violations, when necessary, to cyclists who ride on closed trails or through meadows.
- Encourage local judges to impose work service in the park as the penalty for trail violation citations.

Other measures:

- Use temporary closures to protect the land and wildlife when necessary.
- Design maps for mountain bicyclists that disperse use from trails heavily used by hikers and equestrians.
- Consider seasonal closures of some high use trails.

Visit this site for more useful information on bicycles and bikeways: **International Mountain Bicycling Association**.

Equestrian trails: Trail riding is an increasingly popular sport among Virginia horseback riders. Increased interest in trail riding and decreased availability of private, informal trails lost to construction causes land

managers, saddle club members, and other trail user groups to establish close liaisons to develop new trails and to maintain existing trails. In areas of the state where large tracts of public land suitable for horse or multi-use trail development do not exist, equestrians will need to develop trails on private land. Good public relations with landowners can lead to use agreements where a trail can be developed through several area farms in exchange for agreements to keep gates closed, maintain trail tread, and remove litter.

Because there are many kinds of trail rides, a wide variety of options should be made available. The basic and most important requirement is for trail facilities to be close to where horses are stabled. Trails should be from two to twenty-five miles in length, which is fairly easy to meet in the more rural parts of the state, but becomes increasingly difficult as the more urban areas are approached. Urban sprawl has a tendency to replace farm land and open space with housing and commercial areas, thereby forcing the equestrian ever further from the city center. Public development of greenways, such as stream valley corridors, abandoned roads and railroads, utility corridors, etc., will have to become standard procedure if the future trail needs of equestrians and other trail users are to be met.

Managing horse trails and facilities on public lands can create challenges for land managers. Conflict between user groups often arise. For instance, many trails suitable for hikers are not suitable for horses. Parallel trails are sometimes practical in a wider corridor and should be considered. In the past, off-road vehicles (ORVs) and horses were not considered compatible. Reducing ORV noise levels, proper trail planning, and good trail etiquette can mitigate the vast majority of these past concerns. Using ORVs to support organized horse events has proven mutually beneficial, allowing both user groups to learn more about dual use possibilities.

Numerous opportunities exist to develop horse trails in Virginia. The key is a strong local saddle club with a good working relationship with local planners, government officials, and other trail user groups. Willingness to participate in the process of acquiring the rights-of-way, building the trail, and maintaining and policing the trail after completion will do much to meet current and future demands. Rail-to-trail projects should, as does New River Trail State Park, allow horses with bikes and pedestrians. On trails where the corridor is wide enough, a separate horse trail alongside the bike/pedestrian trail usually works well and should be encouraged.

Visit this site for more useful information on equestrian trails: **Virginia Horse Council**.

Water and river trails: The Department of Game and Inland Fisheries, various federal agencies, and private commercial enterprises have developed a system of public access points along major rivers and lake shores. Most include a parking area and a boat launching ramp. In areas where motorboats are impractical, less developed ramps are provided for canoe and light boat access. DGIF cooperates to provide 222 public boating access sites, 185 sites for power boating, and 37 sites for non-powered use. Fifty-four of these sites are barrier-free.

Identifying public access points along rivers and lakes allows planning for many different water trails. In many areas of the state, public access areas are close enough to facilitate day trips between these points. Many canoe liveries operating in Virginia rent canoes and provide transportation to and from access points. Despite these efforts, there remains a significant shortage of access points to many good sections of streams. Many of the access points identified in canoeing guides are on private property or at bridge crossings with no authorized access or parking. A program identifying suitable access to the best stretches of rivers should be initiated, and a source for funding acquisition and development of these areas is necessary. (Further information on public access to Virginia's waterways can be found in the *Virginia Outdoor Plan's* Section IV-B-1-c, and regional maps in Chapter V.)

When local, state, or federal legislation or regulations require buffer zones or limit development along waterways, trails and greenways may be implemented with appropriate planning measures and landowner involvement. Dedication may provide tax or other incentives to the landowner while providing access to the water.

In addition to access points, river recreationists need places between landings to get out of their boats and rest, picnic, or camp. Few public day use or camping areas exist. One solution to this problem is for landowners to open some of their riverfront lands to public use. Islands, found in most major rivers but privately owned, are particularly desirable for this use. Westvaco Corporation, in an agreement with the Department of Conservation and Recreation (DCR), allows the public to use 100 acres of islands in the James River in Appomattox County.

Motorized trails: Thousands of Virginians head for the country each weekend to see the sights, camp, fish, and enjoy nature. For many of these people, an off-road vehicle is an important part of their recreational experience. Four-wheel drive utility vehicles, off-road motorcycles and dirt bikes, and four-wheeled all-terrain vehicles (ATVs) enhance the excitement of getting away from it all.

Four-wheel drive, high ground clearance utility vehicles have steadily grown in popularity over the last decade. However, many are primarily family transportation, and off-road use is secondary. Recently introduced dual sport motorcycles have similar use patterns to the high ground clearance utility vehicles as they are designed both for highway use and off-highway recreational riding. This dual on- and off-road use allows access to more than traditional trail areas while purely off-road vehicles (ORV) had to be transported separately to the riding area. On the other hand, dirt bikes and ATVs are almost entirely restricted to off-highway uses and are primarily recreational. These vehicles are referred to collectively as off-highway vehicles (OHVs). Planning for varied OHV trail use should reflect the different needs of each vehicle.

ATV sales and ridership continue to grow at a phenomenal rate. These vehicles feature low pressure and high flotation tires, combined with a low profile, which makes them stable. When operated properly, the wide balloon tires impact the environment less than other ORVs.

While the demand for ORV trails is steadily increasing, there are few suitable public trails in Virginia. Consequently, people ride on private property, ORV club leased or owned land, some public forest trails or corporate timber lands, and occasionally on power line rights-of-way, abandoned railroad corridors, old logging roads and beaches. Many of these places are not suitable because of trespassing laws, environmental impacts, or the noise level of the vehicle. A history of improper riding by a few thoughtless people has given motorized trail users a bad name. However, the majority are responsible citizens concerned with the resource and respect the property and privileges of others. The challenge to government, landowners, private industry and the users is to locate, acquire, and develop suitable ORV facilities. They also would be responsible for managing them to buffer incompatible uses. The most urgent need for ORV parks is in the more densely populated parts of the state. These parks would cater mainly to ORVs and should be carefully designed and constructed. Safety, challenge, diversity, and scenery are all key design criteria when planning an ORV facility. Areas should be designated for different skill levels and types of vehicles.

In the more rural parts of the state, especially counties west of the Blue Ridge Mountains, opportunities for trail riding exist in national forests. The U.S. Forest Service has a "closed unless designated open" policy concerning motorized trail use.

The national forests classify two major motorized trails types. The first include the extensive system of primitive roads with travel ways larger than 40-50 inches wide that serve four-wheel drive vehicles. These vehicles are mostly licensed and also can be used on hard-surface roads. The second type of motorized trail is an ORV trail primarily used by unlicensed off-highway cycles that are designed primarily for trail or cross-country use and have a tread 40-50 inches wide.

A new motorcycling population is emerging. Dual sport motorcycles designed for daily commuter riding also are excellent off-road. These motorcycles have made the trail systems far more accessible to riders seeking areas where ORV trails are linked by primitive roads such as in the national forests. The combination of greater mobility and larger rider population represent unique trail area design challenges. This type motorcycle can benefit from trails typically used by the four-wheel drive community.

Another component of the off-road vehicle trail user group is the four-wheel drive vehicle. The traditional group, consisting of jeeps and utility vehicles, has been expanded by the development of the over-sized tire, high suspension pickup trucks, dune buggies of various designs, and a number of other vehicles requiring a fairly wide trail resource. All national forest development roads are open unless designated closed to licensed vehicles. These roads meet much state demand for ORVs. Because few public facilities exist in the eastern part of the state, most use in this area occurs on private land.

Rural communities are beginning to recognize the economic development potential available by establishing ORV trails on adjacent public or private lands. Other states have chosen ORV trail systems as principle components of their tourist industry. Revenue producing trail systems offer excellent opportunities for improving the economic base of rural communities.

Trail opportunities: The 1992 *Virginia Outdoors Survey* indicates that many Virginians recreate within 20-30 minutes of their home. Trails can provide close-to-home, accessible recreation with health benefits, non-polluting transportation routes, and more. While associated with parks, they usually have much less financial burden.

The emphasis on most trails has shifted to multi-use design and management. Hikers, walkers, strollers, joggers, bicyclists and/or horses all can be accommodated on the same trail or corridor in many instances. Innovative strategies for sharing corridors with motorized trail users also are being tested throughout the country. The key to successful corridor sharing is proper planning and design, along with educational programs and some enforcement. Many voluntarily patrol multi-use trails for misuse and educate people about proper etiquette.

The American Association of State Highway and Transportation Officials (AASHTO) guidelines and publications such as *Greenways: A Guide to Planning, Design and Development* and *Trails for the Twenty- First Century*, both available through Island Press, have emerged to address designing, planning, and managing multi-use trails and greenways.

Trail users, environmental groups, local businesses, and the community should be included in new trails development or existing trail maintenance. Adjacent landowners must be included early in the planning stage and often can help identify concerns and issues and develop potential solutions for effective implementation. Many trail projects have utilized volunteers significantly in planning and implementation. Examples are: the Willis River Trail in Cumberland State Forest, the Zoar trail in Zoar State Forest, the Virginia Highlands Horse Trail in Mount Rogers National Recreation Area, the trails system in Richmond's James River Park, the Big Blue Trail in northwest Virginia, and the Bull Run-Occoquon Trail in Northern Virginia.

Privately-owned corporate properties also may help meet trail needs. In some cases, trail recreation may suitably interface with management activities on lands owned by forest product companies, utility companies, or mining companies. Cooperative management programs for limited recreational use have been developed with Westvaco Corporation on some of its lands. For example, Westvaco Corporation maintains a 2.8-mile nature trail along Buffalo Creek in Bedford County, which is used for recreational and environmental education purposes. Hundreds of miles of corporate forest roads, which provide access to timber, offer a wide variety of potential trail opportunities.

Many local businesses have developed trails through their properties to connect to existing trails and allow public access. With more businesses realizing the value of trails for employees' physical and mental health, private, corporate trails are more numerous and need to be included in comprehensive trail plans. In addition, many developers realize that the incorporation of a trails system can help increase housing and office space values and/or increase sales. Where possible, private trails should connect into public systems.

Private individuals often voluntarily offer trails development through their property. They may give an easement on a portion of their land or may allow access through an agreement with a governmental agency. In these instances, the landowner's liability is limited. (§29.1-509 of the *Code of Virginia*)

Intermodal Surface Transportation Efficiency Act (ISTEA) funding for certain trails is available (see Chapter IV-B-4). ISTEA also emphasizes a need for long-term planning on the local, metropolitan, and state level. Long-term trails plans should be included in comprehensive plans and Transportation Improvement Plans (TIP). VDOT should include significant trails in appropriate state bicycle, pedestrian, and transportation plans. Regional cooperation should be emphasized to be sure trail systems connect and cross jurisdictional boundaries where appropriate.

Trail recommendations: There are numerous and readily available opportunities for extending and improving trails on public lands:

- On those sites with an extensively established trails network, access to select trails could be improved. [PN-B]
- New construction should focus on linking existing trails to form continuous networks of 10 miles or longer. While trail systems are usually implemented one section at a time, long-range planning should be emphasized so continuous corridors are eventually created. [PN-B]
- Emphasis also should be given to connecting people to destinations such as neighborhoods, parks, water resources, schools, and work. [PN-B]
- On new sites and lands with few trails, trail systems should be included as an integral part of the area's recreational development. [PN-B]
- The Department of Game and Inland Fisheries should seek to improve trails in its wildlife management area system where compatible. Unique opportunities may be available through the Nongame Wildlife Fund's environmental education/ interpretation programs. [PN-B]

- The Department of Forestry should seek to improve trails within the state forest system where compatible. (PN-B)

Bikeways recommendations

- Local, regional, and state planners should coordinate bicycle facility planning to ensure continuous systems. Bicycle plans, including on and off-road and multi-use trails, should be included in local, metropolitan, and state comprehensive and/or transportation plans. [PN-B]
- Since the Virginia Department of Transportation (VDOT) has determined that producing a statewide bicycle suitability map is not feasible, they should look at alternatives to the proposal to assist cyclists traveling through Virginia. [PN-B]
- The Department of Conservation and Recreation (DCR), with VDOT and localities, should develop a network of bikeways to link state parks together. [PN-B]
- The economic and environmental impacts of bicycling in Virginia should be documented. [PN-B]

Mountain bike recommendations

- The economic impact of mountain bike facilities should be documented, and comprehensive facilities to attract tourism developed. [PN-A]
- Mountain bikes should be incorporated into new trail plans where appropriate. [PN-B]
- Existing trails should be adapted to multi-use to accommodate mountain bikes where appropriate. Proper planning, design, and management would minimize conflict and environmental problems. [PN-C, PN-D]
- State and local agencies should cooperatively develop an educational program directed toward mountain bike and multi-use trail users. [PN-C, PN-D]

Water and river trail recommendations

- Public access areas should be developed at convenient intervals on the state's rivers. [PN-B]
- Identify landowners willing to allow public use of riverfront property for day use and overnight camping. [PO-A]
- Identify a funding source to cover the cost of renting lands for public use. [PN-E]
- Develop an improved system for reporting river levels throughout the state. Post signs at each public access area showing the range of safe river use by experience class. [PO-B]
- Produce brochures for each river showing access points, day use and camping areas, hazards, historical structures along the river, etc. [PO-B]

Motorized trail recommendations

- Consideration should be given to registration and tags for all motorized vehicles, including dirt bikes and three- or four-wheeled off-road or all-terrain vehicles. Registration fees could be used to acquire and develop off-road vehicle parks and trails, as well as provide educational programs and materials. [PO-E]

- DCR should work with the organized ORV trail clubs to identify areas open to trail use and to inform users of trail closings. A brochure could be developed that identifies public or semi-public trails. [PO-B]
- Clubs and organizations should cooperate with dealers to inform new off-road vehicle buyers of their responsibilities and to encourage club membership. Clubs should provide education and organized rides, and may have access to areas unavailable to individuals. [PO-B]
- Public providers should evaluate their properties for their potential to meet the need for ORV trails. Special facilities should be acquired and developed in areas where demand is high but no facilities exist. [PN-B]
- A demonstration project should be designed to examine the potentially positive economic impact of an ORV trails system in one or more economically challenged rural areas. [PN-A]

Last modified 3/10/04 . Address general inquiries to **pco@dcr.state.va.us**. DCR's central phone number is (804) 786-1712. DCR's street address is:

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203 Governor Street, Suite 213
Richmond, VA 23219-2094

Please address website comments to **webmaster** (shawks@dcr.state.va.us).

Recreational Planning

Greenways

Greenways are open space corridors that can be managed for conservation, recreation, and/or alternative transportation. Greenways often follow natural or existing land or water features such as ridgelines, stream valleys, rivers, canals, utility corridors, abandoned rail lines and others. Although each greenway is unique, most connect recreational, natural, cultural, and/or historic areas. Some greenways are designed for people to use for recreation and non-motorized transportation, while others are designed for wildlife, biodiversity, and scenic beauty. Greenways may be publicly or privately-owned.

Resources that greenways might connect include: schools, playgrounds, forests, parks, historic sites, rivers, neighborhoods, businesses, and wildlife refuges. Linkages vary depending on the landscape and community preferences. Greenways may include features such as hiking, bicycling and equestrian trails, sidewalks, streams and rivers suitable for canoeing and boating, abandoned railroad rights-of-way, utility rights-of-way, scenic roads, and scenic easements.

Greenway benefits are many and varied, including economic, transportation, environmental, health and recreational benefits. Greenways:

- Connect people, communities, and countryside.
- Provide for hiking, strolling, biking, picnicking, fishing, and other recreational activities.
- Provide important open space resources.
- Link important cultural and historic sites -- fostering greater awareness and appreciation for them.
- Provide refuge and safe migration routes for wildlife.
- Provide alternative transportation routes by providing bicycle and pedestrian facilities.
- Soften urban and suburban landscapes by providing buffers to developed areas.
- Improve water quality by buffering streams and trapping pollutants.
- Reduce flood damage and costs related to damage.
- Increase real property values.
- Enhance economic development and tourism.
- Provide close-to-home access to greater proportions of the population than traditional parks.
- Improve overall quality of life.

Numerous studies have been conducted to show the greenway benefits and impacts. *Economic Impacts of Protecting Rivers, Trails, and Greenway Corridors* was prepared by the National Park Service and is summarized below. Other studies like *The Impact of Rail-Trails*, also conducted by the National Park Service, have concluded there are various and numerous benefits to users, local landowners, and trail communities. Although legitimate issues and concerns were raised at the onset of many greenways projects, the study showed that adjacent landowners' fears prior to greenway development proved to be unwarranted. Residents and visitors alike enjoy the benefits of trail use, aesthetic beauty, protected open space, and in some instances, higher property resale values.

Greenways go beyond physical connections and include visual linkages. Under most circumstances, a 300-foot strip of forested area provides an adequate buffer to give a passerby or a homeowner the sense that the area is preserved in its natural state. Furthermore, wildlife experts indicate that a 600-foot corridor is suitable for habitat and provides migratory routes for larger species (deer, fox, etc). Even smaller natural corridors, such as those found adjacent to a stream valley, provide significant visual relief. A greenway of adequate width can effectively hide and buffer residents from more intensive land uses and can protect vital natural and wildlife resources.

Areas that lend themselves to greenway designations are frequently considered unsuitable or undesirable for development; therefore, these lands can often be made available by easements, zoning, or by donation from the owner. This saves local governments from using scarce funding on fee simple acquisition. In cases where fee simple acquisition may be necessary, studies have found real property values adjacent to greenways and parks increased in value. This, in turn, increases local tax revenues and offsets any acquisition costs born by the locality. Proffers from developers often are effective tools for greenway acquisition and development.

State and national surveys continually are finding that walking, bicycling, jogging, hiking and horseback riding are some of the most popular forms of outdoor recreation. The 1992 *Virginia Outdoors Survey* ranked walking for pleasure the most popular activity based on percentage of households participating (65 percent). Bicycling (31 percent), visiting natural areas (24 percent), jogging (20 percent), hiking/backpacking (15 percent), nature study, horseback riding, four-wheel drive off-road use and fitness trail were within the top 30 activities. Other greenway-related activities such as visiting historical sites, picnicking, and camping were ranked in the top 10.

Greenways also may help meet the growing demand for water-oriented recreation. The 1992 *Virginia Outdoors Survey* found that water-related activities are considered one of the most sought after types of recreation in the state. Both natural area and active recreation-oriented greenways can help protect water resources and facilitate public access to these areas.

Greenway efforts around the state are increasing rapidly. Examples include the Northern Virginia Greenways project, Metro Richmond Greenways, Loudoun County/Leesburg Greenways Plan, Charlottesville's Rivanna River Greenway, Historic Rivers Greenway initiative in the City of Williamsburg, James City and York Counties, the Roanoke Valley Greenways Plan, the Giles County/New River Greenways Plan, and the Potomac River Greenways Coalition. Significant existing regional and state greenways include the Washington and Old Dominion Trail, New River Trail State Park, and Virginia Creeper Trail. For detailed information related to greenway plans, contact the appropriate Planning District Commission or locality.

Greenway planning: Greenways are created primarily through local or regional initiatives reflecting community needs, defined by the people who create them. Greenways are best formed from cooperative public and private partnerships, including citizen and user groups, government agencies, and private businesses. Greenway planning should begin by establishing a local or regional committee made up of a broad cross-section of the community. The committee may include representatives of potential user groups such as hikers, bikers, equestrians, nature study/birdwatchers, and boaters, fishermen, swimmers, as well as businesses, utility companies, conservation groups, and economic councils.

Successful greenway planning requires dedicated work with many diverse citizens and adjacent landowners, including those opposed to greenways or specific greenway projects. In addition, community leaders and citizens with expertise in planning, safety, security, environmental and liability issues should be included. Effective public involvement of landowners and professionals can address most issues and concerns which would result in a better finished project.

Several publications and resource materials have emerged to deal effectively with greenways planning, design, and implementation, including the public involvement process. *Greenways: A Guide to Planning, Design and Development*, available through Island Press, is one such example.

One method of greenway planning, the overlay method, begins with an inventory of social, historic, cultural, and natural features. Available land, including utility and railroad rights-of-way (existing and abandoned) is then inventoried to determine the most suitable methods for greenway dedications. Finally, soils and steep slopes are inventoried. The inventory layers are combined in a composite of the region to be used to identify linkages between communities, parks, schools, historic sites, open spaces, and other resources. The final step identifies greenway routes based on linkages. Corridors are prioritized and included in the greenways plan to be adopted by local or regional governments. Map 2 on page 93 identifies trails and greenways.

Once planning is complete, implementation begins. Implementation strategies should be listed in the plan. A successful greenway planning committee can evolve into a strong support group to assist various partners in acquiring, developing, and managing the greenways system.

New opportunities for greenways: The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) provides new impetus for trail development and maintenance through several programs.

Funded by the National Recreational Trails Act, a component of ISTEA, the Virginia Recreational Trails Fund Program was established to provide and maintain recreational trails and related facilities. Administered by the Department of Conservation and Recreation (DCR), grant funding may be provided to private individuals, organizations or government agencies, but must consider guidance from the DCR Trails Advisory Committee, which advises DCR on trails-related issues. Committee members represent trail user groups including: ATV, bicycle (off-road and paved surface), four-wheel drive, hike (close-to-home and long-distance), equestrian, motorcycle, cross-country ski, and water-related trail use. A minimum of 30 percent of funding annually must be used for motorized recreational trail uses, 30 percent must be used for non-motorized recreational trail uses, and the remaining 40 percent is discretionary. However, preference must be given to projects with the greatest number of compatible recreational purposes and/or that provide for innovative recreational trails corridor sharing.

Program funding is not guaranteed; it may not be available each year.

Other provisions in the ISTEA legislation encourage bicycle and pedestrian facilities and a Scenic Byways Program. Renewed interest in, and increased funding opportunities for, youth service programs, youth conservation corps, and urban renewal projects offer great opportunities for affordable greenways development, especially in urban areas. In addition, non-profit organizations such as The Conservation Fund's American Greenways Program and the National Park Service's Rivers and Trails Assistance Program provide technical assistance and grant funding for greenways.

Recommendations

- Economic impacts of greenways for Virginia should be documented so related tourism can be encouraged. [PN-A]
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- A stable source of funding would enhance the development of greenways including public/private partnerships. [PO-E]

Ten common conservation buffer practices

1. Alley cropping
2. Contour buffer strips
3. Cross wind trap strips
4. Field borders
5. Filter strips
6. Grassed waterways with filters
7. Herbaceous wind barriers
8. Riparian forest buffers
9. Vegetative barriers
10. Windbreaks/shelterbelts

CORE 4 0000 4 MORE 0000

CORE 4 Principle #4: Conservation Buffers

Conservation buffers are areas or strips of land maintained in permanent vegetation to help control pollutants and manage other environmental problems. Buffers are strategically located on the landscape to accomplish many objectives. Although this module only focuses on a few types, there are ten conservation practices commonly thought of as buffers (*see list at left*).

Conservation buffers use permanent vegetation to enhance certain ecological functions. For example, the roots of plants stabilize soil and the plant foliage block wind or provide shade. Buffers can vary widely in their vegetation and location on the landscape in order to enhance specific ecological functions that achieve conditions landowners and other stakeholders want. The ecological functions of buffers include creating stable and productive soils, providing cleaner water, enhancing wildlife populations, protecting crops and livestock, enhancing aesthetics and recreation opportunities, and creating sustainable landscapes.

Section 16 of 35

B. Rec. Planning, Greenways

Department of Conservation and Recreation

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Greenways

In general | Greenway planning | New opportunities | Recommendations | Visit the Greenways and Trails Toolbox page

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Please send website comments to **web@dcr.virginia.gov**
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The Virginia Creeper Trail: An Analysis of Use, Economic Impacts, Visitor Characteristics, and Preferences

J.M. Bowker
USDA Forest Service

John C. Bergstrom & Joshua Gill
University of Georgia

Abingdon, VA
April 28, 2004

Partners

- Virginia Creeper Club
- Creeper Cabins
- Virginia Trails
- Virginia Dept Conservation & Recreation
- Virginia Dept Forestry
- National Park Service
- University of Georgia, Dept Ag & Applied Econ
- USDA Forest Service, Region 8 & SRS
- Numerous Volunteers

Major Objectives

- Measure Annual Trail Use
- Estimate Local Economic Impacts
- Describe Trail Users
- Examine User Attitudes / Preferences
  - Trail Attributes
  - Management / Policy
  - Benefits

Trail Use

Stratified Random Sampling

Trail Exits

- Season
  - Winter 02-03 / Summer 03
- Day type
  - Sat / Sun, Fri, Hol / Weekday
- Exit type
  - High / Low
- Time of day summer
  - Morning / Afternoon / Evening

Winter Counts

- Total cells 1629 = 9 (26 + 60 + 95)
- Cells sampled 77 = 4.7 percent
- Lots of 0's Dec – Feb
- Sat ave = 217
- Sun / Fri / Hol ave = 177
- Weekday ave = 77
- Winter Visits = 23, 614 +/- 2,985

Summer Counts

- Total cells 4968
- Cells sampled 107 = 2 percent
- Very few 0's and higher missings Abingdon
- Sat ave = 1181
- Sun / Fri / Hol ave = 676
- Weekday ave = 358
- Summer Visits = 106,558 +/- 7,282

Annual Visits

- Total = 130,172
- Range 119,905 to 140,439

Survey Instruments

- Screener Survey N= 1430
  - Systematic random sample
- Detailed Survey N= 1036
  - Systematic random sample
  - Local
  - Nonlocal A & B

Survey Hierarchy

Total Detailed Surveys = 1036

Screener
Total-1430
Winter-681
Summer-749

Local	Nonlocal A	Nonlocal B
Total-431	Total-168	Total-437
Winter-250	Winter-75	Winter-91
Summer-181	Summer-93	Summer-346

Screener Survey Content

- Local vs Nonlocal
- Group size
- Activity
- Race
- Gender
- Willingness to be surveyed

Detailed Survey Content

- Trip characteristics
- Spending characteristics
- Travel time and distance to site
- Trail issues and benefits
- Area features
- Household demographics
- Annual usage
- Primary purpose

Visit Breakdown

- Screener Survey
  - 47 percent Washington & Grayson
  - Local visits = 61,503
  - 53 percent Nonlocals
  - Nonlocal visits = 66,669

Nonlocal Visits to Trips

- Detailed Survey
  - Primary purpose
  - Day use vs overnight
  - Trail visits per trip to area

Nonlocal Visits to Trips

	Visits	Person-trips
PP Day Use	40,034	33,642
PP Ovr Nite	10,305	5,725
NP Day Use	9,473	7,578
NP Ovr Nite	8,857	3,918
	66,669	50,864

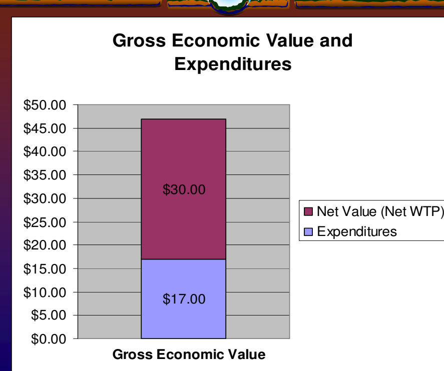
Economic Impact Analysis

Expenditures by Locals and Nonlocals

Grayson and Washington Counties

Local Resident Expenditures Per Person Per Day Trip (example: $10 average)

Nonlocal Resident Expenditures Per Person Per Day Trip (example: $17 average)



Regional Economic Impact Analysis

- Basic steps:
- Estimate Use
- Estimate recreation expenditures per person per trip by nonlocals for major expenditure categories
- Define Local Impact Region
- Allocate Local Impact Region expenditures to economic sectors in the Local Impact Region
- Use IMPLAN model to estimate output, jobs and income in the Local Impact Region supported by nonlocal resident expenditures.

Overview of IMPLAN
Impact Modeling for PLANning

- Computer-based, input-output economic model
- Designed for regional economic impact analysis
- Developed by the U.S.D.A. Forest Service
- Provides comprehensive, science-based system for estimating economic impacts of natural resource related projects
- Since 1979, it has been used in a multitude of private and public sector applications to estimate the economic impacts of natural resource related and non-natural resource related projects on regional economies

Overview of IMPLAN

- IMPLAN has two major components:
- Nationwide database describing county-level economic activity and a computer model for constructing regional input-output models and estimating economic impacts from changes in economic activity.
- The model is based on input-output accounting and analysis procedures used by the U.S. Bureau of Economic Analysis and recommended by the United Nations

Nonlocal Spending & Impacts

- Detailed Survey NLB
  - Group expenditures whole trip
  - Group expenditures Washington & Grayson
  - Spending party size
  - Per-person trip expenditures
- IMPLAN Model
  - Economic Impacts per 1,000 person-trips

Primary Purpose Day User Exp Profile
Ave Spending Party Size = 3.34

	Whole trip	25 miles VCT	VCT person/trp
Priv. Lodg	14.69	0.00	0.00
Pub. Lodg	0.09	0.00	0.00
Food In	38.13	21.29	6.37
Food Out	6.49	2.65	0.79
Prim. Trans.	18.68	11.42	3.39
Other Tran.	0.06	0.06	0.02
Bike Rent	12.98	11.68	3.50
Shuttle	10.51	9.17	2.75
Use Fees	0.14	0.14	0.42
Other	1.42	0.89	0.27
Total	103.19	57.30	17.16

Primary Purpose Overnight Exp Profile
Ave Spending Party Size = 4.5

	Whole trip	25 miles VCT	VCT person/trp
Priv. Lodg	211.86	126.95	28.21
Pub. Lodg	29.30	22.29	4.95
Food In	137.02	99.71	22.16
Food Out	40.02	28.23	6.27
Prim. Trans.	61.50	36.32	8.07
Other Tran.	1.90	1.85	0.41
Bike Rent	18.44	17.28	3.84
Shuttle	20.96	19.26	4.28
Use Fees	0.00	0.00	0.00
Other	18.32	17.57	4.39
Total	539.32	369.46	82.10

Non-primary Purpose Day Use Exp Profile
Ave Spending Party Size = 4.3 Time Share = .193

	Whole trip	25 miles VCT	VCT person/trp
Priv. Lodg	165.13	0.00	0.00
Pub. Lodg	31.18	0.00	0.00
Food In	154.18	51.00	3.51
Food Out	23.63	5.90	0.10
Prim. Trans.	82.18	59.00	3.98
Other Tran.	72.72	0.00	0.00
Bike Rent	47.13	47.13	2.66
Shuttle	3.09	3.09	0.14
Use Fees	0.18	0.00	0.00
Other	100.95	54.81	0.70
Total	680.37	161.93	11.11

Non-primary Purpose Overnight Exp Profile
Ave Spending Party Size = 3.40 Time Share = .04

	Whole trip	25 miles VCT	VCT person/trp
Priv. Lodg	175.53	125.17	1.74
Pub. Lodg	47.89	46.19	0.20
Food In	120.51	97.32	1.31
Food Out	28.19	17.23	0.13
Prim. Trans.	100.51	44.73	0.56
Other Tran.	29.19	6.80	0.01
Bike Rent	17.59	17.25	0.35
Shuttle	9.03	8.50	0.15
Use	1.06	0.00	0.00
Other	3.93	3.40	0.10
Total	533.43	366.59	4.55

Nonlocal Expenditures per Person-trip by User Type

- **PPDU-** $ 31 total ➔ $ 17 in local area
- **PPON-** $ 120 total ➔ $ 82 in local area
- **NPDU-** $ VCT share ➔ $ 11 in local area
- **NPON-** $ VCT share ➔ $ 4 in local area

*These numbers have been trimmed for outliers

Creeper Impacts

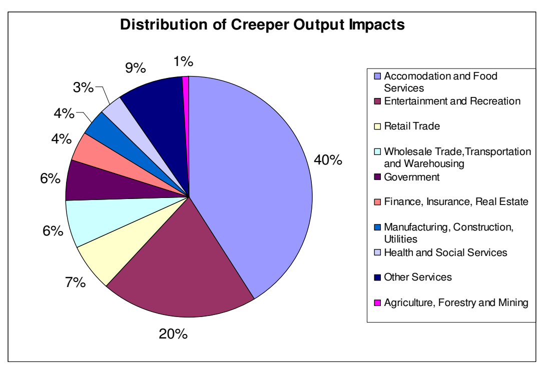
Economic Impacts Per 1,000 Person Trips of VCT Use in Grayson & Washington Counties, VA, 2003 dollars

Economic Impact Indicators	Economic Impacts Per 1,000 Person Trips			
	Primary Day Use	Primary Overnight	Non Prim Day Use	Non Prim Overnight
Output	$23,606	$114,398	$14,968	$6,411
Employment	0.4	2.1	0.2	0.1
Total Income	$10,270	$45,944	$6,014	$3,200

Nonlocal Economic Impacts

Combined Local Economic Impacts of Nonlocal VCT Use Grayson & Washington Counties, VA, 2003 dollars

Economic Impact Indicators	Total Economic Impact
Output	$1,600,000
Employment	30
Total Income	$670,000



VCT Users

VCT User Demographics

	Locals	Nonlocals
Household size	2.6	2.9
College education %	60	66
Respondent age	47	47
Full-time employ %	58	77
House Income $1000	59	80.5
Gender % Male	61	65
Race % White	99	99

VCT Market

Nonlocal travel one-way miles

Ave	260.5
Max	2747

Nonlocal nights per trip

Ave	2.95
Max	73

Nonlocal spending party

Ave	3.79
Max	45

Primary Activities

Locals	%	Nonlocals	%
Walking	52	Biking	74
Biking	26	Walking	20
Jogging	13	Jogging	2

On Trail Time & Distance

	Locals	Nonlocals
Time on Trail	80 min	176 min
Distance Traveled	5.5 mi	16.7 mi

Group Size & Trips

	Locals	Nonlocals
Group Size		
ave	1.9	3.6
max	30	45
Trips per year		
ave	141	6
max	606	300

Trail Benefits

	Locals	Nonlocals
Health	3.87	3.64
Nature	3.82	3.70
Pets	2.31	2.00
Community	3.41	2.94

High=4, Med=3, Low=2, None=1

Trail Attributes for Locals

	Importance	Condition
Safety	3.75	3.42
Scenery	3.83	3.67
Surface	3.59	3.19
Structure	3.72	3.40

High=4, Med=3, Low=2, None=1

Trail Attributes for Nonlocals

	Importance	Condition
Safety	3.79	3.54
Scenery	3.86	3.76
Surface	3.51	3.44
Structure	3.55	3.60

High=4, Med=3, Low=2, None=1

Policy Questions

	Locals	Nonlocals
Maintenance attract visitors	99	99
User fee for maintenance	32	60
Local taxes for maintenance	89	71
Volunteers for maintenance	61	62
Crowding affects trips neg.	40	33
Paving trail	6.5	13

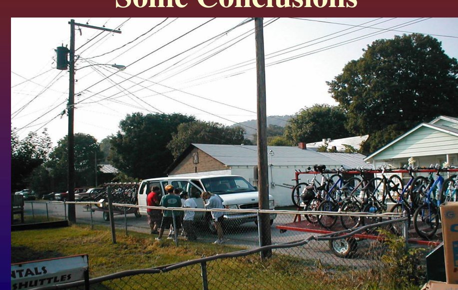
percent 'strongly agree' or 'agree'

Management Issues

	Locals		Nonlocals	
	All	Disabled	All	Disabled
Electric golf carts	3	44	<1	14
Gas golf carts	1	12	<1	12
Motorized bicycles	3	12	2	9
Horse carts	11	9	12	10
ATV's	1	2	1	2

percent 'strongly agree' or 'agree' type of use is allowed on VCT

Some Conclusions



Trail Use

- Over 130,000 visits annually
- Over 50,000 nonlocal person-trips
- Majority of nonlocals are day users
- Primary purpose over nighters
  - 15% of primary purpose nonlocal trips
  - 11% of all nonlocal trips

Economic Impact of Nonlocal Spending

- Nonlocal spending supports
  - $1.6 million local economic output
  - 30 local jobs
  - $670 thousand local income
  - 40% to accommodation & food service sector
  - 20% to recreation & entertainment sector
- To increase economic impacts
  - Increase share of primary purpose overnighters
  - Induce them to stay another night

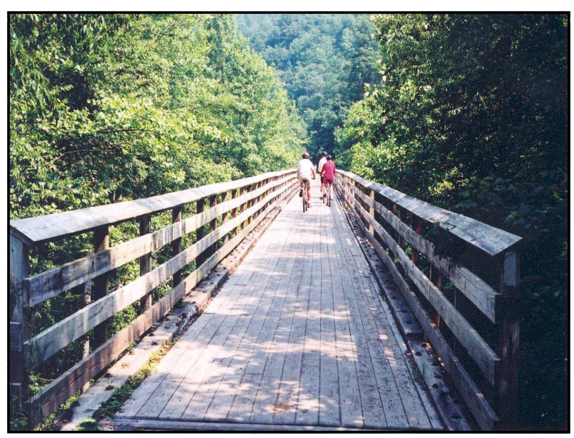
Trail Users

- Predominantly white
- Majority male
- Above average household incomes
- Average 1+ to 3 hours per VCT visit
- Health & nature most important benefits
- Safety & scenery most important attributes
- Surface & safety biggest impt-cond difference

Trail Users

- Maintenance important to attract visitors
- Locals favor taxes to fund maintenance
- Locals don't support user fees
- Nonlocals support taxes, fees, volunteers
- Alternative uses of VCT have very low support
- But… Locals support elect golf carts for disabled
- Don't even think about paving the VCT

Stay tuned for the estimated **economic benefits** of taking a trip to the VCT



D. Intro to BMPs

Chapter 3
Best Management Practices

The 40 best management practices (BMPs) presented in this chapter are organized into the two broad categories: Runoff Pollution Prevention and Stormwater Treatment. The names and page numbers of individual BMPs are listed immediately before each category, on pages 3-3 and 3-139.

Runoff Pollution Prevention

By far the most effective control of nonpoint source pollution is to prevent its release. This section of the manual discusses five families of runoff pollution prevention:

- Impervious Surface Reductions: Reducing the amount of hard surface.
- Housekeeping Techniques: Basic clean-up and management practices.
- Construction Practices: Ways to reduce opportunities for sediment release in stormwater.
- Soil Erosion Control: Techniques to prevent exposed soils from eroding.
- Sediment Control: Methods to catch sediment already suspended in stormwater.

Stormwater management begins with thoughtful design. Site planning that integrates comprehensive stormwater management from the outset is the most effective way to reduce and prevent pollution and flooding. Good site planning can also reduce the size and cost of structural solutions; when BMP stormwater structures are proposed only at the final stages of design and construction, the result is often unnecessarily large and costly facilities. Planning ahead can prevent the need for large structures.

Stormwater Treatment BMPs

A variety of BMPs are effective in filtering stormwater, reducing the speed at which it leaves a site, and reducing the volume of runoff. These three actions are critical to reducing nonpoint-source water pollution and protecting downstream water bodies.

This section of the manual presents six families of BMP practices:

- Infiltration Systems. Encourage stormwater to soak into the ground while filtering.
- Filtration Systems. Capture heavy metals, grease and oil, nutrients and sediment.
- Constructed Wetlands. Filter stormwater and reduce runoff rate while providing wildlife habitat.
- Retention Systems. Primarily designed to retain pollutants.
- Detention Systems. Primarily designed to reduce runoff rate.
- Alternative Outlet Designs. Primarily designed to regulate stormwater flow.

E. Selecting BMPs

ERROR: undefined
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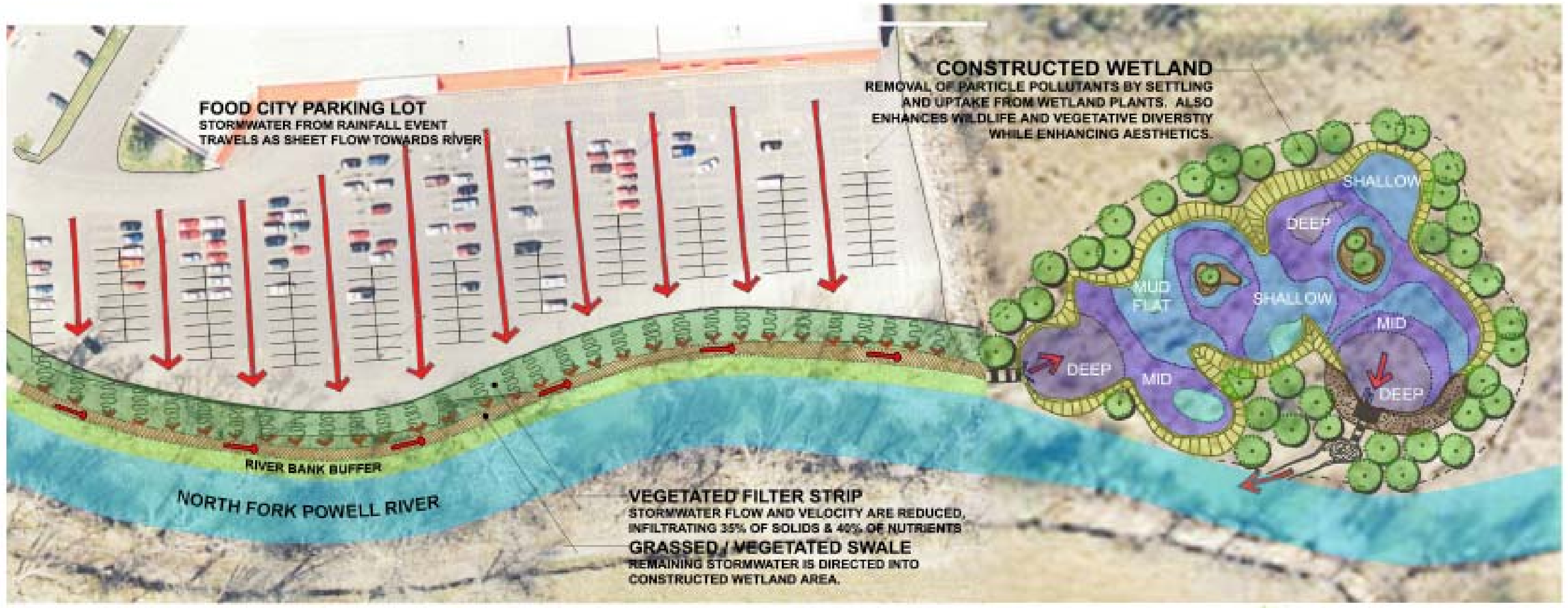
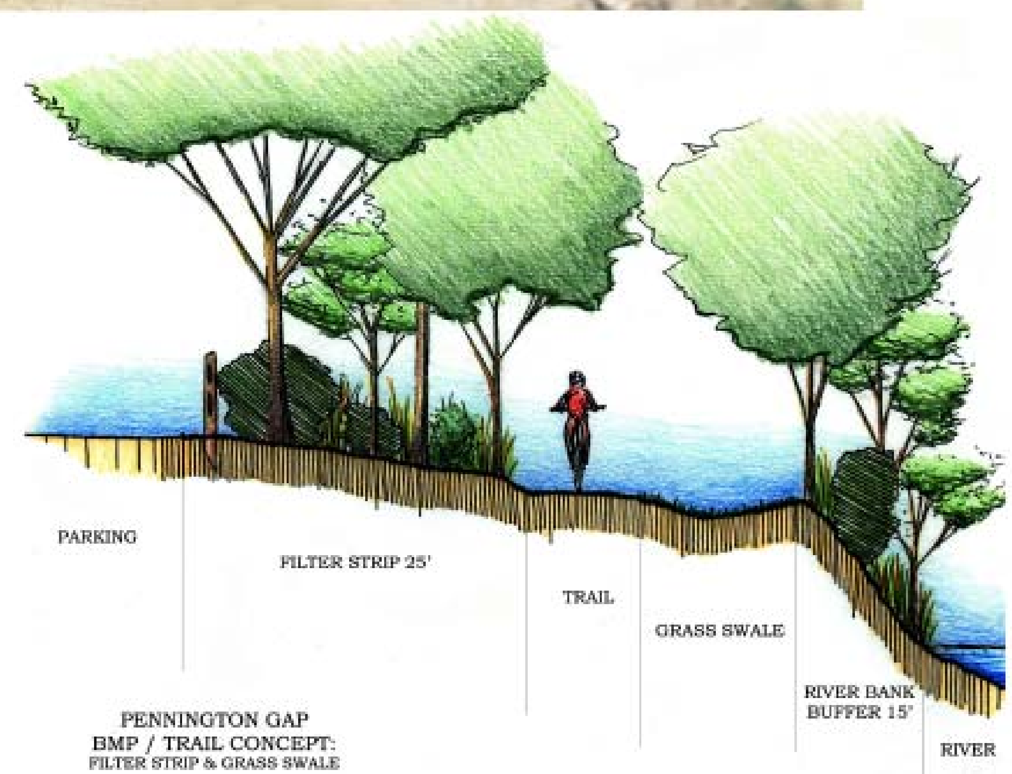
-dictionary-
-mark-

Wetlands Diagram



Perspective of boardwalk through wetlands



This drawing is conceptual and was prepared to show approximate location and arrangement of site features. It is subject to change and is not intended to replace the use of construction documents. The client should consult appropriate professionals before any construction or site work is undertaken. The Community Design Assistance Center is not responsible for the inappropriate use of this drawing.

North Fork Powell River Greenway - Riverbend Shopping Center
Stormwater BMP - Wetlands Concept

community design assistance center
College of Architecture and Urban Studies
Virginia Polytechnic Institute and State University

H. Ag. Management Practices for water quality protection

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Core Principle 4: Conservation Buffers

Conservation buffers are areas or strips of land maintained in permanent vegetation to help control pollutants and manage other environmental problems. Buffers are strategically located on the landscape to accomplish many objectives. Although this module only focuses on a few types, there are ten conservation practices commonly thought of as buffers.

Conservation buffers use permanent vegetation to enhance certain ecological functions. For example, the roots of plants stabilize soil and the plant foliage block wind or provide shade. Buffers can vary widely in their vegetation and location on the landscape in order to enhance specific ecological functions that achieve conditions landowners and other stakeholders want. The ecological functions of buffers include creating stable and productive soils, providing cleaner water, enhancing wildlife populations, protecting crops and livestock, enhancing aesthetics and recreation opportunities, and creating sustainable landscapes.

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Without proper erosion and sedimentation control, soils can be lost from croplands and reduce future productivity. Soils carried from fields in runoff can also degrade streams and other receiving waters.

Supplemental Measure 4: Erosion and Sediment Control

It is not possible to completely prevent all erosion, but erosion can be reduced to tolerable rates through proper management. In general terms, tolerable soil loss is the maximum rate of soil erosion that will permit indefinite maintenance of soil productivity (i.e., erosion less than or equal to the rate of soil development). Sedimentation causes widespread damage to our waterways. Water supplies and wildlife resources can be lost, lakes and reservoirs can be filled in, and streambeds can be blanketed with soil lost from cropland.

Management measures can be implemented by using one of two general strategies, or a combination of both. The first, and most desirable, strategy is to implement practices on the field to minimize soil detachment, erosion, and transport of sediment from the field. Effective practices include those that maintain crop residue or vegetative cover; improve soil properties; reduce slope length, steepness, or unsheltered distance; and reduce effective water and/or wind velocities. The second strategy is to route field runoff through practices that filter, trap, or settle soil particles. Examples of effective management strategies include vegetated filter strips, field borders, sediment retention ponds, and terraces. Site conditions will dictate the appropriate combinations for any given situation.

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Wind and water erosion can combine to remove tons of soil from a field each year.

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Supplemental Measure 4: Erosion and Sediment Control (continued)

For both water and wind erosion, the first objective is to keep soil on the field. The easiest and often most effective strategy to accomplish this is to reduce soil detachment. Detachment occurs when water splashes onto the soil surface and dislodges soil particles, or when wind reaches sufficient velocity to dislodge soil particles on the surface. Crop residues (e.g. straw) or living vegetative cover (e.g. grasses) on the soil surface protect against detachment by intercepting and or dissipating the energy of falling raindrops. A layer of plant material also creates a thick layer of still air next to the soil to buffer against wind erosion. Keeping sufficient cover on the soil is therefore a key erosion control practice.

The implementation of practices such as conservation tillage (see Part One - CORE 4 practices) also preserves or increases organic matter and soil structure, resulting in improved water infiltration and surface stability. In addition, creation of a rough soil surface through practices such as surface roughening will break the force of raindrops and trap water, reducing runoff velocity and erosive forces. Reducing effective wind velocities through increased surface roughness or the use of barriers or changes in field topography will reduce the potential of wind to detach soil particles. Some common examples of practices used to reduce soil detachment are:

- Conservation cover and tillage

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Poor sedimentation and erosion control resulted in a highly degraded waterway. This stream has badly eroded banks and deep deposits of mucky fine sediment.

Supplemental Measure 4: Erosion and Sediment Control (continued)

If soil does become detached by wind or water, the transport of sediment within the field can reduced with the use of crop residues and vegetative cover. Other methods to reduce sediment transport within the field include terraces and diversions. Runoff can be slowed or even stopped by placing furrows perpendicular to the slope, through practices such as contour farming that act as collection basins to slow runoff and settle sediment particles. Practices are also typically needed to trap sediment leaving the field before it reaches a wetland or riparian area. Deposition of sediment is achieved by practices that slow water velocities or increase infiltration, including sediment basins, field borders, and filter strips.

Properly functioning natural wetlands and riparian areas can significantly reduce nonpoint source pollution. Loss of these systems allows a more direct contribution of nonpoint source pollutants to receiving waters. Therefore, natural wetlands and riparian areas should be protected and should not be used as designed erosion control practices. There pollution control functions are most effective as part of an integrated land management system focusing on nutrient, sediment, and erosion control practices applied to upland areas.

For additional guidance, the United States Department of Agriculture (USDA) - Natural Resources Conservation Service (NRCS) or the local Soil and Water Conservation District (SWCD) can assist with planning and application of erosion control practices. Two useful references are the *USDA-NRCS Field*

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Core Principle 4: Conservation Buffers - Riparian Forest Buffer

A riparian forest buffer is an area of trees and shrubs located adjacent to streams, lakes, ponds, and wetlands. Riparian forest buffers of sufficient width intercept sediment, nutrients, pesticides, and other materials in surface runoff and reduce nutrients and other pollutants in shallow subsurface water flow. Woody vegetation in buffers provides food and cover for wildlife, helps keep water temperatures cooler by shading small streams, and slows out-of-bank flood flows. In addition, the vegetation closest to the stream or waterbody provides litter fall and large woody debris important to aquatic organisms. Also, the woody roots increase the resistance of streambanks and shorelines to erosion caused by high water flows or waves.

For riparian forest buffers to achieve specific purposes, they must be properly located and sized (width, length, area) in relation to the stream or waterbody. The general widths listed in the figure are based on the average findings from many scientific studies. The right buffer width for a given purpose actually may vary from stream to stream based on stream size and other factors. Because of this variability in buffer width requirements from place to place, a 3-zone minimum buffer is sometimes used as a minimum guideline when planting a buffer where there is little or none.

The 3-zone minimum buffer concept starts with a zone (identified as zone 1) that begins at the normal water line, or at the upper edge of the active channel (or top of the bank), and extends a minimum of distance

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Grassed Waterway with Vegetative Filter

A grassed conveyance can protect against erosion and helps to filter sediment and pollutants carried in runoff.

Core Principle 4: Conservation Buffers - Grassed Waterway with Vegetative Filter

A grassed waterway is a natural or constructed channel that is shaped or graded to required dimensions and established in suitable vegetation for the stable conveyance of runoff. The primary purposes of a grassed waterway are to convey runoff from terraces, diversions, or other water concentrations without causing erosion or flooding and to improve water quality. The additional benefits of grassed waterways include wildlife habitat, corridors connection, vegetative diversity, noncultivated strips of vegetation, and improved aesthetics.

Design considerations for grassed waterways include soil conditions and erodibility, slope, vegetative cover, maintenance, and channel shape. NRCS's National Handbook of Conservation Practices and Engineering Field Handbook are two references that provide guidance in how to plan and design a grassed waterway for its primary purposes. The basic design can be modified to further enhance its performance. For example, providing an additional vegetative width to the grassed waterway allows the waterway to serve as a filter strip/buffer.

As with any filter strip, to be effective in reducing sediment loading from the adjacent field, the runoff must enter a filter strip along the grassed waterway as sheet flow. Vegetation in the grassed waterway must be well established to withstand velocities that it is designed to accommodate. In some areas special measures, such as mulching or flow diversion, are needed to ensure that

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Filter strips intercept undesirable contaminants from runoff before they enter a waterbody.

Core Principle 4: Conservation Buffers - Filter Strip

A filter strip is an area of grass or other permanent vegetation used to reduce sediment, organics, nutrients, pesticides, and other contaminants from runoff and to maintain or improve water quality. Filter strips intercept undesirable contaminants from runoff before they enter a waterbody. They provide a buffer between contaminant sources, such as crop fields, and waterbodies, such as streams and ponds. Filter strips slow the velocity of water, allowing the settling out of suspended soil particles, infiltration of runoff and soluble pollutants, adsorption of pollutants on soil and plant surfaces, and uptake of soluble pollutants by plants. The mechanisms of filter strip function can vary according to the characteristics of a pollutant. Secondary benefits of filter strips may also include:

- Forage - for farm use or as cash crop
- Field borders
- Turnrows and headlands
- Access
- Aesthetics

Filter strips apply to lower edges of cropland fields where contributions of pollutants may move off the cropland area. They can also be used above conservation practices, such as ponds, drainageways, and terraces, to reduce the load of sediment and other contaminants moving into the practice areas. The slope of the filter and the soil of the filter area impact the overall performance. Steeper slopes increase flow velocity and shorten the time the contaminant material carried in the runoff, both particulate and soluble, has an opportunity to interact with the vegetation and soil in the filter area.

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Parallel barriers divide field into short tilled strips, making tillage impact greater.

Core Principle 4: Conservation Buffers - Vegetative Barriers

Vegetative barriers (also referred to as grass hedges) are narrow, parallel strips of stiff, erect, dense grass planted close to the contour. These barriers cross concentrated flow areas at convenient angles for farming. This practice differs from other conservation buffers because vegetative barriers are managed in such a way that any soil berms that develop are not smoothed out during maintenance operations. Vegetative barriers can be used for the following purposes:

- Control sheet and rill erosion, trap sediment, and facilitate benching of sloped cropland
- Control rill and gully erosion and trap sediment in concentrated flow areas
- Trap sediment at the bottom of fields and at the ends of furrows
- Improve the efficiency of other conservation practices

Coarse, stiff, hedge-forming grasses can withstand high water flows that would bend and overtop finer vegetation. They retard flow velocity and spread out surface runoff. Reduced velocity prevents scouring, causes deposition of eroded sediment, and lessens ephemeral gully development. Vegetative barriers can also disperse flow where water enters other types of conservation buffers, increasing the efficiency of these practices. Placing vegetative barriers on the landscape divides fields into cropped and vegetative strips. Under tillage, soil moves downslope from the upper part of each cropped area and is deposited upslope of the next barrier, gradually leveling the tilled area and

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Core Principle 4: Conservation Buffers - Wind Control Buffers

Vegetation can also be used as a buffer to protect soil, crops, animals, and waterbodies from wind. Three common conservation buffers for wind control are **cross wind traps**, **herbaceous wind barriers**, and windbreaks. Cross wind traps are plantings resistant to wind erosion and grown perpendicular to the prevailing wind erosion direction.

Cross wind traps strips entrap wind-borne sediment and establish a stable area to resist wind erosion. Trap strips are designed to be 12 to 15 feet wide, 1 to 2 feet high, consist of 50 percent or greater vegetation, and maintain 50 to 75 per square foot stem density. Herbaceous wind barriers are tall grass and other non-woody plants established in 1- to 2-row narrow strips spaced across the field perpendicular to the normal wind direction.

Herbaceous wind barriers reduce wind velocity across the field and intercept wind-borne soil particles. Species selected for perennial herbaceous wind barriers should consist of stiff, erect grasses and forbs adapted to local soil and climate conditions. Barrier species must have sufficient strength to remain erect against anticipated high velocity wind and waterflows. They should also have good leaf retention and pose minimum competition to adjacent crops. Additional desirable characteristics include tolerance to sediment deposition, long life expectancy, and highly competitive with weeds. NRCS's Field Office Technical Guide is an excellent resource for plant species

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Part Two: Supplemental Agricultural BMPs

The CORE 4 practices discussed in the Part One of the module are most effective when integrated into an overall management system that addresses all natural resource concerns and the objectives of the landowner or operator. Other agricultural management measures, beyond the CORE4 practices already discussed, may provide additional benefits to the farmer and the environment. These measures can be considered as part of a comprehensive management plan. The supplemental measures include irrigation water management, animal grazing management, animal feeding operations (AFOs) management, and erosion and sediment control.

Irrigation Water Management

A primary concern for irrigation water management is the discharge of salts, pesticides, and nutrients to ground water and discharge of these pollutants plus sediment to surface water. Effective and efficient irrigation begins with a basic understanding of the relationships among soil, water, and plants. The amount of water the plant needs, its consumptive use, is equal to the quantity of water lost to evapotranspiration. Due to the inefficiencies in the delivery of irrigated water (e.g., evaporation, runoff, wind drift, and drip percolation losses), the amount of water needed for irrigation is greater than the consumptive use. In arid and semi-arid regions, salinity control may be a consideration, and additional water may be needed to flush the salts from the root zone.

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Center-pivot irrigation systems produce these distinctive circular patterns on the agricultural landscape.

Supplemental Measure 1: Irrigation Water Management

Irrigation systems consist of two basic elements: the transport of water from its source to the field, and the distribution of transported water to the crops in the field. Transport of irrigation water from the source of supply to the irrigated field via open canals can be a source of water loss if the canals are not lined. In many soils, unlined canals lose water through evaporation and seepage in bottom and side walls. Seepage water can percolate into the ground water, carrying with it any soluble pollutants in the soil and creating potential for pollution of ground or surface water.

Factors that are typically considered in selecting an appropriate irrigation method include land slope, water intake rate of the soil, water tolerance of crops, and wind. Additionally, the chemical characteristics of the soil and the quantity and quality of the irrigation water will determine whether irrigation is a suitable management practice that can be sustained without degrading the soil or water resources.

There are four basic methods of applying irrigation water: surface, sprinkler, trickle, and subsurface. Gravity-based surface systems use canals or ditches to transport the water to the fields. Pressure-based systems, such as sprinklers, depend on pumping water to the fields and applying the water with a variety of equipment types. Micro-irrigation systems, including trickle and subsurface methods, are designed to apply the required water needs at the root zone of each plant, thus

Irrigation water management uses effective techniques to minimize wasted time, energy, and water.

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Supplemental Measure 1: Irrigation Water Management (continued)

Ultimately, cost-effective irrigation matches crop needs while limiting erosion from applied water, reducing the movement of pollutants from land into ground or surface waters, and minimizing wasted time, energy, and water. These goals can be achieved through consideration of the following aspects of irrigation systems:

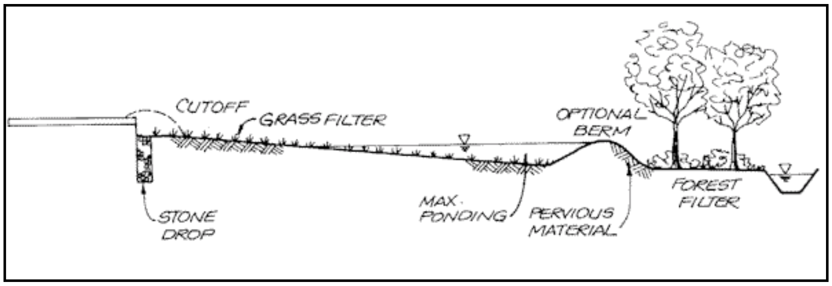
1. Irrigation scheduling
2. Efficient application of irrigation water
3. Efficient transport of irrigation water
4. Use of runoff or tailwater
5. Management of drainage water

Irrigation scheduling is the use of water management strategies to prevent over-application of water while minimizing yield loss from water shortage or drought stress. Irrigation scheduling should be based on knowing the daily water use of the crop, the water-holding capacity of the soil, and the lower limit of soil moisture for each crop and soil, and measuring the amount of water applied to the field. Therefore, proper irrigation scheduling depends on daily accounting of the cropland field water budget. The tools required to complete this budget include water measuring devices (e.g., irrigation water meter, flume, or weir) and soil and crop water use data (reported in USDA publications).

Efficient application of irrigation water ensures proper use and distribution of water, minimizes runoff or deep percolation, and minimizes soil erosion. The method of application should be suitable to

I. Filter Strips

Filter Strips



Description

Filter strips (also known as vegetated filter strips, grass filter strips and grassed filters) are densely vegetated, uniformly graded areas that treat sheet flow from adjacent impervious surfaces. Filter strips function by slowing runoff velocities, trapping sediment and other pollutants and providing some infiltration. While frequently planted with turf grass, filter strips may also employ native vegetation, such as meadow or prairie, which may be more effective in treating nutrients. In addition, trees and shrubs may be incorporated into portions of the strip to create visual screening as well as a physical barrier. (See Figure 1.)

Filter strips are best suited to treating runoff from roads and highways, roof downspouts and small parking lots, and they are ideal components of the "outer zone" of a stream buffer. In addition, filter strips are frequently used as a pretreatment system for stormwater destined for other BMPs such as filters or bioretention systems.

A challenge associated with filter strips is the difficulty of maintaining sheet flow. Urban filter strips are often short-circuited by concentrated flows, which results in little or no treatment of stormwater runoff. To avoid this problem, filter strip design can incorporate a level spreader to distribute concentrated flow along the width of the strip.

Filter strips were originally used as an agricultural treatment practice and have more recently evolved into an urban practice. Studies in agricultural areas indicate that a 15-foot wide grass buffer can achieve a 50 percent removal rate of nitrogen, phosphorus and sediment and that a 100-foot buffer can remove 70 percent of these constituents. Urban runoff studies suggest a minimum removal rate of 35 percent of solids and 40 percent of nutrients. This assumes a filter strip that is properly designed, constructed and maintained.

Purpose

Water Quantity	
Flow attenuation	◧
Runoff volume reduction	◧
Water Quality	
Pollution prevention	
Soil erosion	□
Sediment control	◧
Nutrient loading	◧
Pollutant removal	
Total suspended sediment (TSS)	◧
Total phosphorus (P)	□
Nitrogen (N)	□
Heavy metals	□
Floatables	◧
Oil and grease	◧
Other	
Fecal coliform	□
Biochemical oxygen demand (BOD)	□

■	Primary design benefit
◧	Secondary design benefit
□	Little or no design benefit

Filter Strips

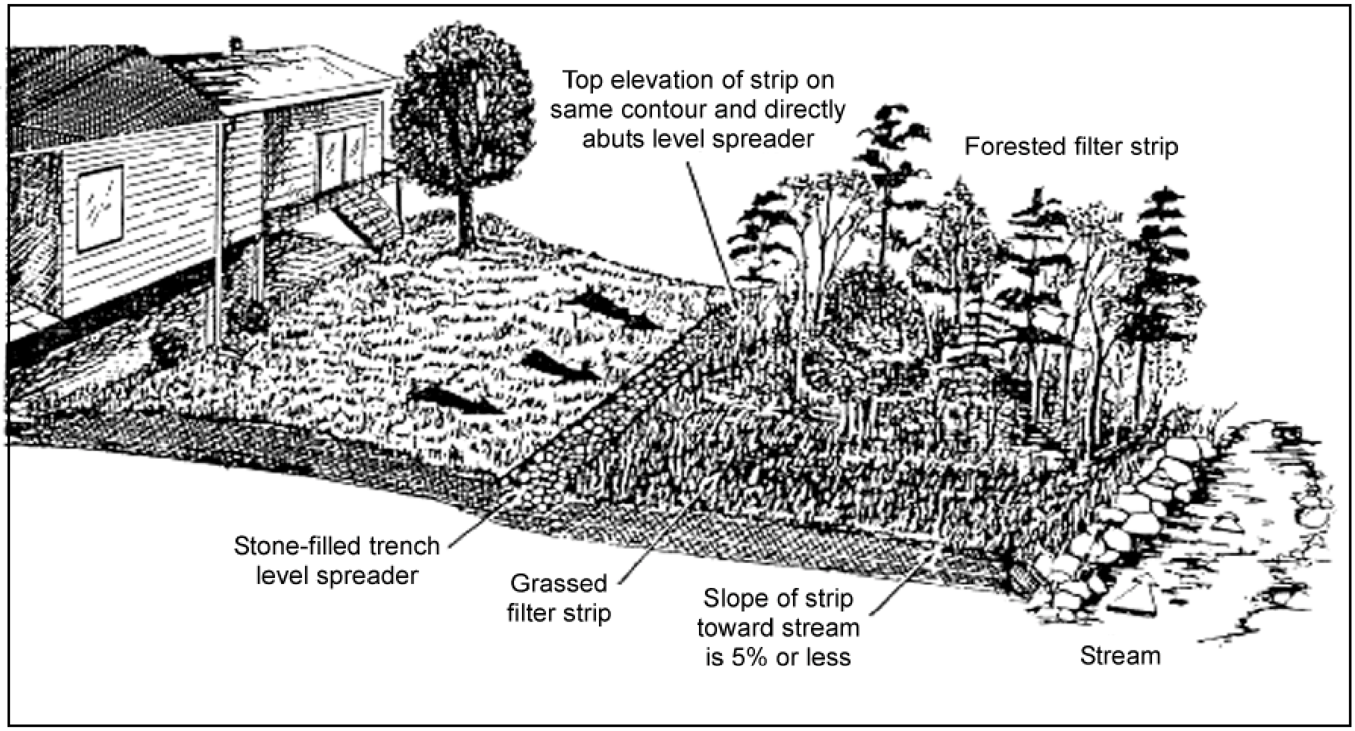


Figure 1: Filter Strip Combining Grassed and Wooded Areas
Source: Claytor, 1996

Advantages

- Filter strips help remove sediment and associated insoluble contaminants from runoff.
- They allow increased infiltration opportunity for soluble nutrients and pesticides to drain into the soil.
- Filter strips work well in residential areas, where they provide open space for recreation activities, help maintain riparian zones along streams, reduce streambank erosion and provide animal habitat. (See Figure 2)
- Since they do not pond water on the surface for long periods, filter strips help maintain temperature norms of the water, thereby protecting or providing habitat for aquatic life.
- Filter strips can be useful as sediment filters during construction. In some settings, this may only require preservation of an appropriately located area of existing vegetation. (See Design section for details.)
- Filter strips with taller, denser vegetation can help provide a visual barrier from such areas as roads, factories or recreation sites.
- Filter strips with dense native vegetation can trap dust blowing off a construction site.
- They are relatively simple and inexpensive to install, employing only planting and perhaps some earthwork.
- Filter strips are relatively low-maintenance practices.

Filter Strips

- They tend to be low-cost as well, since their plantings and maintenance often overlap with what would be done on the site regardless of stormwater management practices.

Limitations

- They are not appropriate for hilly or intensively paved areas due to high-velocity runoff.
- These systems are difficult to monitor, and thus there is less available data on their effectiveness for pollutant removal.
- Use of filter strips tend to be impractical in watersheds where open land is scarce and/or expensive.
- In general, filter strips should not accept highly contaminated “hotspot” runoff, since infiltration could result in groundwater pollution and damage to vegetation..
- Filter strips tend to be poor retrofit options since they consume a relatively large amount of space and cannot treat large drainage areas.
- Improper grading can render the practice ineffective.
- Since filter strips cannot provide enough storage or infiltration to significantly reduce peak discharge or volume of runoff, the practice may be best implemented as one of a series of stormwater BMPs.
- Filter strips are only effective if sheet flow can be maintained through the filter strip.

Requirements

Design

- Ordinarily, forests and other natural areas should not be destroyed to create a filter-strip system. Such areas may already be functional or may only need to be enhanced (with, for example, level spreaders or repair to eroded spots) to function properly as treatment systems.
- The design of filter strips must be specific to the site; widths, for example, vary greatly depending on proximity of streams or lakes.
- Filter strips must be at least 15 feet wide in the direction of flow in order to be effective, however greater widths will enhance treatment. The steeper the slope, the wider the strip should be.
- The Natural Resources Conservation Service (NRCS) recommends a minimum of 150 feet of filtering buffer between a land disturbance activity and a water body. Depending on soil types and slopes, the width may need to be even greater.
- The length of the filter strip should stretch the entire length of the impervious surface from which stormwater originates, and when adjacent to a natural water body, they should stretch the entire length of the property or shoreline.
- If soil and vegetation within designated buffer areas or zones are disturbed as part of the site work, they should be designed to act as filter strips. Disturbance of native vegetation in buffer areas should be avoided whenever possible.

Requirements

Design (continued)

- In general, filter strip slopes should be no less than 1 or 2 percent and no greater than 6 percent. Greater slopes will encourage concentrated flow and flatter slopes may result in ponding.
- Top and toe of slope should be as flat as possible to encourage sheet flow and prevent erosion.
- The area immediately upslope from the filter strip may also need to be shaped and graded to ensure sheet flow.
- Concentrated flow should not be discharged into filter strips. If flows are concentrated, a level spreader should be included to spread the flow out over the entire length of the filter strip.

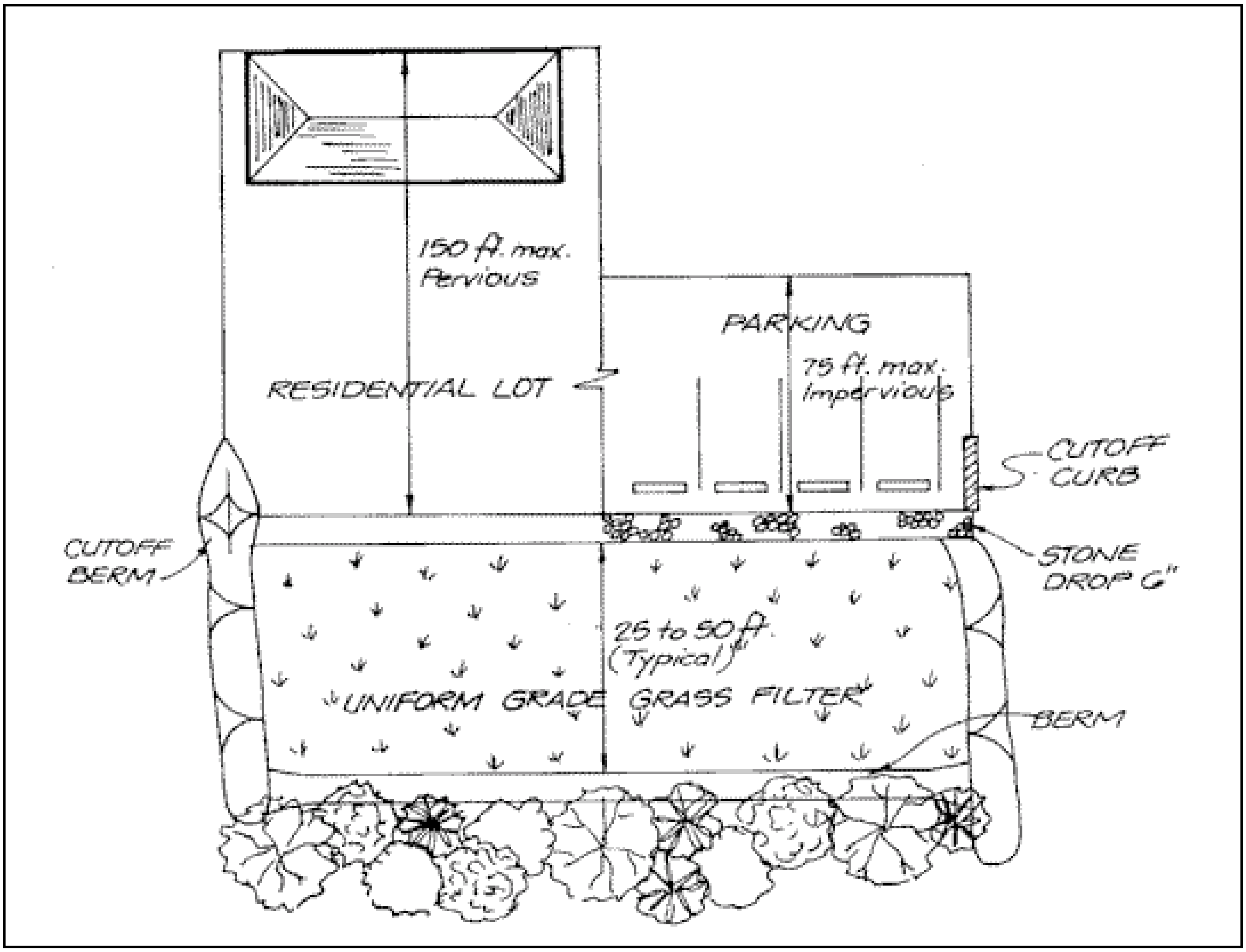


Figure 2: Filter Strip Plan
Source: Center for Watershed Protection, 2000

- Level spreaders can take on many configurations. Level spreaders must take concentrated flow and spread it out into sheet flow upstream of the filter strip. This can be accomplished in many different ways. The key is that there must be a long, continuous and level overflow elevation. This can be a curb, a concrete weir or a level trench (12 inches wide by 24 inches deep), filled with pea gravel or crushed stone.

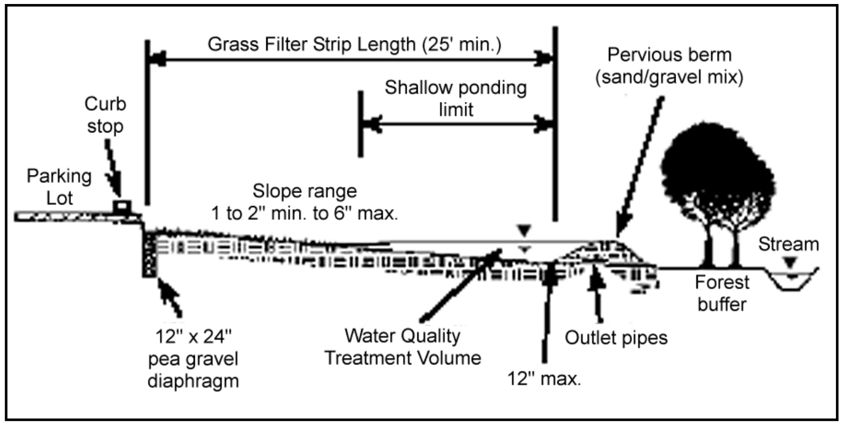


Figure 3: Filter Strip Profile
Source: Claytor & Schueler, 1996.

- To enhance the effectiveness of the filter strip, install a pervious berm of sand and gravel (see Fig. 3) at the toe of the slope. This could also include outlet pipes flowing through it or an overflow weir. This provides an area for temporary shallow ponding to accommodate a portion or all of the water quality volume.
- Select plants that are able to withstand flowing water and both wet and dry periods. See On-Lot Infiltration BMP for plant lists.
- When a filter strip is used during construction, its design should be incorporated into the final post-construction landscape. This may mean selecting vegetation that will reach an appropriate height at maturity and offer an attractive appearance.
- Depending on adjacent land use and traffic, filter strips may require fencing to control destructive access by vehicles, pedestrians and animals.
- Filter strips are typically designed to handle flows from the 1 to 2 year storms and are unable to reduce flow rates of large storm events. Depending on slope and vegetation, the flows from larger storms could damage filter strips. If this is the case, the design should incorporate a bypass system into supplementary BMPs.

Requirements

Construction

- Accurate grading is essential, since even small departures from design slopes can eliminate sheet flow and decrease effectiveness.
- All filter strips should use appropriate soil-stabilization methods, such as mulch (at a minimum), or preferably mats or erosion control blankets (see other BMP sections).
- If a filter strip must be interrupted by construction entrances, resulting in removal of natural vegetation, artificial buffer techniques must be installed: for example, vehicle tracking pads or silt fences.

With minimal maintenance, filter strips can be effective indefinitely. Those that are not maintained properly may

Requirements
Maintenance

quickly become nonfunctional. Maintenance basically involves normal grass or shrub-growing activities such as mowing, trimming, removal of invasive species, and replanting when necessary.

Filter strips require more tending as the volume of sediment increases. Periodically, strips used for sediment removal may require regrading and reseeding of their upslope edge. When used during construction activities, and if a high volume of sediment builds up, the strip may need to be reworked and replanted. The same would be necessary if concentrated flow erodes a channel through the strip.

Annual

(Semiannual in Year 1)

- Inspect pea gravel diaphragm/level spreader for clogging and effectiveness and remove built-up sediment.
- Inspect for rills and gullies. Immediately fill with topsoil, install erosion control blanket and seed or sod.
- Inspect to ensure grass is well established. If not, either prepare soil and reseed or replace with alternative species. Install erosion control blanket.

Regular, Frequent

- Mow turf grass with low ground pressure equipment to a three- or four-inch height. Cut only when soil is dry to prevent tracking damage to vegetation, soil compaction and flow concentrations.

Regular, Infrequent

- Remove sediment and replant in areas of buildup.
- Limit fertilizer applications based on plant vigor and soil test results.

Filter Strips

Sources

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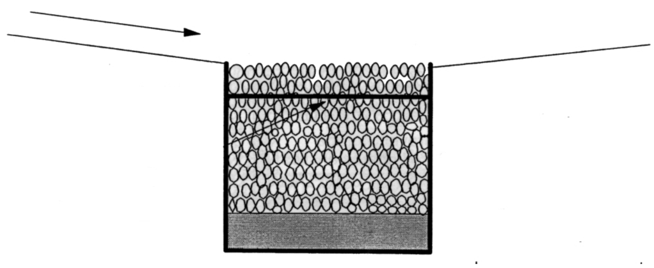
J. Infiltration Trenches

Infiltration Trenches



Description

Infiltration trenches are shallow (3- to 12-foot) excavations that are lined with filter fabric and filled with stone to create underground reservoirs for stormwater runoff from a specific design storm. The runoff gradually percolates through bottom and sides of the trench into the surrounding subsoil over a period of days. Infiltration trenches are typically implemented at the ground surface to intercept overland flows. Runoff can be captured by depressing the trench surface or by placing a berm at the down gradient side of the trench.

Infiltration trenches in this BMP Section refer to surface trenches that collect sheet flow from a few lots or properties as opposed to soakaway pits which are primarily used for a single lot application (see the On-Lot Infiltration BMP Section for information on this type of BMP).

Infiltration trenches require pretreatment of stormwater in order to remove as much of the suspended solids from the runoff as possible before it enters the trench. Pretreatment practices, such as grit chambers, swales with check dams, filter strips, or sediment fore-bays/traps should be a fundamental component of any BMP system relying on infiltration. Source controls should also be investigated (e.g., eliminate excessive sanding/salting practices). Public education with respect to street/driveway sediments should be provided in areas where an infiltration trench is proposed.

The design storm for an infiltration trench is typically a frequent, small storm such as the 1-year event. This provides treatment for the "first flush" of stormwater runoff. Infiltration trenches provide total peak discharge, runoff volume and water quality control for all storm events equal to or less than the design storm. This infiltration reduces the volume of runoff, removes many pollutants and provides stream baseflow and groundwater recharge.

Infiltration trenches have limited capabilities for controlling peak discharge for storms greater than the design storm. Because infiltra-

Purpose

Water Quantity	
Flow attenuation	◧
Runoff volume reduction	■
Water Quality	
Pollution prevention	
Soil erosion	**N/A**
Sediment control	**N/A**
Nutrient loading	**N/A**
Pollutant removal	
Total suspended sediment (TSS)	■
Total phosphorus (P)	■
Nitrogen (N)	■
Heavy metals	■
Floatables	◧
Oil and grease	◧
Other	
Fecal coliform	◧
Biochemical oxygen demand (BOD)	◧

■ Primary design benefit
◧ Secondary design benefit
□ Little or no design benefit

tion trenches will not significantly impact peak discharges of runoff, they are best used in conjunction with other BMPs; downstream detention is often still needed to meet peak runoff rate requirements.

Dissolved pollutants are effectively controlled for storm events less than the design storm, but these substances may not be removed from the runoff water as it infiltrates, and a portion could move to the groundwater. For this reason, the impact of infiltrated runoff on the groundwater should be considered, although in most cases, the magnitude of this impact is unknown. Chloride from road salt is an example of a soluble material that will not be removed during the infiltration process. Currently, there is much disagreement as to whether chlorides do, indeed, pose a significant threat to groundwater. A general guideline for groundwater protection is to design infiltration trenches with the bottom of the trench a minimum of 3 feet above the seasonally high groundwater table. This is consistent with the MPCA's guidelines for septic systems (MPCA, 2000). If the water table is too close to the ground surface, infiltration practices should not be used.

Figure 1 provides a schematic of a typical infiltration trench. Figures 2 and 3 illustrate two different examples of infiltration trench layouts- in a parking lot and in a median strip.

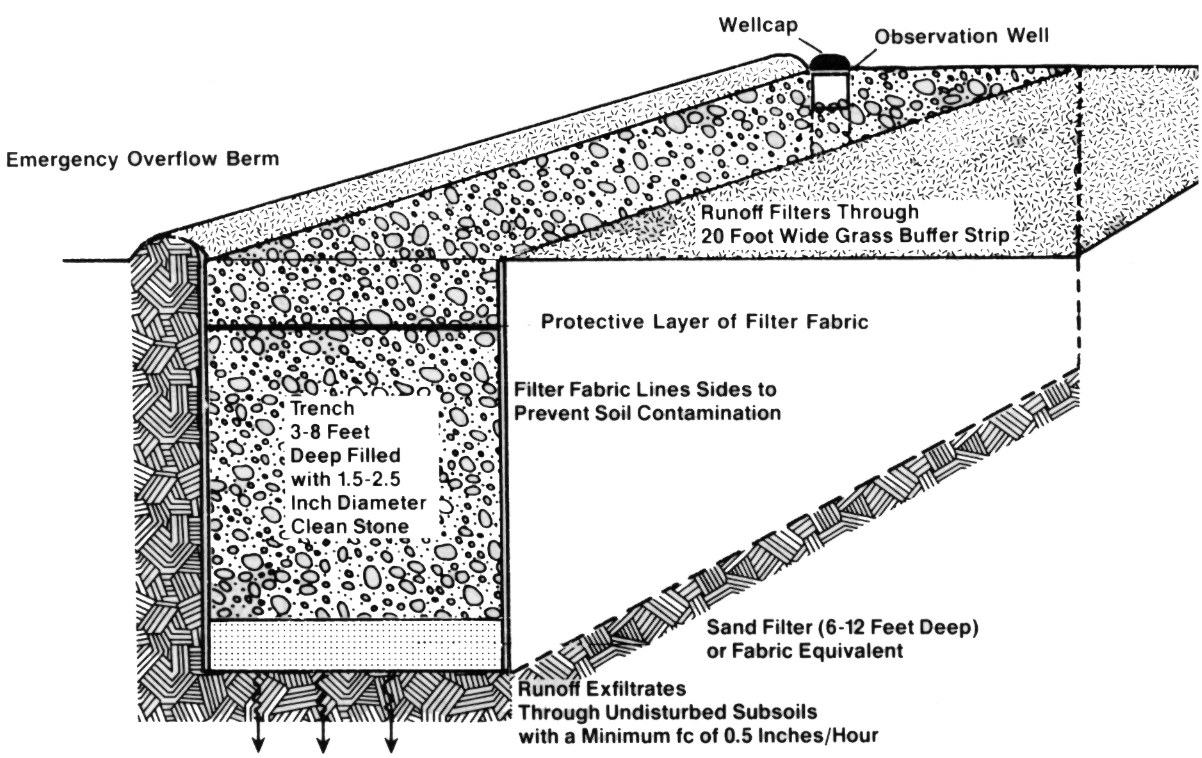


Figure 1: Typical Infiltration Trench Design
Source: Schueler, 1987.

Infiltration Trenches

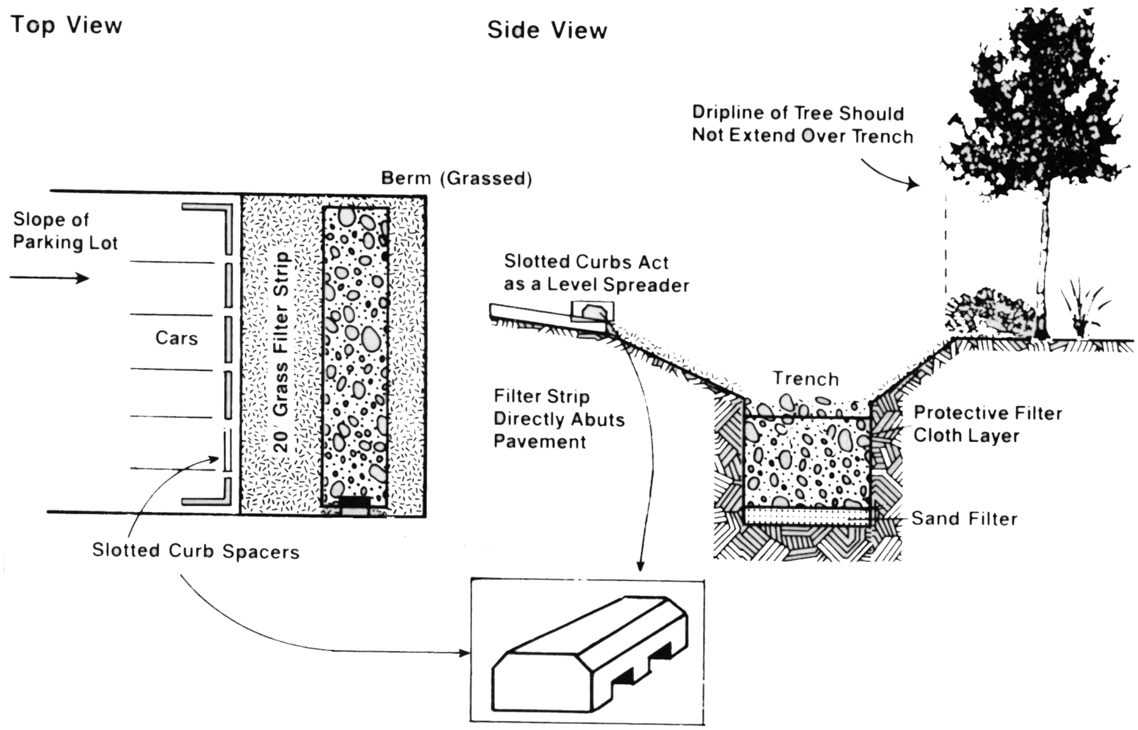


Figure 2: Parking Lot Perimeter Trench Design

Source: Schueler, 1987.

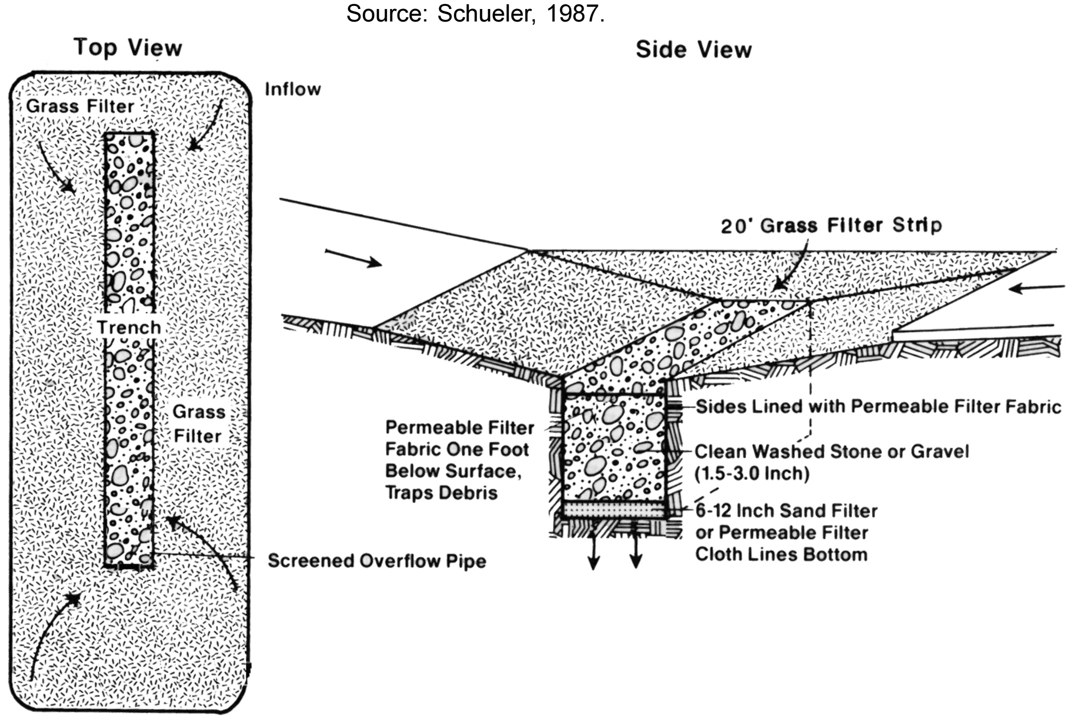


Figure 3: Median Strip Trench Design

Source: Schueler, 1987.

Infiltration Trenches

Advantages

- Reduces the volume of runoff from a drainage area
- Can be very effective for removing fine sediment, trace metals, nutrients, bacteria, and oxygen-demanding substances (organics)
- Reduces downstream flooding and protects streambank integrity
- Reduces the size and cost of downstream stormwater control facilities and/or storm drain systems by infiltrating stormwater in upland areas
- Provides groundwater recharge and baseflow in nearby streams
- Reduces local flooding
- Appropriate for small sites (2 acres or less)
- Can be utilized where space is limited, due to their narrow dimensions

Limitations

- Potential failure due to improper siting, design and lack of maintenance, especially if pretreatment is not incorporated into the design.
- Depending on soil conditions, land use in the watershed and groundwater depth, a risk of groundwater contamination may exist.
- Not appropriate for industrial or commercial sites where the release of large amounts or high concentrations of pollutants is possible.
- Susceptible to clogging by sediment, resulting in frequent maintenance
- Requires frequent inspection and maintenance

Requirements

Design

Infiltration trench failure can be avoided with proper design, taking the following topics into consideration:

- Careful site selection (discussed further in the Site Sensitivity Analysis section)
- Treatment of sheet flow from a small drainage area
- Incorporation of pretreatment and a bypass for high flow events
- Good construction techniques that prevent smearing, over-compaction, and operation of the trench during the construction period.
- Performance of regular maintenance

All of these topics are discussed in further detail below.

Infiltration Trenches

Site Sensitivity Analysis

Before an infiltration system can be designed, a site sensitivity analysis must be performed. This evaluation may eliminate an infiltration practice from consideration because of soil characteristics or potential effects on ground-water. Because of varying geologic settings, a site evaluation needs to be tailored to the specific site conditions. A team approach to this evaluation is recommended where various disciplines such as engineering, hydrogeology and soil science are represented.

The applicability of infiltration trenches on a site depends on numerous site factors including, soils, slope, depth to water table, depth to bedrock or impermeable layer, contributing watershed area, land use, proximity to wells, surface waters, foundations, and others. Generally, infiltration trenches are suitable to sites with gentle slopes, permeable soils, relatively deep bedrock and groundwater levels, and a small contributing watershed area (less than 2 acres, ideally).

When performing a site evaluation, the following items should be considered:

- Runoff water quality: If runoff water will contain a significant concentration of soluble pollutants that could contaminate groundwater, an infiltration trench should not be used. Specifically, infiltration trenches are not recommended for industrial and commercial land uses where there is a high potential for groundwater contamination from chemical spills. In site specific cases where infiltration trenches are deemed acceptable for these land uses, the design must incorporate some form of upstream pretreatment.
- Degree of detail: The level of detail required for the study should be considered. For instance, a small structure receiving runoff from a roof top will not require as much detail as a structure serving a larger area and having a higher potential pollutant load.
- Geologic (groundwater) sensitivity: A site with a highly sensitive geology, such as one with a carbonate or surficial sand aquifer, may eliminate this practice from consideration.
- Depth to water table and bedrock: The seasonally high water table must be far enough below the bottom of the infiltration trench (at least 3 feet) to allow the structure to function hydraulically and to allow trapping and treatment of pollutants by the soil. Similarly, the bottom of the infiltration trench should be at least 3 feet from bedrock, although in the case of fractured bedrock, separations up to 10 feet may be required. This minimum separation distance is required to trap or treat pollutants before they reach the groundwater or bedrock and to maintain vegetation in the trench (MPCA, 2000).
- Frost line of the soil: The maximum effective depth of the trench should be located below the frost line to promote continued percolation of runoff water throughout the winter months. The maximum effective depth is defined as the depth to which the design volume of runoff actually fills the trench; trenches can be constructed to be deeper than they need to be to fit certain site characteristics or shallower if excess space is provided for storage.
- Proximity to drinking water wells and building foundations: Trenches should be located at least 150 feet away from drinking water wells to limit the possibility of groundwater contamination, and should be situated at least 10 feet down-gradient and 100 feet up-gradient from building foundations to avoid potential seepage problems.
- Soil percolation rate: The percolation rate of the soil must be great enough to drain the structure in a reasonable amount of time, generally 72 hours or less. Sites with clayey soils are not appropriate for infiltration trenches. Percolation rates are discussed in further detail below. If the percolation rate of the site's soils are not acceptable, the filtration family of BMP systems should be considered.

Design Requirements (continued)

- Size of the tributary drainage area: Although infiltration trenches were originally designed to accommodate larger drainage areas, the monitoring which has been undertaken to-date indicates that large scale infiltration is not feasible. One of the main problems with centralized infiltration trenches is that water from a large area is expected to infiltrate into a relatively small area. This does not reflect the natural hydrologic cycle and generally leads to problems (groundwater mounding, clogging, compaction). For these reasons, the contributing drainage area to any individual infiltration trench should be restricted to 2 acres or less.

General Design Considerations

Design Volume

Infiltration trench systems infiltrate a portion of the runoff from a rain event (usually the first flush or up to the first inch) while the remaining runoff bypasses the infiltration trench. The design infiltration volume can be calculated in many ways. Ultimately, the magnitude of the design infiltration volume depends on local authorities' practices and requirements.

Duration of Ponding

Trenches should be designed to provide a detention time of 6 to 72 hours. A minimum drainage time of 6 hours should be provided to ensure satisfactory pollutant removal in the infiltration trench (Schueler, 1987; SEWRPC, 1991). Although trenches may be designed to provide temporary storage of stormwater, the trench should drain prior to the next storm event. The drainage time will vary by precipitation zone. In Minnesota, the average time between storm events is estimated to be 72 hours. Therefore, the depth of the infiltration trench should be adjusted so that maximum drain time (based on the soil permeability at the site) is 72 hours for the total design infiltration volume.

Site Soil Permeability

The soils of a prospective site are an important consideration when determining the suitability for an infiltration trench. County soil surveys are useful for preliminary screening of a site for soil infiltration rate. The Natural Resource Conservation Service (formerly the Soil Conservation Service) hydrologic classifications for different soil types can be found in the National Engineering Handbook (NRCS, 1972) or on the NRCS' website at www.wcc.nrcs.usda.gov/water/quality/common/neh630/4content.html.

Permeability, also called "percolation rate" or "hydraulic conductivity", as opposed to infiltration rate, should be used to define the rate at which runoff can seep into the bottom and sides of an infiltration trench. Typically, the permeability of a soil is much higher than infiltration rate, and can be estimated by referencing an NRCS (formerly SCS) Soil Survey Report.

A geologic investigation of the site, however, is always preferable. Several methods of measuring soil permeability have been developed. The most commonly used test is the falling head percolation test. This method is described in detail in:

- Annual Book of ASTM Standards, 1998, Section 4, Vol 4.09, Soil and Rock (II): Designation D 5084-90, Standard Test Method for Measurement of Hydraulic Conductivity of Saturated Porous Materials Using a Flexible Wall Permeameter, pp 62-69.
- *Onsite wastewater Treatment and Disposal Systems Design Manual.* 1980. EPA, pp 39-49.

Infiltration Trenches

A minimum of two borings should be taken for each infiltration trench. Trenches over 100 feet in length should include at least one additional sample for each 50 foot increment. Borings should be taken at the actual location of the proposed infiltration trench to identify localized soil conditions.

The designer should use their best judgement to determine if the slowest or average measured percolation rate in the proposed trench area should be used for the design of the trench.

Where feasible, larger-scale of measurements of permeability are encouraged, using a procedure such as the Pilot Infiltration Test described in the State of Washington's Stormwater Management Manual (Washington State Department of Ecology, 1999). This document is currently available on the internet at www.ecy.wa.gov. This type of procedure can avoid some of the error associated with smaller-scale tests and can provide an indication of the longer-term infiltration rate that better represents the future conditions of the site.

Trench Volume and Configuration

The volume and surface area of an infiltration trench relate to the design volume of runoff entering the trench from the contributing watershed and the permeability of the soil below the trench. In addition, since the infiltration trench is filled with stone, only the space between the stone (hereafter called the void space in the storage media) is available for runoff storage.

The length and width of the trench will largely be determined by the characteristics of the site in question (topography, size and shape). The dimensions of the trench will also depend on the path of influent water. If stormwater is conveyed to the trench as uniform sheet flow, the length of the trench perpendicular to the flow direction should be maximized. If stormwater is conveyed as channel flow, the length of trench parallel to the direction of flow should be maximized.

The appropriate bottom area of the trench can be calculated using the equation shown below. This equation assumes that all of the infiltration occurs through the bottom of the trench.

$$A = 12V / (P\ n\ t)$$

where A = bottom area of the trench (ft^2)

V = runoff volume to be infiltrated

P = percolation rate of surrounding native soil (in/h)

n = void space fraction in the storage media (0.4 for clear stone)

t = retention time (maximum of 72 hours)

Trench depths are usually between 3 and 12 feet (SEWRPC, 1991, Harrington, 1989). A site specific, maximum effective trench depth can be calculated based on the soil percolation rate, aggregate void space, and the trench storage time (Harrington, 1989).

$$D = P * t / (n * 12)$$

Where D= depth of the trench, in feet

P = percolation rate of surrounding existing soil (in/hr)

t = retention time (maximum of 72 hours)

n = void space fraction in the storage media (0.4 for clear stone)

Infiltration Trenches

Requirements

Design (continued)

Infiltration trenches can be constructed to be deeper than they need to be to fit certain site characteristics. The maximum effective depth is defined as the depth to which the design volume of runoff actually fills the trench.

Filter Fabric

The sides and bottom of the infiltration trench should be lined with geotextile fabric (filter fabric). Also, there can be a layer of nonwoven filter fabric 6 to 12 inches below the ground surface to prevent suspended solids from clogging the majority of the storage media. It should be recognized, however, that there may be a need to frequently replace this filter fabric layer depending on the volume of suspended solids transported to the trench.

The filter fabric material must be compatible with the surrounding soil textures and application purposes. The cut width of the filter fabric must have sufficient material for a minimum 12-inch overlap. When overlaps are required between rolls, the upstream roll must lap a minimum of two feet over the downstream roll to provide a shingled effect. The bottom of the infiltration trench can be covered with a six to twelve inch layer of clean sand in place of filter fabric.

Storage Media

The basic infiltration trench design utilizes stone aggregate in the top of the trench to provide storage. The trench should be filled with clean, washed stone with a diameter of 1.5 to 3 inches. This aggregate size provides a void space of 40 percent (SEWRPC, 1991, Harrington, 1989, Schueler, 1987).

This design can be modified by substituting pea gravel for stone aggregate in the top 0.3 meter (1 foot) of the trench. The pea gravel improves sediment filtering and maximizes the pollutant removal in the top of the trench.

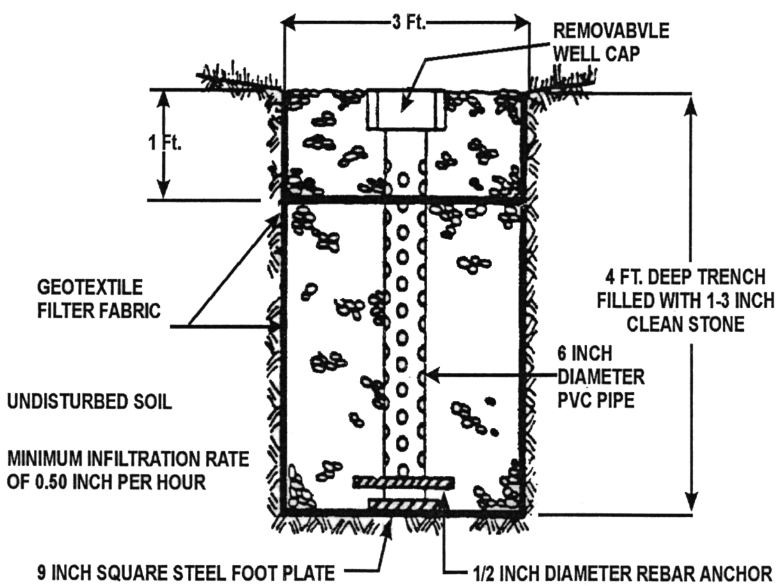


Figure 4: Observation Well Details
Source: SWRPC, 1991.

Infiltration Trenches

When the modified trenches become clogged, they can generally be restored to full performance by removing and replacing only the pea gravel layer, without replacing the lower stone aggregate layers.

It should be noted that while stone is the most common form of storage media in infiltration trenches, there are suppliers that manufacture precast infiltration storage media. These alternative storage media solutions are generally acceptable and should be reviewed and implemented on a case by case basis until there is adequate research/ experience with their performance.

Observation Well:

An observation well located at the center of the trench is recommended to monitor water drainage from the system. The well can be a 4 to 6 inch diameter PVC pipe, which is anchored vertically to a foot plate at the bottom of the trench as shown in Figure 4 . This well should have a lockable above-ground cap.

Pretreatment:

Infiltration trenches are susceptible to high failure rates due to clogging from sediments, and therefore require pretreatment of stormwater in order to remove as much of the suspended solids from the runoff as possible before it enters the trench. Pretreatment, such as grit chambers, swales with check dams, filter strips, or sediment forebays/traps should be a fundamental component of any BMP system relying on infiltration. Even when infiltrating rooftop runoff, it is a practical decision to implement some form of pretreatment to remove sediments, leaf litter, and debris. This pretreatment will help to ensure the proper functioning of the infiltrating facility and allow for longer periods between maintenance. When designed properly, pretreatment devices should remove 25 to 30 percent of sediment loads. Figure 2 and 3 show an infiltration trench with pretreatment in the form of a grass filter strip.

Designs for infiltration trenches should emphasize accessibility and ease of maintenance.

Bypass:

A bypass system should be implemented for all infiltration trenches. A bypass flow path should be incorporated in the design of an infiltration trench to convey high flows around the trench.

The overland flow path of surface runoff exceeding the capacity of the infiltration trench should be evaluated to preclude erosive concentrated flow. If computed flow velocities do not exceed the non-erosive threshold, overflow may be accommodated by natural topography.

Groundwater Mounding:

Calculations to determine groundwater mounding (local elevation of the water table as a result of infiltrated surface water) may be necessary in cases where slope stability is a concern, and/or a high water table is encountered. A hydrogeologist should be consulted with respect to the potential for groundwater mounding in these areas. The results from groundwater mounding calculations should be regarded as an indication of the mounding potential rather than as an accurate representation of the actual mounding depth.

Infiltration Trenches

Design (continued)

Cold Weather Considerations:

Consideration should be given to the operation of infiltration trenches during the winter period. Winter sanding of roads can clog an infiltration trench without adequate pretreatment, and winter salting will increase the potential for the chloride contamination of groundwater.

In cold climates, the trench surface may freeze, thereby preventing the runoff from entering the trench and allowing the untreated runoff to enter surface water. The surrounding soils may also freeze, reducing the percolation of the water into the soils and groundwater. However, recent studies indicate that if properly designed and maintained, infiltration trenches can operate effectively in colder climates. By keeping the trench surface free of compacted snow and ice, and by ensuring that part of the trench is constructed below the frost line, the performance of the infiltration trench during cold weather will be greatly improved.

If infiltration practices are used as a stand-alone, all-season water quality treatment facility, then oversizing (to account for reduced percolation) and/or extended pretreatment should be considered. Doubling the storage volume for surface infiltration devices is recommended. Redundant pretreatment (more than one pretreatment device in series) is recommended for all infiltration facilities receiving runoff from roads.

Sequencing

Care should be taken during construction to minimize the risk of premature failure of the infiltration trench. This failure is caused by the deposition of sediments from disturbed, unstabilized areas. This can be minimized or avoided by proper sequencing.

- Ideally, construction of the infiltration trench should take place after the site has been stabilized.
- Diversion berms or silt fence should be placed around the perimeter of the infiltration trench during all phases of construction. Sediment and erosion controls should be used to keep runoff and sediment away from the infiltration trench.
- Heavy equipment should not operate on the surface location where the infiltration trenches are planned. Soil compaction will adversely effect the performance of the trench, and infiltration trench sites should be roped off and flagged. During excavation and trench construction, only light equipment such as backhoes or wheel and ladder type trenchers should be used to minimize compaction of the surrounding soils.
- During and after excavation, all excavated materials should be placed downstream, away from the infiltration trench, to prevent redepositing during runoff events.

Construction

Experience has shown that the longevity of infiltration practices is strongly influenced by the care taken during construction. The construction sequence and specifications for each infiltration practice must be precisely followed.

- Infiltration trenches should not be used as temporary sediment traps during construction.

Infiltration Trenches

- Infiltration trenches will only operate as designed if they are constructed properly. There are three main rules that must be followed during the construction of an infiltration trench :

  1) Trenches should be constructed at the end of development construction

  2) Smearing of the soil at the interface with the trench bottom and sides must be avoided. Smearing of the trench bottom can be corrected by raking or rototilling.

  3) Compaction of the trench storage media and surrounding soils during construction must be minimized

- Before the development site is graded, the area of infiltration trench should be roped off to prevent heavy equipment from compacting the underlying soils.
- Light earth-moving equipment should be used to excavate the infiltration trench. Use of heavy equipment causes compaction of the soils beneath the trench floor and side slopes, resulting in reduced percolation capacity.

Maintenance

Maintenance is required for the proper operation of infiltration trenches as it is with all BMPs. Plans for infiltration trenches should identify owners, parties responsible for maintenance, and an inspection and maintenance schedule.

- The use of pretreatment BMPs will significantly minimize maintenance requirements of the trench itself. Removing accumulated sediment from a sump pit or a vegetated swale is considerably less difficult and less costly than rehabilitating a trench. Eventually, the infiltration trench should be rehabilitated, but this time span is relative to the effective performance of the trench. With appropriate design and aggressive preventive maintenance, this rehabilitation may not be necessary for a decade or more.
- Once the trench has gone online, inspections should occur after every major storm for the first few months to ensure proper stabilization and function. Water levels in the observation well should be recorded over several days to check trench drainage.
- After the first few months of operation, the infiltration trench should be inspected at least twice per year. Important items to check for include: accumulated sediment, leaves and debris in the pretreatment device, clogging of inlet and outlet pipes and ponded water both inside and on the surface of the infiltration trench.
- When ponding occurs at the surface or in the trench, corrective maintenance is required immediately.
- Clogging in trenches occurs most frequently on the surface. Grass clippings, leaves, and accumulated sediment should be removed routinely from the surface of the trench. If the clogging appears only to be at the surface, it may be necessary to remove and replace the first layer of stone aggregate and the filter fabric.
- Ponded water inside the trench (as visible from the observation well) after 24 hours or several days after a storm event often indicates that the bottom of the trench is clogged, indicating a percolation failure from the bottom. In this case, all of the stone aggregate and filter fabric or media must be removed. Accumulated sediment should be stripped from the trench bottom. At this point the bottom may be scarified or tilled to help induce infiltration. New fabric and clean stone aggregate should be refilled.
- Pretreatment devices associated with trenches should be inspected and cleaned at least twice a year, and ideally every other month.

Infiltration Trenches

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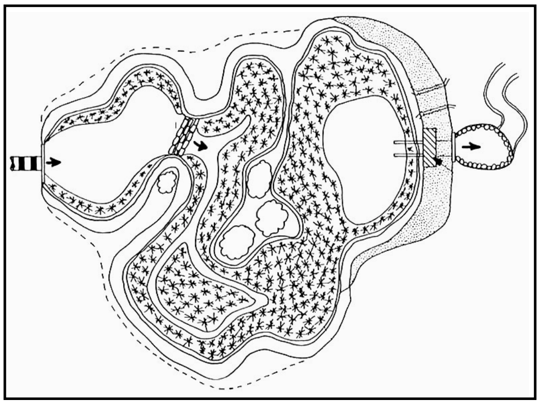
K. Stormwater wetlands

Stormwater Wetlands



Description

Stormwater wetlands are constructed wetland systems designed to maximize the removal of pollutants from stormwater runoff via several mechanisms: microbial breakdown of pollutants, plant uptake, retention, settling and adsorption. Stormwater wetlands temporarily store runoff in shallow pools that support conditions suitable for the growth of wetland plants. Stormwater wetlands also promote the growth of microbial populations which can extract soluble carbon and nutrients and potentially reduce BOD and fecal coliform levels concentrations.

Like detention basins and wet ponds, stormwater wetlands may be used in connection with other BMP components, such as sediment forebays and micropools. These engineered wetlands differ from wetlands constructed for compensatory storage purposes and wetlands created for restoration. Typically, stormwater wetlands will not have the full range of ecological functions of natural wetlands; stormwater wetlands are designed specifically for flood control and water quality purposes. Similar to wet ponds, stormwater wetlands require relatively large contributing drainage areas and/or dry weather base flow. Minimum contributing drainage areas should be at least ten acres, although pocket type wetlands may be appropriate for smaller sites if sufficient ground water flow is available.

The use of stormwater wetlands is limited by a number of site constraints, including soils types, depth to groundwater, contributing drainage area, and available land area. Soils, depth to bedrock, and depth to water table must be investigated before designing and siting stormwater wetlands. Medium-fine texture soils (such as loams and silt loams) are best to establish vegetation, retain surface water, permit groundwater discharge, and capture pollutants. At sites where infiltration is too rapid to sustain permanent soil saturation, an imper-

Purpose

Water Quantity	
Flow attenuation	■
Runoff volume reduction	◧
Water Quality	
Pollution prevention	
Soil erosion	**N/A**
Sediment control	**N/A**
Nutrient loading	**N/A**
Pollutant removal	
Total suspended sediment (TSS)	■
Total phosphorus (P)	◧
Nitrogen (N)	◧
Heavy metals	◧
Floatables	◧
Oil and grease	■
Other	
Fecal coliform	■
Biochemical oxygen demand (BOD)	■

■	Primary design benefit
◧	Secondary design benefit
□	Little or no design benefit

meable liner may be required. Where the potential for groundwater contamination is high, such as runoff from sites with a high potential pollutant load, the use of liners should be required.

Advantages

- Improvements in downstream water quality.
- Settlement of particulate pollutants.
- Reduction of oxygen-demanding substances and bacteria from urban runoff.
- Biological uptake of pollutants by wetland plants.
- Flood attenuation.
- Reduction of peak discharges.
- Enhancement of vegetation diversity and wildlife habitat in urban areas.
- Aesthetic enhancement and valuable addition to community green space.
- Relatively low maintenance costs.

Limitations

- Release of nutrients in the fall.
- May be difficult to maintain vegetation under a variety of flow conditions.
- Geese may become undesirable year-round residents if natural buffers are not included in the wetland design.
- May act as a heat sink, and can discharge warmer water to downstream water bodies.
- Depending upon design, larger land requirements than for other BMPs.
- Until vegetation is well established, pollutant removal efficiencies may be lower than anticipated.
- Relatively high construction costs in comparison to other BMPs.

Requirements

Design

A site appropriate for a stormwater wetland must have adequate water flow and appropriate underlying soils. Baseflow from the drainage area or groundwater must be sufficient to maintain a shallow pool in the wetland and support the vegetation, including species susceptible to damage during dry periods. Underlying soils that are NRCS Types B, C or D will have only small infiltration losses. Sites with type A (sandy) soils have high infiltration rates and may require a geotextile liner or a 15 centimeter (6 inch) layer of clay. After excavation and grading of a basin, at least 10 centimeters (4 inches) of soil should be applied to the site. This material, which may be the previously-excavated soil or other suitable material, is needed to provide a substrate in which vegetation can become established.

Stormwater Wetlands

Wetland Treatment

The design criteria for stormwater wetlands are the same as those for active settling ponds. They can be designed to meet particle size removal efficiencies and treatment volume criteria. However, care must be taken to design the wetland so that the bounce in the pool is compatible with the wetland vegetation. The bounce must be considered in addition to any discharge requirements for particle size, flood control or downstream erosion control settling ponds with special attention to keeping solids from overtaking the vegetation.

Factors which increase the settling rate of suspended solids in stormwater wetlands include:

- Laminar settling in zero-velocity zones created by plant stems
- Anchoring of sediments by root structure, helping to prevent scour in shallow areas
- Increased biological activity removing dissolved nutrients
- Increased biological floc formation.

Basic Stormwater Wetland Design Types

Design criteria and other considerations for the following four wetland types are summarized in Table 2.

Design 1: Shallow Marsh System (Fig. 1)

- Shallow marsh systems are configured with different low marsh and high marsh areas, which are referred to as cells (see Fig. 5). They also include a forebay for coarse particulate settlement before the wetland cell and a micropool at the outlet.
- Shallow marshes are designed with sinuous pathways to increase retention time and contact area.
- Most shallow marsh

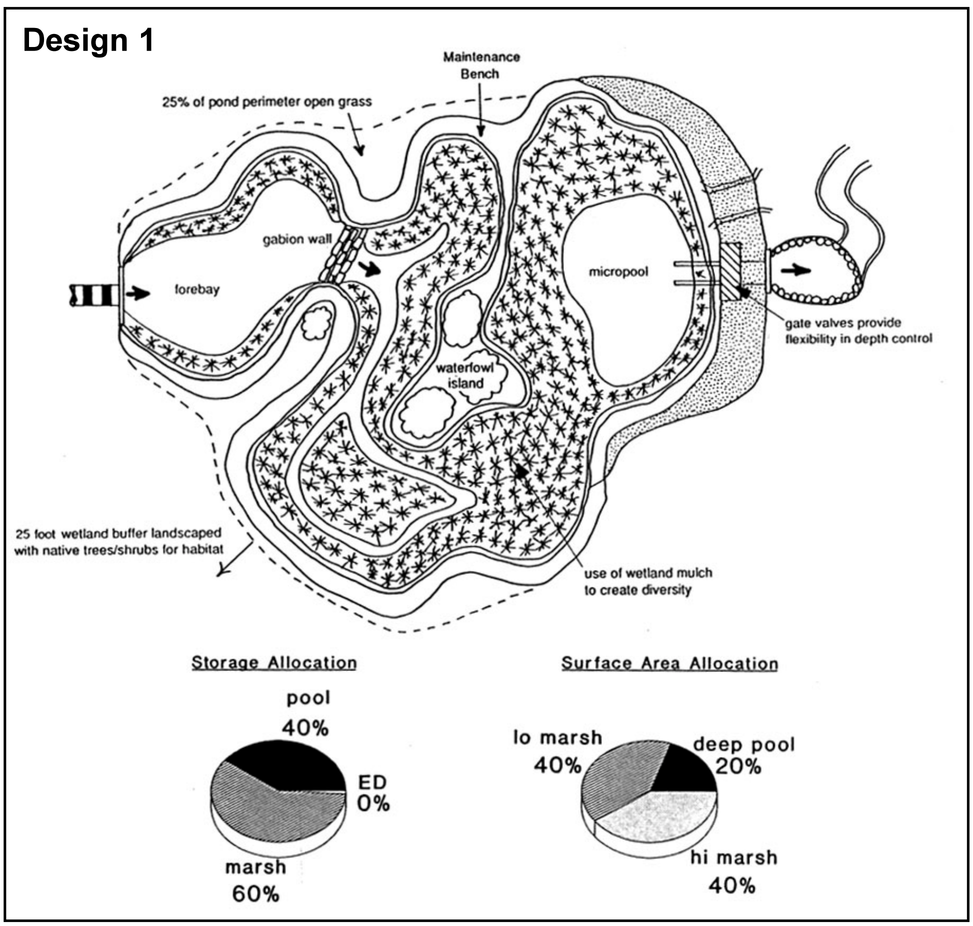


Figure 1. Shallow Marsh System
Source: Schueler, 1992.

ATTRIBUTE	DESIGN No. 1 SHALLOW MARSH	DESIGN No. 2 POND/ WETLAND	DESIGN No. 3 ED WETLAND	DESIGN No. 4 POCKET WETLAND
POLLUTANT REMOVAL CAPABILITY	moderate, reliable removal of sediments and nutrients	moderate to high, reliable removal of nutrients and sediment	moderate, less reliable removal of nutrients	moderate, can be subject to resuspension and groundwater displacement
LAND CONSUMPTION	high, shallow marsh storage consumes space	moderate, as vertical pool substitues for marsh storage	moderate, as vertical ED substitutes for marsh storage	moderate, but can be shoehorned in site
WATER BALANCE	dry weather baseflow normally recommended to maintain water elevations. Groundwater not recommended as the primary source of water supply to wetland			water supply provided by execavation to groundwater
WETLAND AREA / WATERSHED AREA	minimum ratio of .02	minimum ratio of .01	minimum ratio of .01	minimum ratio of .01
CONTRIBUTING WATERSHED AREA	DA of 25 acres or greater, with dry weather Q	DA of 25 acres or greater, with dry weather Q	minimum of ten acres required for ED	1 to 10 acres
DEEP WATER CELLS	forebay, channels micropool	pond micropool	forebay micropool	micropool, if possible
OUTLET CONFIGURATION	reversed slope pipe extending from riser, withdrawn approximately one foot below normal pool. Pipe and pond drain equipped with gate valve			broad crested wier with half round trash rack, and pond drain
SEDIMENT CLEANOUT CYCLE (approximate)	cleanout of forebay every 2-5 years	cleanout of pond every ten years	cleanout of forebay every 2 to 5 years.	cleanout of wetland every 5 to 10 years, onsite disposal and stockpile mulch
NATIVE PLANT DIVERSITY	high, if complex microtopography is present	high, with sufficient wetland complexity and area	moderate, fluctuating water levels impose physiological constraints	low to moderate, due to small surface area and poor control of water levels
WILDLIFE HABITAT POTENTIAL	high, with complexity and buffer	high, with buffer, attracts waterfowl	moderate, with buffer	low, due to small area and low diversity

Table 1: Wetland Characteristics

Source: Schueler, 1992.

Stormwater Wetlands

systems consist of pools ranging from 6 to 18 inches during normal conditions.

- Shallow marshes may require larger contributing drainage areas than other systems, as runoff volumes are stored primarily within the marshes, not in deeper pools where flow may be regulated and controlled over longer periods of time.

Design 2: Pond/Wetland Systems (Fig. 2)

- Multiple cell systems, such as pond/wetland systems, utilize at least one pond component in conjunction with a shallow marsh component.
- The first cell is typically the wet pond which provides for particulate pollutant removal. The wet pond is also used to reduce the velocity of the runoff entering the system.

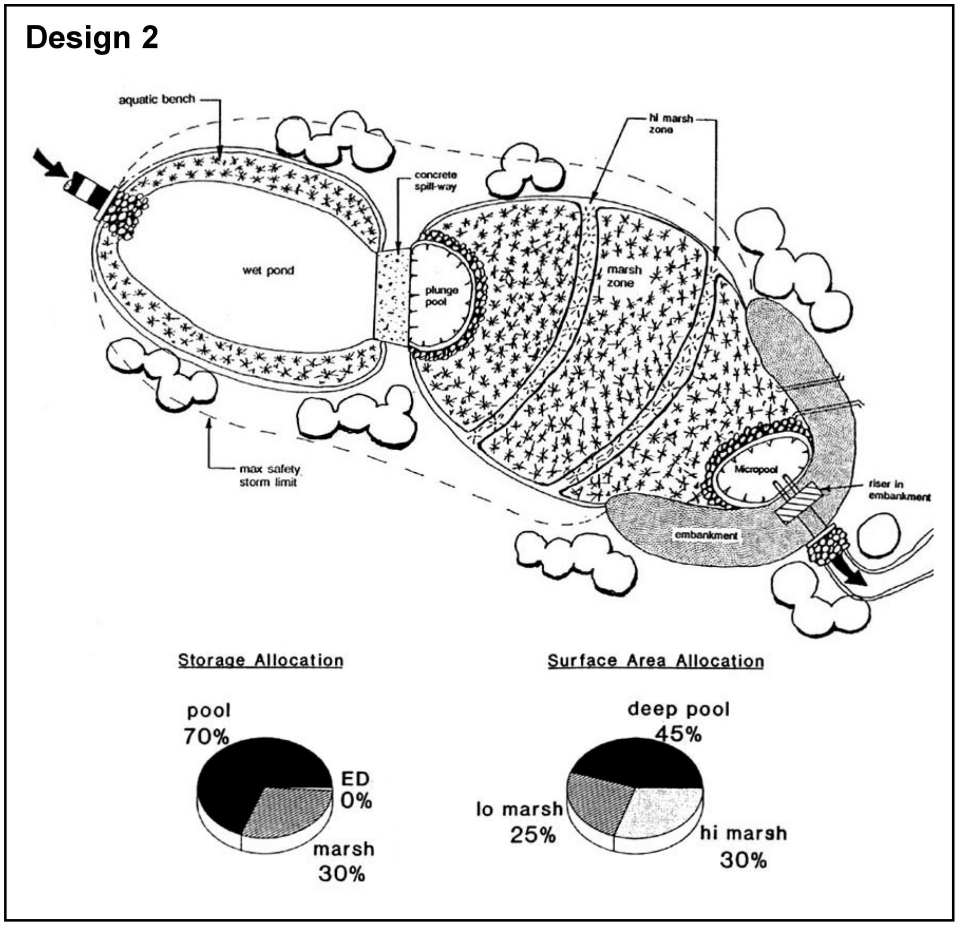


Figure 2. Pond/Wetland System
Source: Schueler, 1992.

- The shallow marsh provides additional treatment of the runoff, particularly for soluble pollutants. These systems require less space than the shallow marsh systems and generally achieve a higher pollutant removal rate than other stormwater wetland systems.

Design 3: Extended Detention Wetlands (Fig. 3)

- Extended detention wetlands provide a greater degree of downstream channel protection. These systems require less space than the shallow marsh systems, since temporary vertical storage is substituted for shallow marsh storage.
- The additional vertical storage area also provides extra runoff detention above the normal elevations.
- Water levels in the extended detention wetlands may increase by as much as three feet after a storm event and return gradually to normal within 24 hours of the rain event.

Requirements
Design (continued)

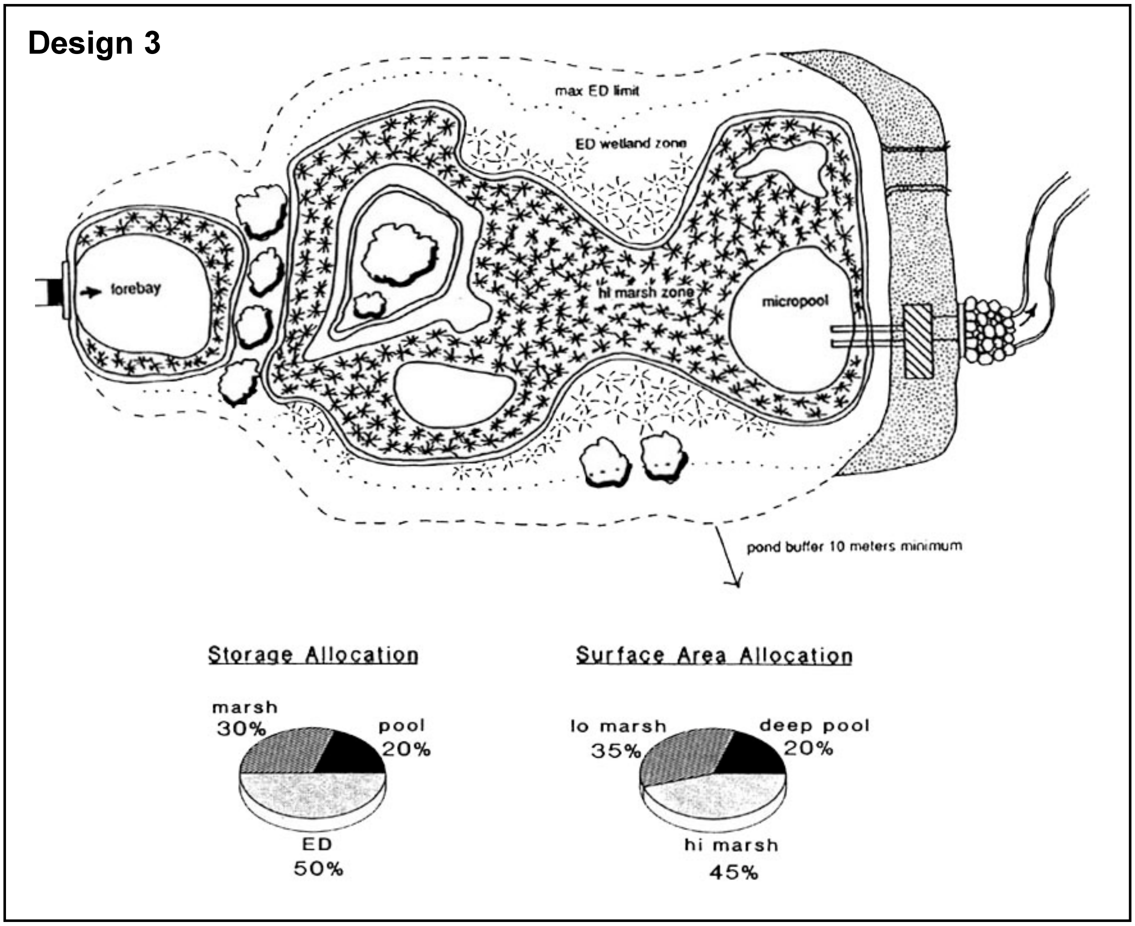


Figure 3. Extended Detention Wetland System
Source: Schueler, 1992.

- The vegetated area in extended detention wetlands expands from the normal pool elevation to the maximum surface water elevation.
- Wetlands plants that tolerate intermittent flooding and dry periods should be selected for the extended detention area above the shallow marsh elevations.

Design 4: Pocket wetlands (Fig. 4)

- These systems may be utilized for smaller sites of one to ten acres.
- To maintain adequate water levels, pocket wetlands are generally excavated down to the groundwater table.
- Pocket wetlands which are supported exclusively by stormwater runoff generally will have difficulty maintaining marsh vegetation due to extended periods of drought.

Stormwater Wetlands

General Design Considerations

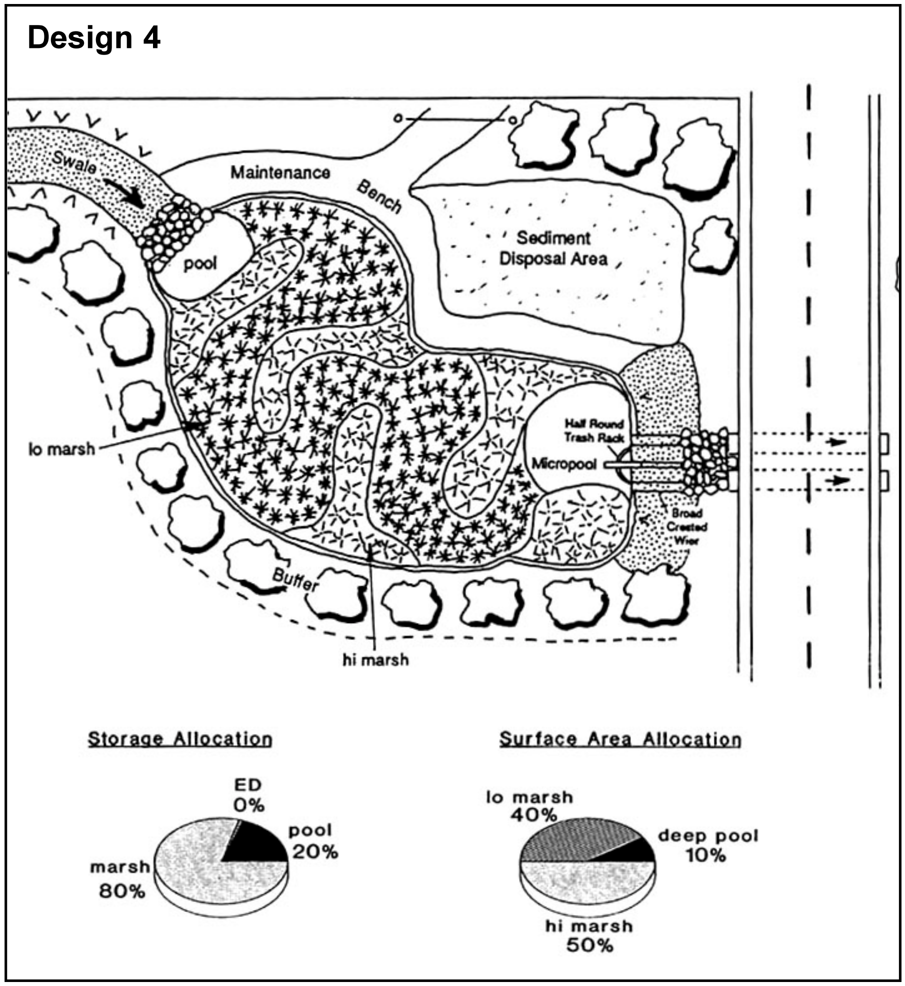


Figure 4. Pocket Wetland System
Source: Schueler, 1992.

- Sediment forebays are recommended to decrease the velocity and sediment loading to the wetland. The forebays provide the additional benefits of creating sheet flow, extending the flow path, and preventing short circuiting. The forebay should contain at least 10 percent of the wetland's treatment volume and should be 4 to 6 feet deep. The forebay is typically separated from the wetland by gabions, gravel/riprap or by an earthen berm.
- The wetland design should include a buffer to separate the wetland from surrounding land. Buffers may alleviate some potential wetland nuisances, such as accumulated floatables, odors and or geese.
- A buffer of 25 feet is recommended, plus an additional 25 feet when wildlife habitat is of concern. Leaving trees undisturbed in the buffer zone will minimize the disruption to wildlife and reduce the chance for invasion of nuisance vegetation such as cattails and primrose willow.
- Above ground berms or high marsh wedges should be placed at approximately 50 foot intervals, at right angles to the direction of the flow to increase the dry weather flow path within the stormwater wetland.
- Before the outlet, a four- to six-foot deep micropool (having a capacity of at least ten percent of the total treatment volume), should be included in the design to prevent the outlet from clogging. A reverse slope pipe or a hooded, broad crested weir is the recommended outlet control (See Figure 3b Wet Ponds BMP).
- The outlet from the micropool should be located at least one foot below the normal pool surface. To prevent clogging, trash racks or hoods should be installed on the riser (See Figure 3b Wet Ponds BMP).
- To facilitate access for maintenance, the riser should be installed within the embankment (See Figure 3b in Wet Ponds BMP).

Stormwater Wetlands

Design (continued)

- Install a bottom drain pipe with an inverted elbow to prevent sediment clogging in order to completely drain the stormwater wetland for emergency purposes or routine maintenance (See Figure 3b Wet Ponds BMP).
- Fit both the outlet pipe and the bottom drain pipe with adjustable valves at the outlet ends to regulate flows (See Figure 3b Wet Ponds BMP).
- Surround all deep-water cells with a safety bench having a minimum width of ten feet and a depth of zero to 18 inches below pool's normal water level.
- Remember that wetland treatment systems' effectiveness in removing urban pollutants depends on the system's physical characteristics, such as wetland-size-to-watershed-size ratio, runoff residence time in the wetland and water budget.
- In general, as the wetland-to-watershed area ratio increases, the average runoff residence time increases and the effectiveness of the wetland for pollutant removal also increases.
- Prepare a water budget to demonstrate that the water supply to the stormwater wetland is greater than the expected loss rate.

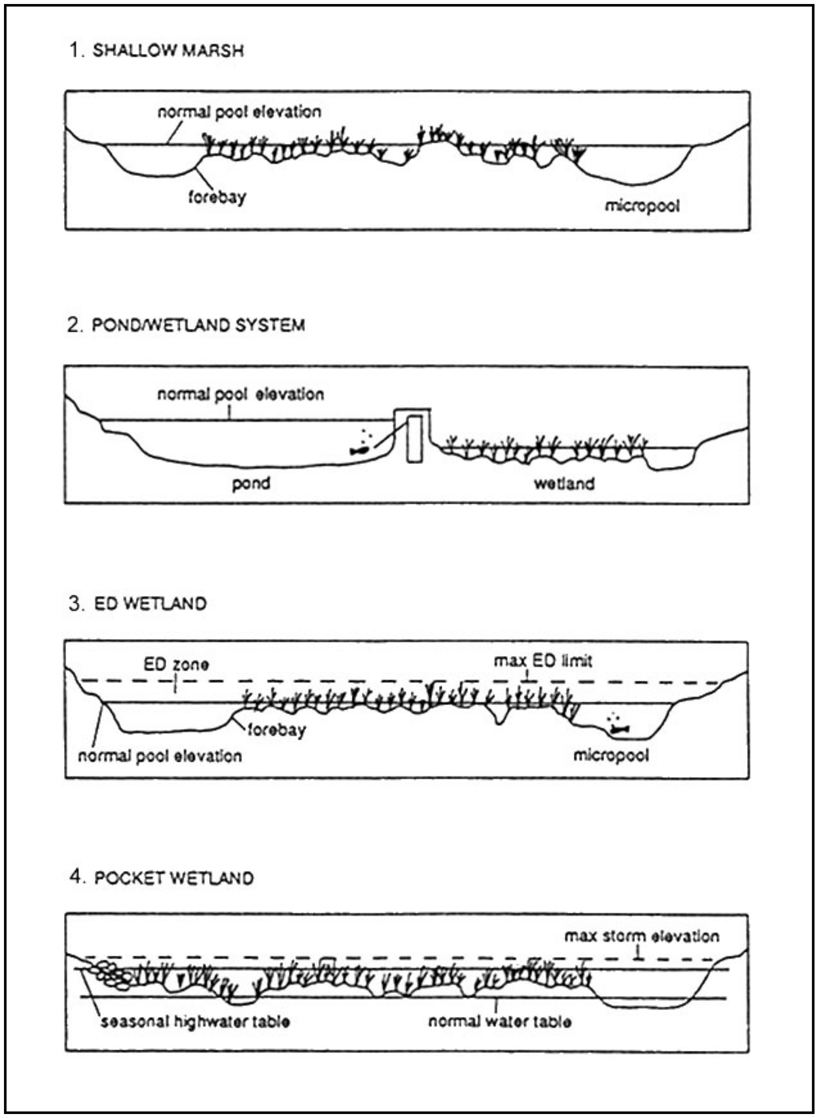


Figure 5: Comparative Profiles of the Four Stormwater Wetland Designs
Source: Schueler, 1992.

Wetland Size

The stormwater wetland should be designed to store the water quality treatment volume as required by the local permitting agency. The Metropolitan Council of Governments (Schueler, 1992) has developed guidelines for constructing wetland stormwater basins (see Table 3). Those guidelines recommend a wetland surface area of 1 to 2 percent of the watershed area, depending on the nature of the watershed and the design of the facility.

Stormwater Wetlands

DESIGN CRITERIA	DESIGN No. 1 SHALLOW MARSH	DESIGN No. 2 POND/ WETLAND	DESIGN No. 3 ED WETLAND	DESIGN No. 4 POCKET WETLAND
Wetland/Watershed Ratio	0.2	.01	.01	.01 (target)
Minimum Drainage Area	25 ac.	25 ac.	10 ac.	1-10 ac.
Length to Width Ratio (minimum)	1:1	1:1	1:1	1:1 (target)
Extended Detention	No	No	Yes	No
Allocation of Treatment Volume (pool, marsh, ED)	40/60/0	70/30/0	20/30/50	20/80/0
Allocation of Surface Area (deep, lo, high)	20/40/40	45/25/30	20/35/45	10/40/50
Cleanout Frequency	2-5 yrs	10 yrs	2-5 yrs	10 yrs
Forebay	Required	No	Required	Optional
Micropool	Required	Required	Required	Optional
Outlet Configuration	reverse-slope pipe or hooded broad crest weir	same	same	hooded broad crested weir
Propogation Technique	Mulch or Transplant	Mulch or Transplant	Mulch or Transplant	Volunteer
Buffer (feet)	25 to 50	25 to 50	25 to 50	0 to 25
Pondscaping Plan Requirements	Emphasize wildlife habitat marsh micro-topography, buffer	Emphasize wildlife habitat and hi marsh wedges	Emphasize stabilization of ED zone, project pondscaping zones	pondscaping plan optional

Table 2: Wetland Design Criteria

Source: Schueler, 1992.

Stormwater Wetlands

Design (continued)

During dry weather, flow must be adequate to provide a baseflow and to maintain the vegetation. The flow path should be maximized to increase the runoff's contact time with plants and sediments.

Outlet Design

- Extended detention design criteria are strongly recommended for the outlet structure design (see Extended Detention).
- An orifice or other outlet structure can be used to restrict the discharge to the required flow. Because of the abundance of vegetation in the wetland, a trash guard should be used to protect the orifice.
- A trash guard large enough so that velocities through it are less than 2 fps will reduce clogging problems.
- Flow from the wetland should be conveyed through an outlet structure that is located within the deeper areas of the wetland. Discharging from the deeper areas using a reverse slope pipe prevents the outlet from becoming clogged. A micropool just prior to the outlet will also prevent outlet clogging.
- The micropool should contain approximately 10 percent of the treatment volume and be 4 to 6 feet deep.
- An adjustable gate-controlled drain capable of dewatering the wetland within 24 hours should be located within the micropool.
- A typical drain may be constructed with an upward-facing inverted elbow. The dewatering feature eases planting and follow-up maintenance.

Wetland Vegetation

(See Figure 6 for techniques to enhance wildlife habitat in stormwater wetlands.)

- Vegetation can be established by three methods: allowing volunteer vegetation to become established (not recommended) planting nursery vegetation and seeding.
- A higher diversity wetland can be established when nursery plants are used. Vegetation from a nursery should be planted during the growing season—not during late summer or fall—to allow vegetation time to store food reserves for their dormant period.
- Select species adaptable to the broadest ranges of depth, frequency and duration of inundation (hydroperiod). Match site conditions to the environmental requirements of plant selections. Take into account hydroperiod and light conditions.
- Give priority to species that have already been used successfully in constructed wetlands and that are commercially available.
- Allowing species transmitted by wind and water fowl to voluntarily become establish in the wetland is unpredictable.
- Wetlands established with volunteers are usually characterized by low plant diversity with monotypic stands of exotic or invasive species.

Stormwater Wetlands

Sizing Criteria	DESIGN No.1 SHALLOW MARSH	DESIGN No.2 POND/ WETLAND	DESIGN No.3 ED WETLAND	DESIGN No.4 POCKET WETLAND
Runoff Treatment Volume (V_t)	Capture 90% of the Annual runoff volume from site Vt = (1.25 inches) (Runoff Coefficient) (Site Area) Minimum Vt of 0.25 watershed-inches			
Wetland to Watershed Area Ratio	.02	.01	.01	.01
Allocation of Surface Area (%)	20 - deep 40 - lo m. 40 - hi m.	45 - deep 25 - lo m. 30 - hi m.	20 - deep 35 - lo m. 45 - hi m.	10 - deep 40 - lo m. 50 - hi m.
Allocation of Treatment Volume (%)	40 - pool 60 - marsh 0 - ED	70 - pool 30 - marsh 0 - ED	20 - pool 30 - marsh 50 - ED	20 - pool 80 - marsh 0 - ED
Flow Path a. length to width ratio b. dry weather path	 1:1 2:1	 1:1 2:1	 1:1 2:1	 NA 2:1
Water Balance	Confirm inflow rate > 0.002 cfs/acre, compute water balance during dry weather			Confirm dry weather water table elevation in field
Extended Detention	Not Employed	Not Employed	EDv = 50% of Vt 12 to 24 hrs ED range ≤3 ft.	Not Employed

Table 3: Wetland Sizing Criteria

Source: Schueler, 1992.

Stormwater Wetlands

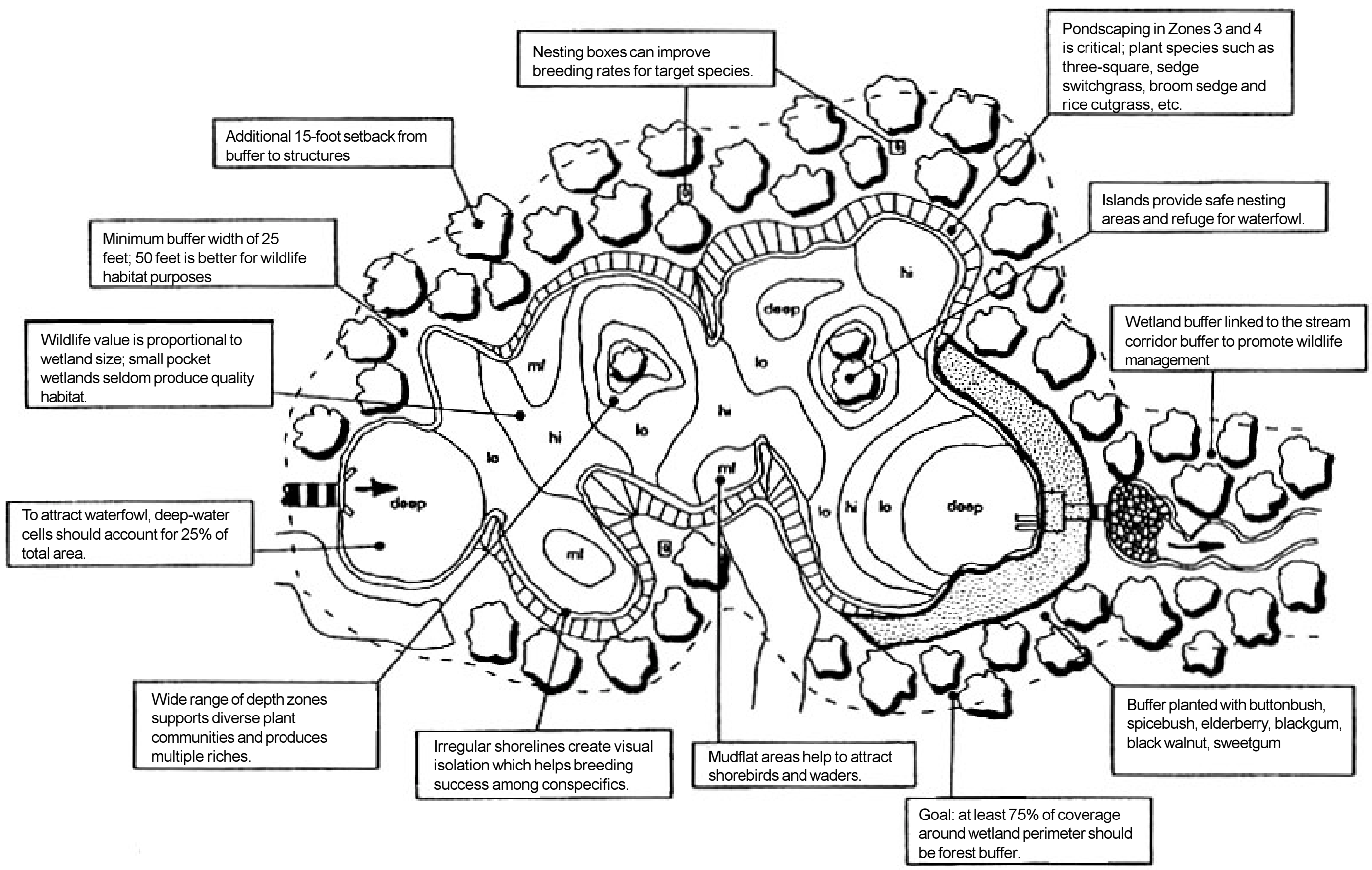


Figure 6. Techniques for Enhancing Wildlife in Stormwater Wetlands.
Source: Schueler, 1992.

Requirements

Sequencing

- Sites must be carefully evaluated when planning stormwater wetlands. Soils, depth to bedrock, and depth to water table must be investigated before designing and siting stormwater wetlands. A “pondscaping plan” should be developed for each stormwater wetland.
- This plan should include hydrological calculations (or water budget), a wetland design and configuration, elevations and grades, a site/soil analysis, and estimated depth zones.
- The plan should also contain the location, quantity, and propagation methods for the stormwater wetland plants. Site preparation requirements, maintenance requirements and a maintenance schedule are also necessary components of the plan.
- The water budget should demonstrate that there will be a continuous supply of water to sustain the stormwater wetland. The water budget should be developed during site selection and checked after preliminary site design.

- Drying periods of longer than two months have been shown to adversely effect plant community richness, so the water balance should confirm that drying will not exceed two months.
- After excavation and grading, the wetland should be kept flooded until planting.
- Six to nine months after being flooded and two weeks before planting, the wetland is typically drained and surveyed to ensure that depth zones are appropriate for plant growth. Revision may be necessary to account for any changes in depth.
- Next, the site is staked to ensure that the planting crew spaces the plants within the correct planting zone.

Maintenance

Stormwater wetlands require routine maintenance. The small forebay should be dredged every other year to protect the wetland from excessive sediment buildup. Careful observation of the system over time is required. In the first three years after construction, twice-yearly inspections are needed during both the growing and non-growing season. Data gathered during these inspections should be recorded, mapped and assessed.

- The following observations should be made during the inspections:
  - Types and distribution of dominant wetland plants in the marsh.
  - The presence and distribution of planted wetland species.
  - The presence and distribution of invasive wetland species.
  - Signs that invasive species are replacing the planted wetland species.
  - Percentage of unvegetated standing water (excluding the deep water cells which are not suitable for emergent plant growth)
  - The maximum elevation and the vegetative condition in this zone, if the design elevation of the normal pool is being maintained for wetlands with extended zones.
  - Stability of the original depth zones and the microtopographic features, accumulation of sediment in the forebay and micropool, and survival rate of plants in the wetland buffer.
- Inspections should be conducted at least twice a year for the first three years and annually thereafter.
- Regulating the sediment input to the wetland is the priority maintenance activity.
- The majority of sediments should be trapped and removed before they reach the wetlands either in the forebay or in a pond component. Gradual sediment accumulation in the wetland results in reduced water depths and changes in the growing conditions for the emergent plants. Furthermore, sediment removal within the wetland can destroy the wetland plant community. Shallow marsh and extended detention wetland designs include forebays to trap sediment before reaching the wetland. These forebays should be cleaned out every other year.
- Pond/wetland system designs do not include forebays as the wet pond itself acts as an oversized forebay. Sediment cleanout of pond/wetland systems is needed every 10 years.

Stormwater Wetlands

Maintenance Requirements (continued)

- The key to using the wetland effectively is that the ponds must function so as not to destroy the wetland vegetation. Slight modification of operations and plantings may be necessary as operations proceed.
- Harvesting of wetland vegetation can also be considered to remove nutrients from the wetland system and to minimize nutrient release when vegetation dies in the autumn. This is not generally recommended, but in special cases it will remove the nutrients contained in the vegetation from the system. If vegetation is to be harvested, design features should be included that will allow the wetland to be dewatered (Schueler, October 1992).
- Maintenance requirements for constructed wetlands are particularly high while vegetation is being established (usually the first three years). This is likely to include removal of invasive species and replanting natives.
- Additional routine maintenance tasks, which can be conducted on the same schedule, include removing accumulated trash from trash racks, outlet structures and valves.

Stormwater Wetlands

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July 8, 2004

Mr. Kippy Freeman
Friendship Home Medical Equipment Inc.
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Wise, VA 24293

Dear Mr. Freeman,

I am writing regarding the proposed greenway and water quality improvements in Pennington Gap, Virginia that I described to you over the phone Thursday, July 8th. The Community Design Assistance Center (CDAC), in conjunction with the Town of Pennington Gap, is developing conceptual plans for a new multiple use greenway along the North Fork of the Powell River. CDAC, an outreach arm of Virginia Tech's College of Architecture and Urban Studies, employs Tech students to provide planning and conceptual design services to communities throughout the state of Virginia.

The primary aims of the greenway in its entirety are to improve the water quality of the North Fork of the Powell River adjacent to the shopping center, to improve the quality of life for Pennington Gap residents by promoting healthy lifestyles and pedestrian connections to Town amenities (i.e. downtown to Leeman Park), to create educational opportunities for residents and the adjacent school, to provide public access to the river in designated areas, and to increase the desirability of the Town to both residents and tourists alike.

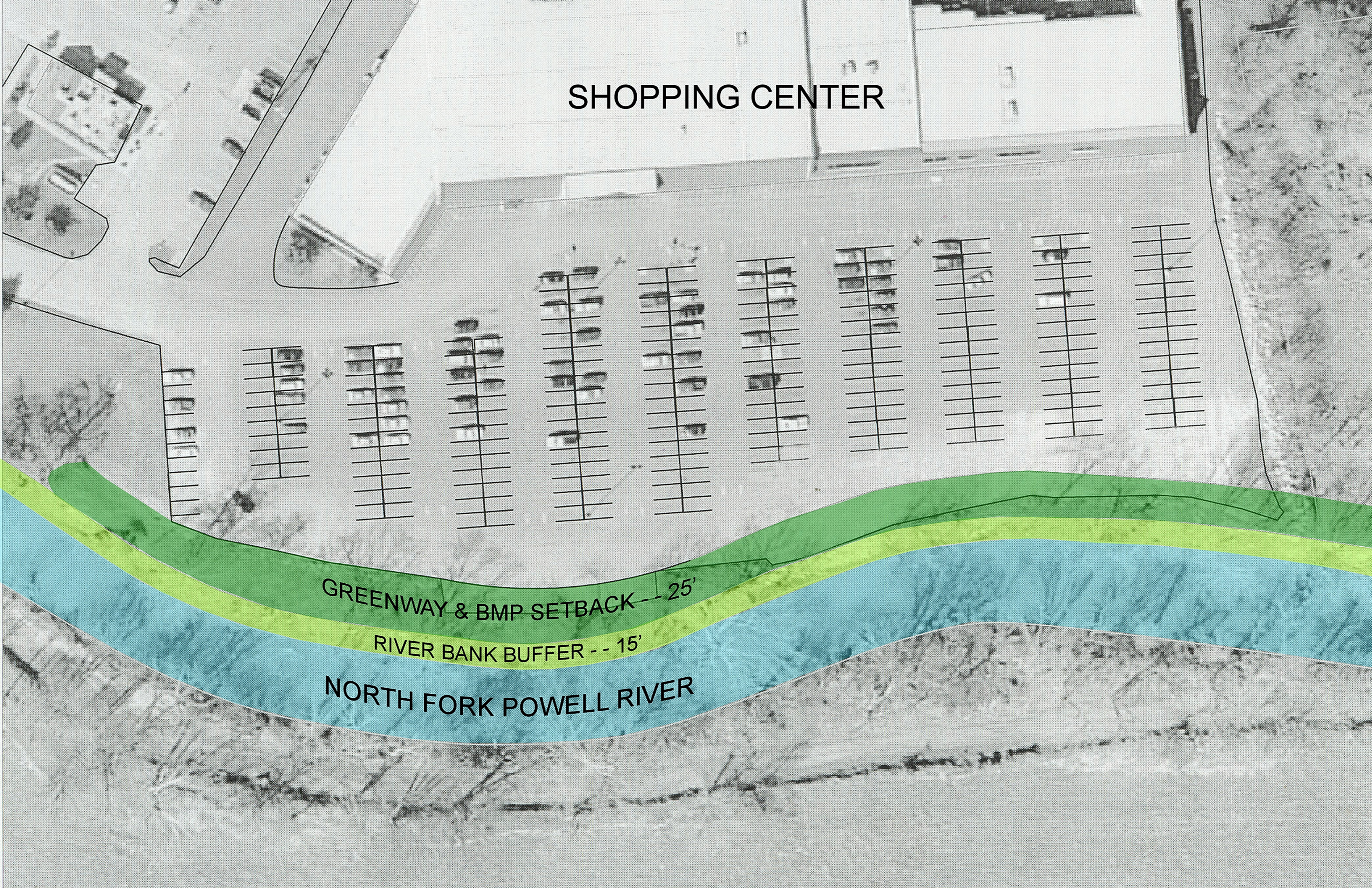
Within the shopping center property, the greenway and proposed filter strip and infiltration trench seek to remediate impacts caused by the current development, namely point source pollution through storm water run-off. Enclosed you will find several conceptual plans and sketches that show what the proposed greenway and buffer would look like. No net parking loss would be incurred as a result of the proposed buffer, though some parking closest to the river would be relocated adjacent to the building.

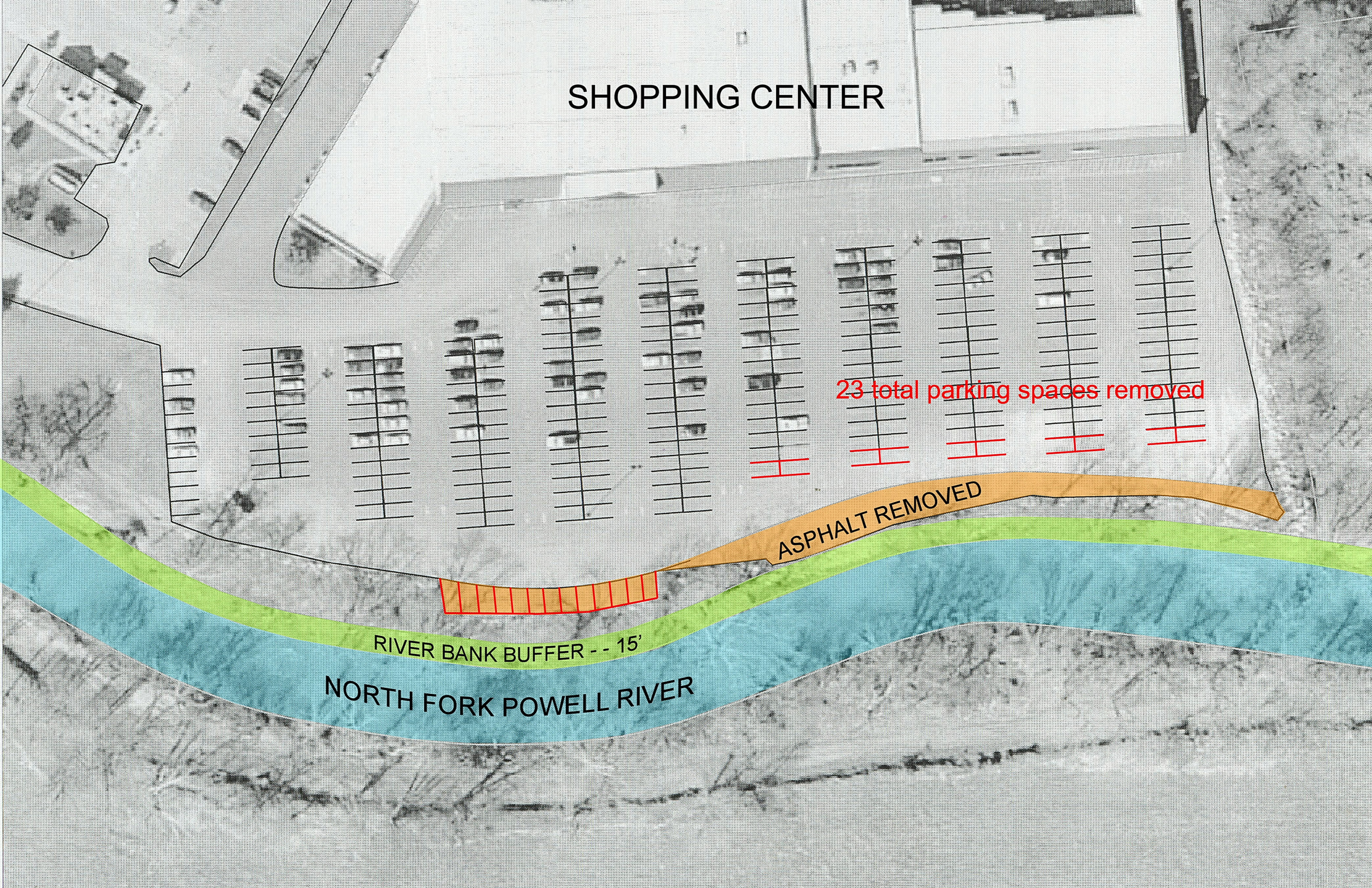
If you have any questions regarding any of the plans or if you need any additional resources from us please do not hesitate to contact me.

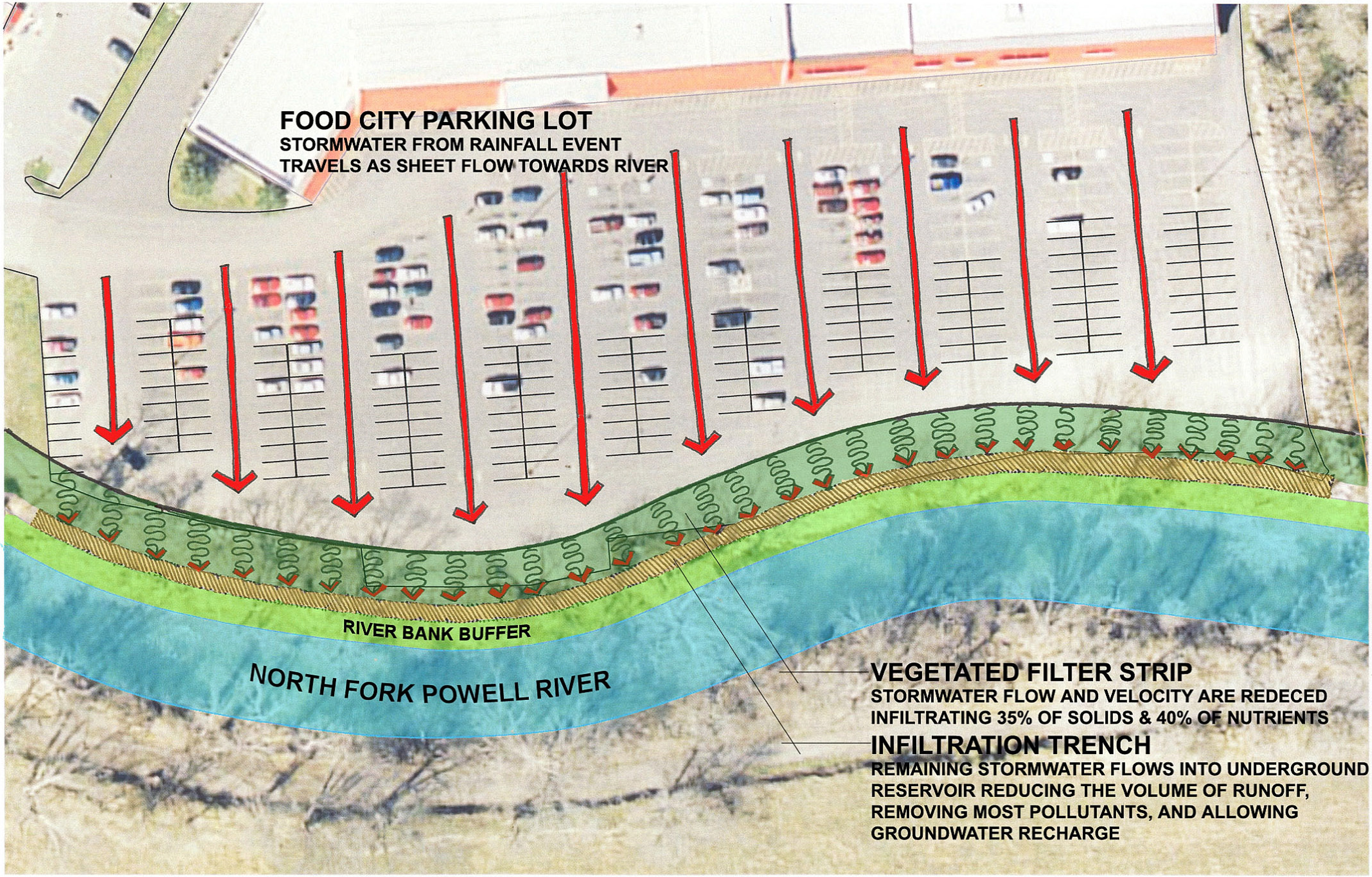
Best regards,

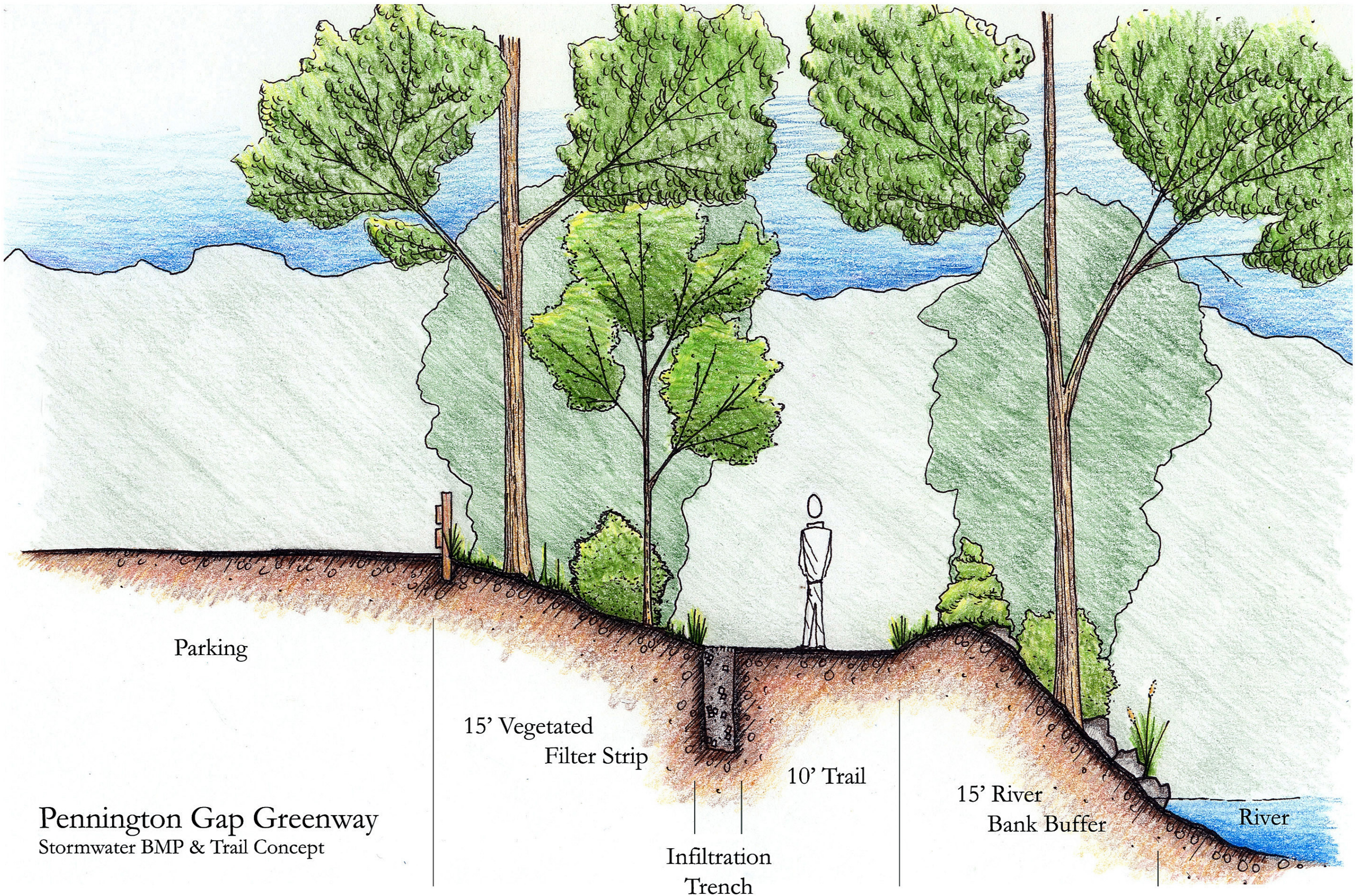
Kim Watson

Kim Watson
Landscape Architecture Project Coordinator

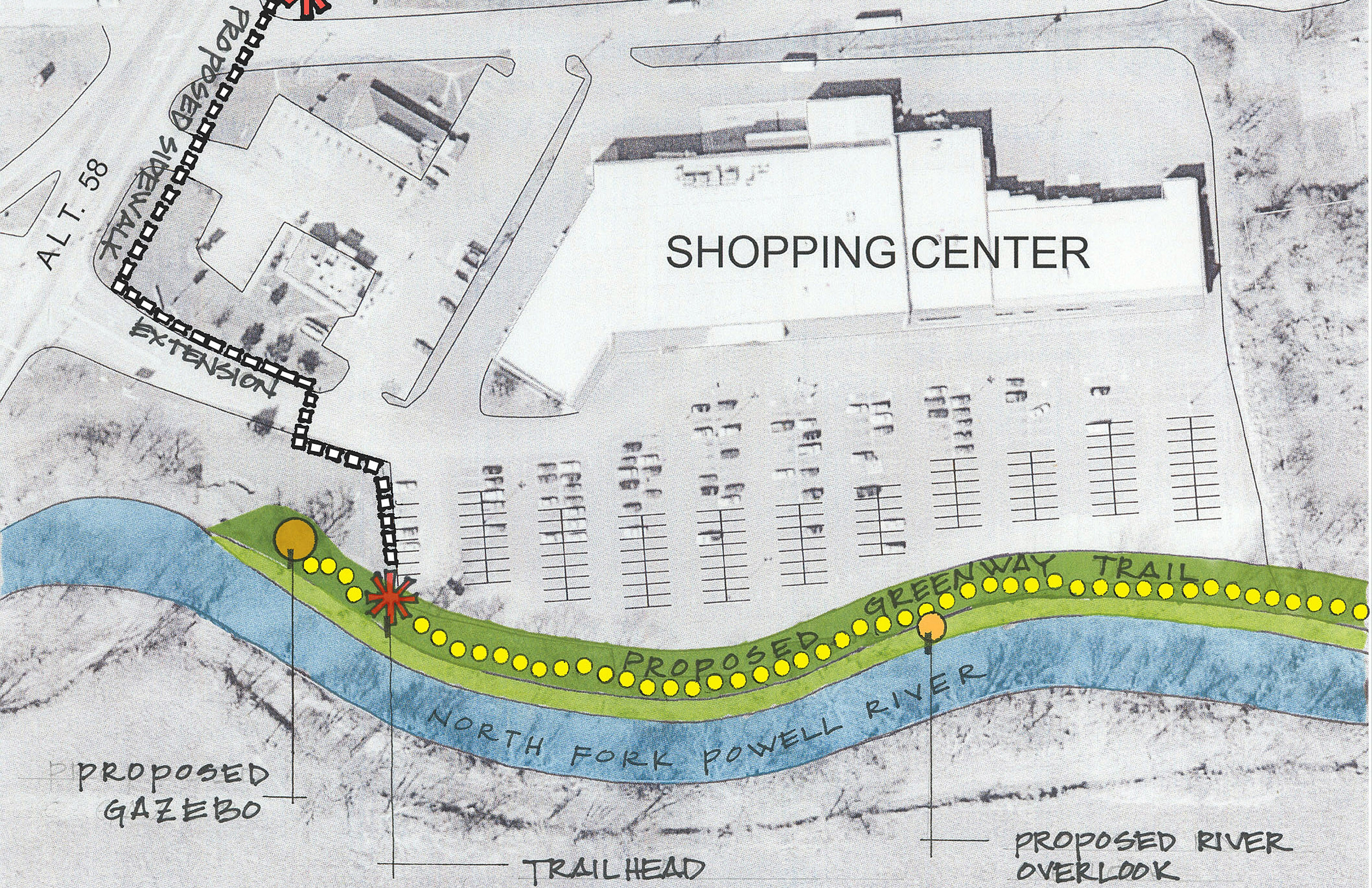

SHOPPING CENTER
GREENWAY & BMP SETBACK - - 25'
RIVER BANK BUFFER - - 15'
NORTH FORK POWELL RIVER


SHOPPING CENTER
23 total parking spaces removed
ASPHALT REMOVED
RIVER BANK BUFFER - - 15'
NORTH FORK POWELL RIVER


FOOD CITY PARKING LOT
STORMWATER FROM RAINFALL EVENT
TRAVELS AS SHEET FLOW TOWARDS RIVER
RIVER BANK BUFFER
NORTH FORK POWELL RIVER
VEGETATED FILTER STRIP
STORMWATER FLOW AND VELOCITY ARE REDECED
INFILTRATING 35% OF SOLIDS & 40% OF NUTRIENTS
INFILTRATION TRENCH
REMAINING STORMWATER FLOWS INTO UNDERGROUND
RESERVOIR REDUCING THE VOLUME OF RUNOFF,
REMOVING MOST POLLUTANTS, AND ALLOWING
GROUNDWATER RECHARGE



Parking
15' Vegetated
Filter Strip
Infiltration
Trench
10' Trail
15' River
Bank Buffer
River
Pennington Gap Greenway
Stormwater BMP & Trail Concept



ALT. 58
PROPOSED SIDEWALK
EXTENSION
SHOPPING CENTER
PROPOSED GREENWAY TRAIL
NORTH FORK POWELL RIVER
PROPOSED GAZEBO
TRAILHEAD
PROPOSED RIVER OVERLOOK

Virginia Tech
VIRGINIA POLYTECHNIC INSTITUTE
AND STATE UNIVERSITY

Community Design Assistance Center

College of Architecture and Urban Studies
101 South Main St. Suite 2, (0450) Blacksburg, VA 24061
(540) 231-5644 Fax: (540) 231-6089
Email: cdac@vt.edu
http://cdac.arch.vt.edu

September 3, 2004

Mr. Kippy Freeman
Friendship Home Medical Equipment Inc.
P.O. Box 2410
Wise, VA 24293

Dear Mr. Freeman,

We at the Community Design Assistance Center (CDAC) are finalizing our work on the conceptual master plan for a greenway in Pennington Gap. In wrapping up the initial conceptual design stage of the project we would like to get a letter of support of the project from the tenants at Riverbend Shopping Center. I have crafted a brief letter that I am sending to each of the tenants and asking them to sign and send back to our office. We will then send all the letters to Mr. Riggs at one time. Please send the signed support letter back to our office in the self-addressed envelope.

CDAC, in conjunction with the Town of Pennington Gap, will be hosting a final public presentation of the design concepts in mid-October. We will notify you of the meeting date and time once it is sent and would be delighted if you could attend.

Best regards and thank you for your assistance!

Kim Watson

Kim Watson
Landscape Architecture Project Coordinator

September 3, 2004

Mr. Sutton Riggs
208 Rigg Avenue NW
P.O. Box 3533
Wise, Virginia 24293

Dear Mr. Riggs:

After reviewing the information sent to us from the Community Design Assistance Center (CDAC) in conjunction with the Town of Pennington Gap regarding the proposed greenway and water quality improvements in Pennington Gap, Virginia, I would like to express to you my support of the project as a tenant in Riverbend Shopping Center. I express my support with the understanding that there would be no net loss of parking in the Riverbend Shopping Center (any spaces lost would be replaced with new parking at the town's expense) and that the development and maintenance of the greenway and filter strip would be at the expense of the Town of Pennington Gap.

Representing Friendship Home Medical Equipment, Inc.

Ronald K. Freeman, (Printed Name)

[signature], (Signed Name)

September 3, 2004

Mr. Sutton Riggs
208 Rigg Avenue NW
P.O. Box 3533
Wise, Virginia 24293

Dear Mr. Riggs:

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Representing Cumberland Drug

Mrs. Linda S. Taylor, (Printed Name)

Mrs. Linda S. Taylor, (Signed Name)

September 3, 2004

Mr. Sutton Riggs
208 Rigg Avenue NW
P.O. Box 3533
Wise, Virginia 24293

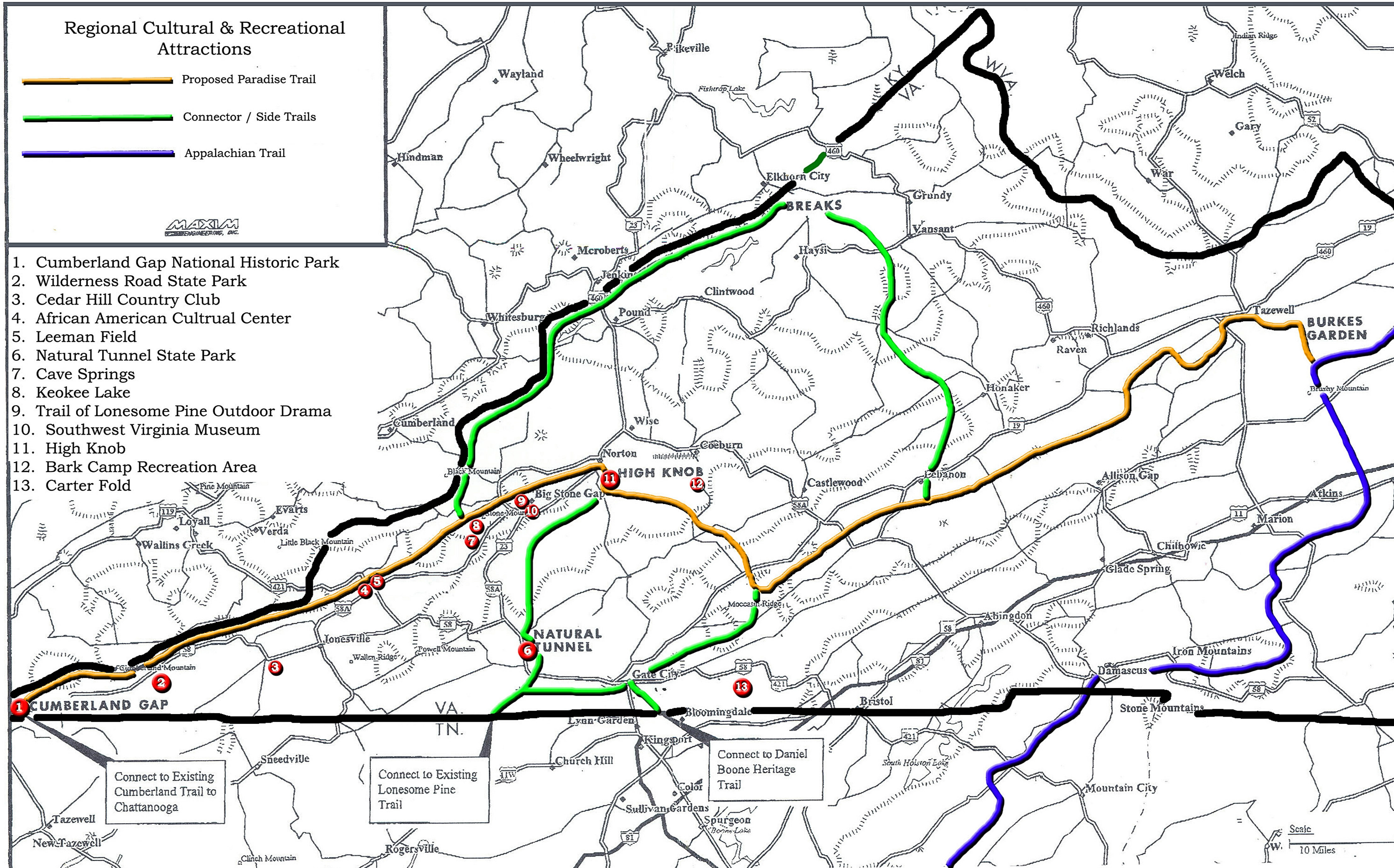
Dear Mr. Riggs:

After reviewing the information sent to us from the Community Design Assistance Center (CDAC) in conjunction with the Town of Pennington Gap regarding the proposed greenway and water quality improvements in Pennington Gap, Virginia, I would like to express to you my support of the project as a tenant in Riverbend Shopping Center. I express my support with the understanding that there would be no net loss of parking in the Riverbend Shopping Center (any spaces lost would be replaced with new parking at the town's expense) and that the development and maintenance of the greenway and filter strip would be at the expense of the Town of Pennington Gap.

Representing Hong Kong Buffet

ZHANG WANG, (Printed Name)

Zhang wang, (Signed Name)


Regional Cultural & Recreational Attractions
Proposed Paradise Trail
Connector / Side Trails
Appalachian Trail
1. Cumberland Gap National Historic Park
2. Wilderness Road State Park
3. Cedar Hill Country Club
4. African American Cultrual Center
5. Leeman Field
6. Natural Tunnel State Park
7. Cave Springs
8. Keokee Lake
9. Trail of Lonesome Pine Outdoor Drama
10. Southwest Virginia Museum
11. High Knob
12. Bark Camp Recreation Area
13. Carter Fold
Pikeville
Wayland
Hindman
Wheelwright
Elkhorn City
BREAKS
Grundy
Vansant
Haysi
Mcroberts
Jenkins
Clintwood
Whitesburg
Pound
Cumberland
Wise
Norton
Coeburn
HIGH KNOB
Big Stone Gap
Castlewood
Lebanon
Tazewell
BURKES GARDEN
Richlands
Raven
Honaker
Allison Gap
Atkins
Marion
Chilhowie
Glade Spring
Abingdon
Damascus
Iron Mountains
Welch
Gary
War
Evarts
Loyall
Verda
Wallins Creek
Jonesville
NATURAL TUNNEL
Gate City
Moccasin Ridge
CUMBERLAND GAP
Bloomingdale
Bristol
Stone Mountains
Lynn Garden
Kingsport
Church Hill
Sneedville
Rogersville
Sullivan Gardens
Spurgeon
Colonial
Mountain City
Tazewell
New Tazewell
KY.
VA.
W.VA.
VA.
TN.
Connect to Existing Cumberland Trail to Chattanooga
Connect to Existing Lonesome Pine Trail
Connect to Daniel Boone Heritage Trail
Scale
10 Miles