3.0 Land Use Plan

The land use plan is based on sound planning and environmental principles critical to balancing growth while protecting water quality. These principles include several key strategies identified by the US Environmental Protection Agency. The EPA has developed a report on protecting water resources while allowing for development that indicates three key goals to protecting water quality:

- Preserve large, continuous areas of open space;
- Preserve critical ecological areas, such as wetlands, floodplains, and riparian corridors; and
- Minimize overall land disturbance and direct connection of impervious surfaces associated with development.

Key Recommendations

- **Protect Tiers 1, 2 and 3 within the Land Conservation Strategy to create a network of green infrastructure.**
- **Focus land acquisition efforts to Tier 1 and 2 areas where resources are most sensitive.**
- **Support local organizations and agencies that are actively involved in land conservation efforts.**
- **Promote regional recreational trail development.**
- **Adopt conservation development land use and zoning with 50% open space for rural areas that are not served by central sewer in Prairie, Brown and Pleasant Townships**
- **Adopt conservation development land use and zoning at 1 unit per acre with 50% open space in the Hilliard growth area, which will be served by central sewer.**
- **Create a new destination with a high density mixed use town center between West Broad Street and Interstate70, which will be served by central sewer.**
- **Adopt new Town Center zoning with base minimum densities, locating the highest density in the core area of the Town Center with transition to surrounding uses.**
- **Provide supporting institutional uses in the town center and where appropriate.**
- **Provide areas for mixed land to support residential development.**
- **Continue agricultural uses in southwest portion of the planning area.**
- **Improve and enhance US Route 40.**
- **Complete an Interchange Justification Study.**
- **Incorporate Leadership in Energy and Environmental Design (LEED) principles of design, particularly Neighborhood Design (ND) into site design.**
- **Apply low impact development (LID) techniques into site design and revise regulations to allow implementation of LID.**
- **Support the 22 development principals from Darby Creek Watershed Stormwater Management Strategies and Standards for New Development.**
- **Support principals from EPA National Management Measure to control non-point source pollution from Urban Areas.**
- **Achieve the water quality goals set forth by OEPA TMDL, for TSS, N and P through changing land uses and application of best management practices.**
- **Encourage the application of best management practices on agricultural lands.**
- **Enhance stream morphology through restoration efforts in the priority stream restoration zone along Clover Groff and Hamilton Runs and the upper portions of the Hellbranch Run.**
- **Promote regional stream restoration that allows connectivity to other watercourses.**

To achieve these goals, the general land use plan includes a strong land conservation strategy, described in Section 3.1. This strategy is based on the environmental sensitivity analysis and incorporates a range of tools and techniques to help conserve critical resources and improve water quality.

Second, the plan focuses a portion of the development within a higher density Town Center located between West Broad Street and I-70. This Town Center encourages higher density development within a limited area, an approach supported by the US EPA in a publication called "Protecting Water Resources with Higher-Density Development." This reports compares analysis of several scenarios of development within a watershed, and indicates that the same amount of development equally distributed across the

Section Outline

watershed creates a higher amount of impervious cover and a higher amount of runoff than the same amount of development clustered into a smaller area. Therefore, the general land use plan illustrates a pattern of more concentrated development as part of the Town Center.

The general land use plan is the sum of two interrelated parts: a land conservation strategy and a land use plan. To achieve the Mission of the Accord, both the land conservation strategy and the land use plan will need to be pursued simultaneously with new policies and standards of development that are more fully described in Section 4.0.

The Big Darby Accord Plan recognizes the property rights of landowners in the watershed and has developed polices to provide several options for landowners. Property owners retain the right to develop their land under the governing policies and regulations, subject to all environmental standards and requirements set forth by regulating agencies such as the Ohio EPA as well as new standards set forth in this plan. Landowners retain the ability to sell their land or participate in new programs recommended in Section 5.0. Some of these programs include tax benefits for landowners.

3.1 Conservation Strategy

The Darby watershed is home to several State and federally listed endangered species and is truly a jewel of Ohio and the Midwest. To further protect this valued watershed, an increased level of protection is needed to protect water quality and preserve the natural resources and unique character of the area.

This planning effort represents a significant opportunity to proactively protect resources which directly and indirectly contribute to biodiversity, improved water quality, habitat areas, and ecological processes of the Darby watershed planning area. Increased protection in the form of land conservation and stewardship can only improve conditions of water quality and will contribute positively to retaining the unique character of the area.

A grand opportunity deserves a bold direction. Through land conservation and stewardship efforts, the Big Darby Accord Plan sets forth a goal of protecting about 25,000 acres of land within a comprehensive green infrastructure network consisting of environmental conservation zones (Tiers) that include existing parks and easements, riparian corridors, easements, open spaces, greenways and trails. This network will be achieved by working together with local jurisdictions, developers, landowners, and conservationists using a variety of existing and new programs, careful planning and development, and spirited cooperation.

Purpose

The land conservation strategy is formulated on the environmental sensitivity analysis described in Section 2.3 and is presented in a system of environmental conservation zones identified as Tiers. It is the goal of this Plan to encourage the protection and conservation of all land within the Tiers. Since green infrastructure elements provide communities with an ecological framework, it is essential to identify and protect these areas prior to development. In addition, restoring natural systems throughout the watershed is far more expensive than protecting undeveloped land, and man-made wetlands and other restoration projects often fail to function as well as their natural counterparts over the long run (Benedict, McMahon, 2002).

Responsible land conservation and open space protection includes deciding where development should and should not occur. In areas where development has already occurred it is still important to assess where restoration could occur to restore habitat areas and improve the overall environmental conditions. Over time, the Land Conservation Strategy should guide the location of development and provide a blueprint for regional open space programs and acquisition efforts, which are more fully explained in Section 5.0.

Green infrastructure is our nation's natural life support system – an interconnected network of waterways, wetlands, woodlands, wildlife habitats and other natural areas; greenways, parks and other conservation lands; working farms, ranches and forests; and wilderness and other open spaces that support native species, maintain natural ecological processes, sustain air and water resources and contribute to the health and quality of life for America's communities and people."

Definition of Green Infrastructure, as noted in Renewable Resource Journal, Autumn 2002 in an article entitled Green Infrastructure: Smart Conservation for the 21st Century, by Mark Benedict and Edward T. McMahon.

Benefits of Open Space

A green infrastructure is based on connecting people to green spaces and parks and linking together natural areas to benefit biodiversity and minimize habitat fragmentation (Benedict, McMahon, 2002). Integrated systems of open space promote the movement of species and the preservation of ecological processes critical to a healthy ecosystem. In fact, in 1999 the President's Council on Sustainable Development identified green infrastructure as a key component in comprehensive approaches to sustainable community development (The President's Council on Sustainable Development, Towards a Sustainable America, 1999).

Conservation is sound investment. Development that destroys or degrades natural features and resources is environmentally and economically wasteful. Protection of natural features provides a public benefit to all.

While open space generates less property tax revenue per acre than developed land, major findings show that open space actually produces an overall tax revenue surplus which subsidizes other land uses, and open space provides public and environmental benefits that more than compensate for preferential tax costs (Economic Benefits of Open Space, Miller, 1992). Development often costs more in services (health and safety services, traffic, community facilities, utilities) than it pays in taxes resulting in a net increase in the local tax rate for the public. Residential development expenditures often exceed revenues while farmland and open space revenues (as well as commercial and industrial) exceed expenditures.

Numerous studies highlight specific open space attributes that can be used to establish economic value. Measurable attributes of open space include things like biological diversity, wildlife habitat, soil conservation, rural character, flood control, quality of life, cost efficient development, climate control, fishery protection, scenic views, scientific opportunity, forestry, public access and many more (Miller, 1992). Assigning monetary values to these attributes can depict significant economic value to open space. One direct benefit of open space is the increase in adjacent property values.

3.1.1 Conservation Strategy Components

The land Conservation Strategy is comprised of a system of elements including areas already protected under existing regulations, existing parks and easements, and proposed tiers. The Tiers are based on a number of factors and include features that were part of the sensitivity analysis described in Section 2.3. Specific policies related to the regulation of elements within the conservation strategy, i.e. riparian corridors, floodplains, etc., are further discussed in Section 4.0.

The goal of this plan is to protect all lands within the land Conservation Strategy. Property owners holding land within the Tiers will be encouraged to participate in voluntary conservation programs while the Accord jurisdictions will work collectively to implement regional open space programs with key partners. Existing development and any newly proposed development in the Tiers will need to occur in accordance with applicable base zoning regulations and other standards for development including best management practices. Policies related to the types of appropriate activities, land management approaches and other considerations for the Tiers are described in Section 4.0.

Overall, the land Conservation Strategy shown in Figure 3.2 identifies approximately 25,000 acres of land in five categories outlined in Figure 3.1.

Conservation Category	Acres
Protected	4,310
Existing	6,131
Tier 1	5,790
Tier 2	1,885
Tier 3	7,150
Total	25,266

Figure 3.1 Conservation Categories Acreages
Note: About 1,300 acres within Metro Parks is classified in the Protected Category.

Existing Parks and Easements

The Battelle Darby and Prairie Oaks Metro Parks encompass and protect almost 7,000 acres within the planning area. These parks, located along the banks of the Big and Little Darby Creeks, include significant riparian zones, forests and open space, and together, represent the single largest contiguous tract of land currently in conservation within the planning area and in Franklin County. The mission of Metro Parks is compatible with the creation of a land conservation strategy for the Accord planning area and Metro Parks is a formidable partner in implementing the Accord Plan. The Metro Parks Strategic Plan, 2005 identifies habitat restoration areas, community restoration areas, community open space and a greenway trails system. The Accord Plan fully supports the efforts of Metro Parks.

Franklin Soil and Water Conservation District (FSWCD) currently has easements on 145 acres of land within the planning area. The FSWCD mission is to "promote responsible land use decisions for the conservation, protection and improvement of soil and water resources by providing assistance through effective partnering and technical guidance in Franklin County". Their services include education, public information, construction and post construction review and inspection, backyard conservation, conservation implementation on private lands, county drainage mapping layer, and conservation easements.

Other municipal parks are located throughout the planning area. Increased development westward into the planning area as well as planned future development areas identified in this plan will require additional park land and facilities, including active recreation fields for soccer and other organized sports. Development of this plan does not include a needs assessment to determine the number of fields, type of facilities, or other specific detail; however, this plan has identified general areas for future facilities based on the general land use plan. Generally, the location of facilities should maximize access and be centrally located to neighborhood centers.

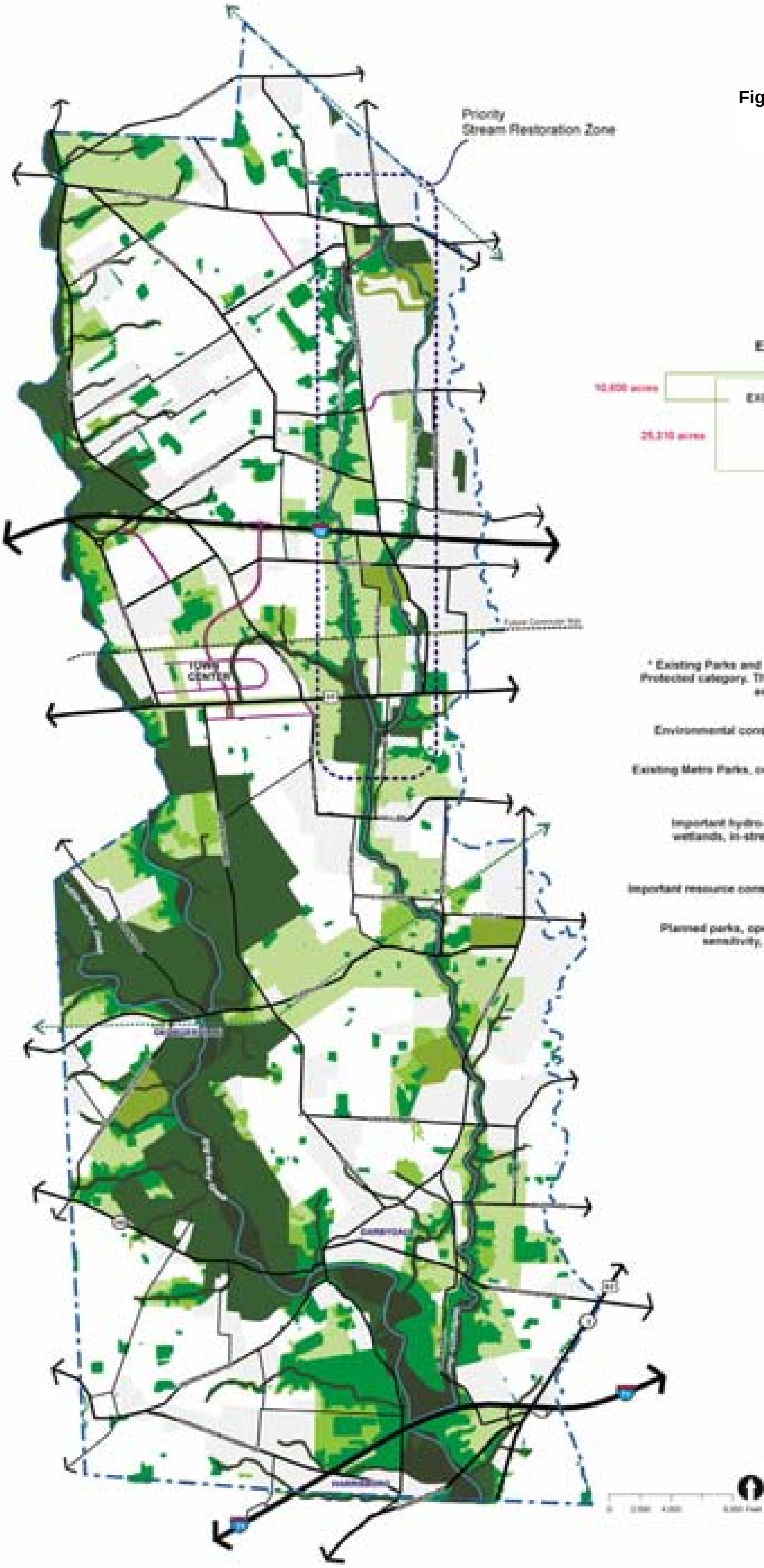


Figure 3.2 Conservation Strategy

Protected Zone

Today, current regulations provide for the protection of about 4,300 acres of land that is encompassed by the FEMA designated floodway or calculated beltwidth. Because these elements are already protected by regulations or ordinances, they have been categorized separately and will retain their protected status in this plan. This plan will maintain the current level of protection and recommends local jurisdictions put in place policies to protect further Tier 1, 2 and 3 areas. Until those policies are developed and adopted, development in Tiers 1, 2, and 3 could occur at the current permitted level, subject to all other regulations.

Tier 1

Land within Tier 1 is considered the primary priority for protection through land acquisition and other programs. Encompassing about 5,800 acres, resources within Tier 1 are significant in maintaining the overall health of the watershed. Resources in Tier 1 include the 100 year floodplain, wetlands, critical groundwater recharge and pollution potential zones. The protection of these elements provides a buffer for sensitive in-stream habitats. Stream corridor protection zones and floodplain protection policies are described in Section 4.0 and have been recommended as guidelines for the minimum standard of protection.

Floodplains

Floodplains are defined along the banks of rivers, streams, or creeks as areas that may be inundated with water following heavy rainstorms. During high water events, floodplains absorb water and help prevent rivers, streams and creeks from overflowing. Water expands into the floodplain areas and infiltrates into the ground, slowing water flow and allowing groundwater recharge. Floodplains in their natural state are beneficial for a number of reasons:

- Reducing the number and severity of floods
- Minimizing non-point source water pollution
- Filtering storm water
- Providing habitat for plants and animals
- Aesthetic beauty and outdoor recreation benefits.

Floodplains are home to many types of plants and animals and may also have forests and wetlands on or adjacent to them. These river edges provide habitat for insects, birds, reptiles, amphibians, and mammals. The vegetation helps filter contaminants out of the water flowing into the river. Additionally, vegetated floodplains provide shade for the adjacent rivers and streams, increasing dissolved oxygen levels and consequently improving habitat for aquatic plants and animals (Center for Earth and Environmental Science, Indiana University- Purdue University).

The effectiveness of a stream's floodplain to convey and store flood water can be adversely affected by human activity. Development practices within and along floodplains affects the land's ability to absorb rain and floodwaters and can contribute to flood events that are larger and more frequent leading to increases in property damage and life threatening situations.

Riparian Corridors

Riparian corridors include grass, trees, shrubs or a combination of natural features along the banks of streams that serve to filter pollutants, provide stream bank stability, protect stream species, improve water quality, slow run-off, and provide a transition between other open space, developed land, and the streams. Riparian corridors at a minimum include the 100 year floodplain or Beltwidth, which ever is greater. For the purposes of this plan, policies related to the riparian corridor are addressed in the Stream Corridor Protection zone in Section 4.0. In some cases, particularly along the Big Darby Creek main stem the riparian corridor is vast due to floodplain and other natural resources found within the zone.

Riparian zones typically comprise a small percentage of the landscape, often less than 1 percent, yet they frequently harbor a disproportionately high number of wildlife species and perform a disparate number of ecological functions compared to most upland habitats. Riparian zones have been widely recognized as functionally unique and dynamic ecosystems only within the past 25 years (US Army Engineer Research and Development Center, Environmental Laboratory, April 2000).

Wetlands

For the purpose of a land conservation strategy, wetlands are included and categorized under the umbrella of open space. Wetlands are a natural feature within the landscape that offer multiple benefits to water quality and habitat and therefore should be preserved and protected. National or state wetland inventory data is a starting point to identify wetlands; however, due to differences in scale and changing environmental factors it is important to evaluate the presence of wetlands on a site by site basis through the development review process.

This type of analysis ensures all wetlands are properly identified and delineated allowing for increased protection.

Groundwater Recharge and Pollution Potential Zones

Groundwater and surface water are fundamentally interconnected and are integral components of the hydrologic cycle. Because the quality and quantity of surface waters can be dramatically affected by groundwater contributions, preservation of the water resources in the Darby Creek planning area requires considerations for the protection of groundwater quality and recharge capacity. Groundwater entering surface waters most frequently comes from unconfined (water table), shallow aquifers. These aquifers interact closely with streams, sometimes discharging water into a stream or lake and sometimes receiving water from the stream or lake. An unconfined aquifer that feeds streams provides the stream's base flow, and the stream is called a "gaining" stream. Because of this base flow support, groundwater is often responsible for maintaining the hydrologic balance of surface streams, springs, lakes, wetlands and marshes. Therefore, to fully understand the source of the stream baseflow and its contribution to the stream system habitat, knowledge of the unconfined aquifers adjacent to streams is essential.

The source of recharge to the groundwater regime is infiltration of precipitation through the soil or percolation of surface water through the substrata of streams, lakes, wetlands and marshes. Recharge to shallow, unconfined aquifers can be locally restricted through the creation of impervious areas (buildings, roads, parking lots, etc.), lined or armored stream channels, and artificial subsurface drainage systems, resulting in a decrease in the amount of groundwater returned to the surface elsewhere.

Tier 2

Land within Tier 2 is considered a secondary priority for protection through land acquisition and other programs. Encompassing approximately 1,885 acres, resources within Tier 2 include highly erodible soils, and contiguous wooded areas that are greater than three acres in size.

Highly Erodible Soils

Highly erodible soils are those that have a high potential to erode based on their physical and chemical properties when combined with particular climatic conditions. Within the planning area, nineteen (19) soils are categorized by the NRCS as highly erodible, four (4) as potentially highly erodible, and two (2) as not highly erodible. These designations are important for federal agriculture programs.

Wooded Areas

While wide, intact, wooded riparian corridors are a crucial factor in the overall aquatic and terrestrial species diversity and richness within the Big Darby Creek watershed, wooded parcels (and wetlands) removed from the riparian corridor also have significant, but lesser benefits to the overall habitat condition. Wooded parcels greater than three acres have been included in Tier 2. Connectivity between wooded parcels is beneficial for wildlife movement and expansive areas of woodland offer excellent opportunities for reducing stormwater runoff and erosion and increasing surface water infiltration and groundwater recharge.

Tier 3

Land within Tier 3 is considered a tertiary priority for protection through land acquisition. These areas should be conserved through permanent conservation easements, within conservation development subdivisions and other suitable mechanisms. Tier 3 is envisioned as providing an integral piece of the open space network by creating linkages among all other components of the Land Conservation Strategy. Passive recreation and certain types of sensitively designed active recreation should be considered suitable for Tier 3 areas.

The overall goal of creating a network will only be possible through careful planning and efforts to link existing and future conservation lands. Corridors of conservation promote habitat movement and diversity and can lead to increased recreational opportunities while preserving rural character. Land within Tier 3 provides buffers and linkages around areas that have been associated with unique habitat, including enhancing the riparian corridors along some stream corridors. Approximately 7,150 acres are identified as Tier 3.

Habitat Connectivity and Buffer Areas

Due to the unique aquatic environment within the Big Darby Creek Watershed and particularly along the main stem of Big Darby Creek, a significant number of threatened and endangered species are present. Protection of these important habitats is accomplished through the Endangered Species Act (ESA), enacted by the U.S. Government in 1973. In addition to the Federal protected species list, Ohio has its own list of State threatened and endangered species that require protection.

The Natural Heritage Database is a compendium of records of rare plants and animals, high quality plant communities, special animal assemblages or colonies, and other natural features within Ohio. The database search revealed the presence of two (2) Federal Endangered species, one (1) Federal Candidate species, eleven (11) State Endangered species, seven (7) State Threatened Species, four (4) State Potentially Threatened species, and six (6) State Species of Concern. Records of mollusk beds and glacial erratics (rocks or boulders deposited by glacial movement) were also noted.

As expected, the highest concentration of rare species is located within the Big Darby Creek main stem and within the downstream portion of Little Darby Creek near the confluence. Essential to support sensitive species, these areas provide the best quality habitat (evidenced by OEPA QHEI scores) and have the greatest amount of wooded riparian buffer within the watershed.

A number of the species listed in the planning area are static species or communities, as indicated on Figure 2.8. *Static* species are generally unable to move around, or to move great distances, under their own power. Mussels and plants fall into this category. Static species are more susceptible to habitat destruction and point source pollution than motile species, which can move upstream or downstream relatively quickly in response to an impact. For this reason, static species should receive special consideration when planning disturbances within the watershed. As a general rule, however, all threatened or endangered species are subject to a number of forms of habitat degradation as the landscape changes form, and their long-term viability must be considered in the planning process.

Trails

Trails within the watershed offer residents and visitors an opportunity to explore nature, take part in a healthy activity by walking, biking or hiking, and can contribute to a better understanding of the dynamic nature of the watershed. Trails already exist within the Metro Park system and efforts are underway to expand the Metro Park trail system to include a more comprehensive network of trails throughout the watershed. This plan supports the efforts of MetroParks in their pursuit of a regional trail network, including efforts to connect with regional trail systems that extend to Cincinnati and Cleveland.

Trail systems should be considered an integral part of community development; serving as a link between neighborhoods, activity centers, employment areas, schools and public facilities and other destinations. From a regional perspective, trails attract visitors supporting the local tourism and travel industry; however, their primary emphasis in the Darby watershed planning area is to encourage a healthy lifestyle and elevate the quality of life for existing and future residents. Developers should coordinate with Metro Parks and local jurisdictions to connect neighborhood trails with regional trail systems, creating a web of off-road connections that improves safety and creates recreational value. Trails should be considered during roadway improvement projects; funding for trail projects could be allocated when funding is pursued for transportation-related infrastructure.

3.2 Existing Land Use

Existing land uses are described below, followed by a description of the proposed general land use plan. Acreages have been determined using GIS and should be considered estimates for master planning purposes only.

Figures 3.3 and 3.4 depict the **existing** land use within the Big Darby Planning area. This information is based on a combination of sources including data from the Mid Ohio Regional Planning Commission (MORPC), information from the local jurisdictions such as comprehensive plans, and aerial photography obtained through the Franklin County Auditor, 2002. The existing development pattern shows a higher concentration of residential uses along the eastern boundary of the planning area, along the edges of Hilliard and Columbus and generally east of Alton Darby Creek Road. The remainder of the planning area is mostly agriculture with pockets of rural residential developments. The subdivision of lots has created rows of very deep 5 acre lots or larger along rural roadways while the interior portion of the tract remains active agriculture.

Open prairie lands
Source: EDAW

Large-lot development
Source: EDAW

Suburban-style development
Source: EDAW

Based on a GIS analysis, about 26% of the planning area is developed, accounting for almost 14,000 acres, not including existing parks. For the purposes of calculation, large lot parcels with only one home that may have additional development capacity were assumed to be fully developed. It is estimated that about 19,000 residential units already exist within the planning area as well as existing commercial, public, park and other uses.

Existing residential land uses, including some small urban, suburban and rural development account for about 22% (12,000 acres) of the planning area.

Existing Land Use	Acres	Percent
Agriculture	31,536	56%
Commercial	218	<1%
Industrial	29	<1%
Public / Institutional	1,355	2%
Residential	12,083	22%
Rural Estate	*4,805*	
Rural	*3,132*	
Suburban	*1,890*	
Suburban High Density	*1,396*	
Urban Medium (5 - 8 du/ac)	*480*	
Urban High (> 8 du/ac)	*380*	
Parks & Open Space	7,490	13%
Golf	782	1%
Roads	2,536	5%
Total	**56,029**	**100.0%**

Figure 3.3 Existing Land Use Acreages

Of the 12,000 acres of residential development, about 4,800 acres is very low density rural development. Less than 1,000 acres is considered medium or high density (5 units per acre or greater). Figure 3.3 lists existing land uses and estimated acreages.

The existing development pattern reflects the continued growth of the urban and suburban development patterns to the west. A range of residential development densities occurs along the eastern edge of the planning area. Limited areas of commercial uses, golf courses, parks and other public/institutional uses also exist in the planning area.

Generally, west of the Hellbranch Run the development pattern is lower density with several pockets of higher density residential particularly along West Broad Street within Prairie Township and the City of Columbus. The remaining areas generally include agriculture uses and larger lot single family residential areas. Agriculture uses occupy approximately 56% of the planning area, or 31,000 acres. About 200 acres of commercial development is clustered near the intersection of Route 62 and I-70 and in the vicinity of Scioto and Darby Creek Road. Existing parks and open space, including Metro Parks, account for approximately 13% (7,443 acres).

Existing Land Use Categories
An effort was made to incorporate existing uses based on their own unique description and not try to assimilate the existing uses into new land use categories. Existing development is indicated by the use of a hatch pattern on the land use map. The following categories on the proposed land use map are related to existing development. Note that mixed use, commercial, public/institutional and agricultural uses relate to proposed land uses as well and are listed under both existing and new land use categories.

- **Rural Residential Estate:** Lots that are greater than 5 acres in size
- **Residential Rural**: 0.2 - 0.5 dwelling units per acre
- **Residential Suburban:** .5-3 dwelling units per acre
- **Residential Urban Medium Density:** 5-8 dwelling units per acre
- **Residential Urban High Density:** Greater than 8 dwelling units per acre
- **Industrial:** Light industrial uses such as warehousing, technology or business parks
- **Mixed Use**: A mix of residential and commercial/retail uses. Actual densities for existing mixed use areas were not determined but were assumed to be between 3-5 dwelling units per acre
- **Commercial:** Local or regionally serving commercial and office uses such as groceries, big box stores
- **Public/Institutional:** Schools, community facilities, government services, libraries
- **Agriculture**: Farmland

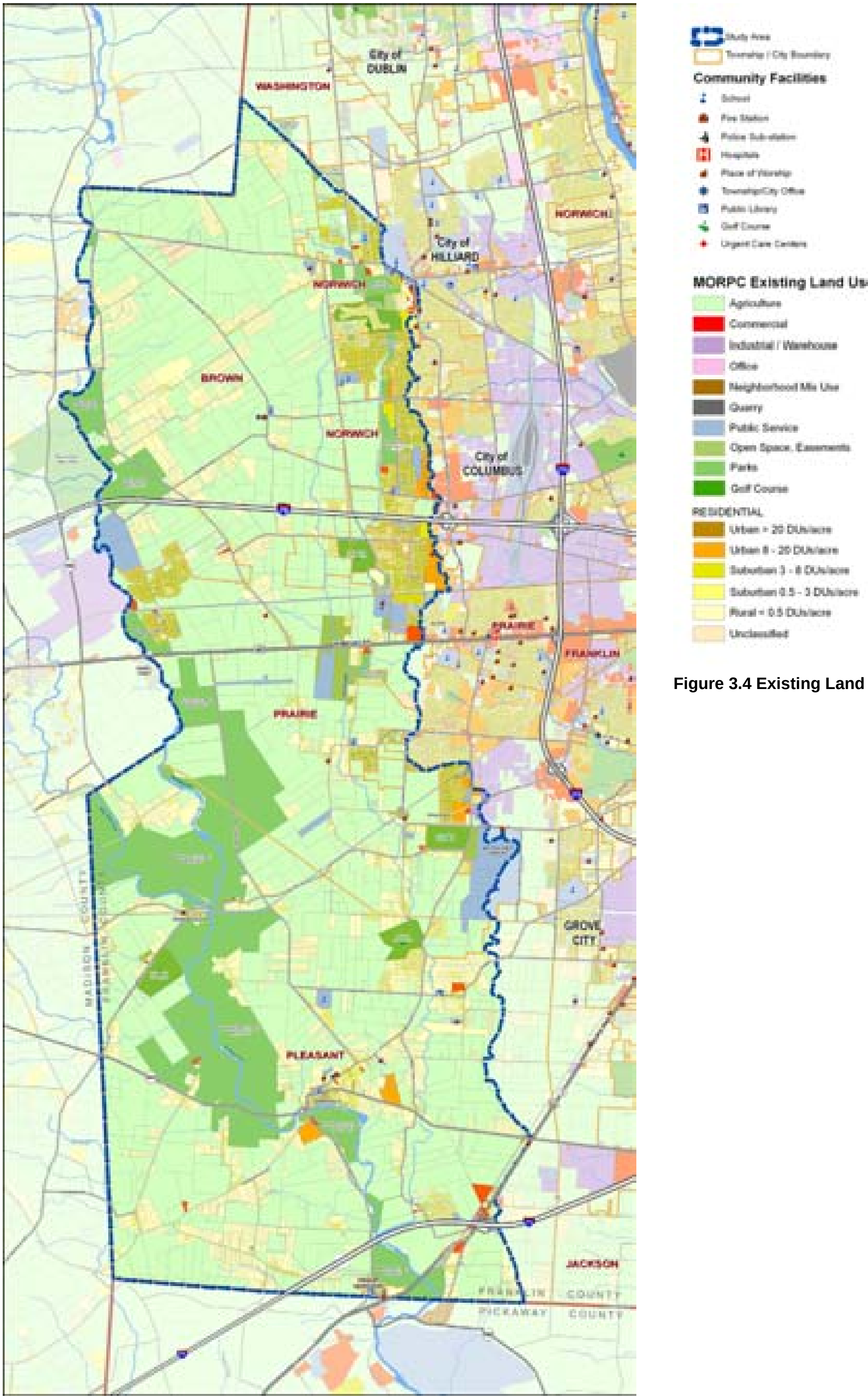


Figure 3.4 Existing Land Use Map

Parks and Trails	Acres	Description	Owner
Alton Road Parkland/Clean Ohio Parkland	103	Undeveloped and Conservation Stewardship	Columbus
Battelle Darby Creek Metro Park	6,251	Woodlands, Conservation	Metro Parks
Clover Groff Natural Area	25	Mitigated Wetland Area and Nature Preserve	Columbus
Franks Park	54	Neighborhood Park	Columbus
Hilliard Municipal Park (Includes Soccer Park, Latham Park)	133	Athletic Fields, Pool, Senior Center, Community Center, Bike Park, Tennis, Picnic Shelters, Amphitheater	Hilliard
Prairie Oaks Metro Park	715	Woodlands, Conservation	Metro Parks
Spindler Road Park	109	Soccer Complex and Stream Corridor Buffer	Columbus
Wexford Green Park	9.8	Playground, Woodlands	Columbus
Total	**7,399**		

Figure 3.5 Existing Parks

Sources: Columbus Park and Recreation Department, Hilliard Parks and Recreation Department, Metro Parks.

Note: Metro Parks acreages include only the area of the park that falls within the Accord planning area.

It is not the intention of the general land use plan to recommend that existing development should be removed or redeveloped to be consistent with Figure 3.6. Rather the land use plan is intended to illustrate how new development should complement the existing development patterns.

Existing Parks and Recreation

Based on existing land use data, about 7,399 acres of parkland currently exist within the planning area and is provided by many jurisdictions. The majority of parkland is concentrated in Metro Parks along Big Darby Creek. The largest park, Battelle Darby Creek Metro Park, is also the largest park within the Metro Park System. Prairie Oaks Metro Park provides an additional 715 acres of park land in the planning area. Heritage Park Metro Park, 58 acres, is located just outside the planning area long the Heritage Trail near Hilliard and offers a respite for trail users.

Metro Parks serve a regional area and provide Franklin County residents with direct access to natural resources through creative programming and education, events and land stewardship. Metro Parks estimates it receives about 5.5 million visitors per year. Their mission is to conserve open spaces, while providing places and opportunities that encourage people to discover and experience nature (Metro Parks Community Update, 2004). Metro Parks' land management practices include wetlands restoration, prairie restoration, wildlife management programs, farming, and species monitoring.

"Conservation and preservation of the best remaining natural areas is an important responsibility of Metro Parks"

Metro Parks Community Update, 2004

Metro Parks started acquiring land in the Darby watershed in 1948 with a purchase of 113 acres. Since then, the system has grown to over 23,000 acres, focusing on conserving significant natural features and resources. Metro Parks owns over 8,100 acres in the Darby watershed (about 7,000 acres in planning area), with about half of those acres acquired since 2000. Programs and initiatives are funded through a 0.65 mill property tax levy that extends to 2009 as well as other state and federal resources, private donations, and grants.

Metro Parks promotes partnerships with willing land owners and jurisdictions to acquire additional park lands. Future goals of Metro Parks are outlined in a 2005 Strategic Plan and include additional park lands and the creation of a greenway trail system linking Battelle Darby Creek Metro Park with Prairie Oaks Metro Park.

With the exception of Metro Parks, parks within the planning area vary in size and are generally located along the West Broad Street corridor or in the northern portion of the planning area, along Clover Groff Run. Hilliard Municipal Park at 133 acres is the third largest park in the planning area and offers a mix of activities including a swimming pool and athletic fields. Spindler Park and Alton Road Park are the next largest park facilities in the planning area at 109 and 103 acres respectively. Together these three parks offer about 300 acres of parkland to residents in the central and north part of the watershed. Other parkland accounts for less than 100 acres. Homestead Park in Washington Township is located along the planning area boundary and provides facilities. By contrast, the majority of parks in the southern portion of the planning area are part of the Metro Parks system.

The Westland Area Commission is currently undertaking a recreation facilities study. The Department's recreation service delivery standards established in the 2003 Columbus Recreation and Parks Master Plan show a need for a recreation center in this area. Columbus is interested in establishing partnerships with other jurisdictions to deliver and maintain recreational services.

Trails and Greenways

Trail systems or greenways within the planning area are generally confined to existing park systems. Efforts to expand the greenway and trail system within the planning area and County are underway. The park agencies in Franklin County are partnering to deliver an interconnected multi-use trail system. The Heritage Rail Trail near Hilliard is a seven-mile multi-purpose trail from Old Hilliard to Plain City along the northeastern planning area boundary and provides a dedicated corridor for walking, jogging, bicycling, rollerblading and horse back riding. This effort is jointly managed and owned by Metro Parks and the City of Hilliard.

Metro Parks and Columbus Recreation and Parks are working to develop a greenway trail along right-of-way of the Camp Chase Rail corridor that when complete, will be an important regional linkage for central Ohio. The Camp Chase Rail Corridor could potentially connect into the Ohio-Erie trail systems of Cincinnati and Cleveland. Columbus is also planning a connecting trail along the Clover-Groff Run. Additional connections along Big Run Creek would link this corridor to the Scioto River Greenways Corridor.

Golf Courses

Golf courses within the planning area are generally evenly dispersed. However, most of the courses are privately operated and require membership for access. The five golf courses within the planning area include: Heritage Golf Club (private), Hickory Hills Golf Club (private), Mentel Memorial Golf Course at Bolton Field (public), Oakhurst Country Club (private), and Thorn Apple Country Club (semi-private).

3.3 Proposed Land Use

The proposed general land use plan, shown in Figure 3.7 is guided by several key concepts.

- Focus higher density development in a town center located between I-70 and US 40.
- Incorporate additional areas of higher density adjacent to the existing development of Hilliard and the City of Columbus along the eastern edge of the planning area where utility service can be provided.
- Provide for a Hilliard growth area that includes conservation development of 1 unit per acre.
- Provide several larger areas of conservation development in Brown, Prairie and Pleasant Townships – these are the areas that are unlikely to be served by sewer service.
- Incorporate the sensitive natural areas as part of a tier system that includes a protected zone as well as areas that should be targeted for protection in Tiers 1, 2 and 3.

The proposed general land use plan categorizes future land uses within the watershed into generalized land use categories. These categories were developed with consideration of current types of development in the watershed as well as standard categories that are typically found in community land use plans. The following paragraphs briefly describe all the land use categories, both conservation and development categories, that are part of the proposed general land use plan.

Proposed Generalized Land Use Categories	Acres	Percent
Agricultural Use	3,356	6%
Commercial	196	0%
Industrial	50	0%
Public / Semi Public	1,053	2%
Mixed Use	357	1%
Res Conservation Devp 50% Open Rural densities	9,406	17%
Res Conservation Devp 50% Open 1 du/ac	1,189	2%
Rural Residential	1,026	2%
Rural Estate	4,805	9%
Suburban Low Density 0.5-3 du/ac	149	0%
Suburban Medium Density 3-5 du/ac	4,073	7%
Urban Medium Density 5-8 du/ac	130	0%
Urban High Density 8+ du/ac	447	1%
Special Residential LEED	328	1%
Town Center*	1,825	3%
Golf Course**	729	1%
Existing Park**	6,266	11%
EC Protected	4,334	8%
Tier1	5,600	10%
Tier2	1,850	3%
Tier3	7,160	13%
Roads & Transportation***	1,701	3%
	56,029	**100%**

Figure 3.6 Proposed Land Use Categories
**Excludes identified Conservation areas in Town Center (about 675 acres)*
***Excludes Conservation protected area*
****Calculation considers only major* roads.

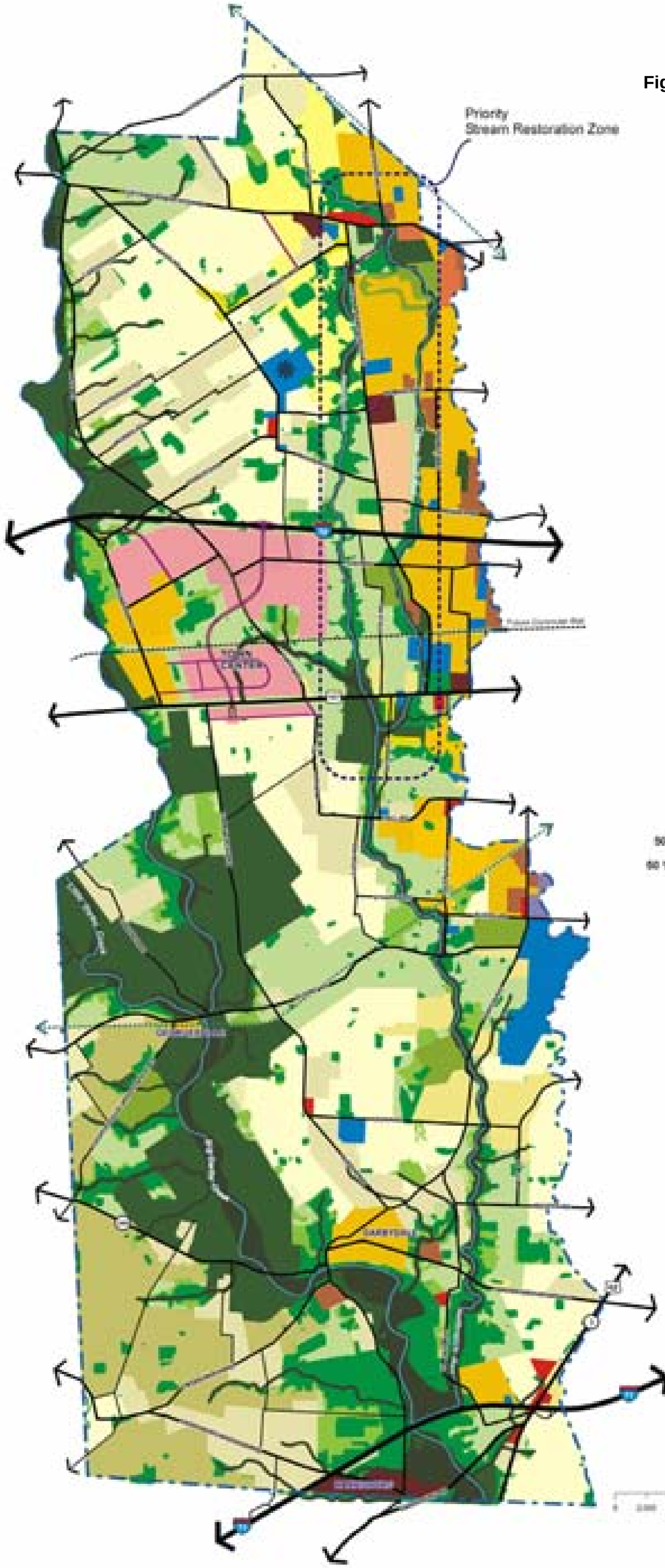
Conservation Land Use Categories
Land uses related to conservation, as described in Section 3.1, are an important part of the proposed land use plan and are referenced again below.

- **Protected Zone**: FEMA designated floodway or calculated beltwidth on all stream channels
- **Tier 1**: 100-year floodplains, wetlands, high potential groundwater pollution, high groundwater recharge areas
- **Tier 2**: Highly erodible soils, wooded areas greater than 3 acres
- **Tier 3**: Endangered habitat sensitive zones, proposed parks, corridors and connections, trails
- **Parks**: Existing parks
- **Golf Course**: Existing golf courses

Development Land Use Categories
Categories of land use have been developed to provide for future residential, commercial and institutional uses. These include the following

- **Conservation Development Low Density:** 50% open space at 1 dwelling unit (du) per acre; sewer service required
- **Conservation Development Rural Density**: 50% open space based on existing zoning; no central sewer provided
- **Special Pilot LEED ND Residential:** 3 dwelling units per acre and LEED ND certification suggested
- **Residential Suburban Density:** 3-5 dwelling units per acre
- **Agriculture**: Farmland
- **Town Center Zone:** Mixed use residential, retail and commercial center
- **Mixed Use**: 5-8 dwelling units per acre with limited neighborhood retail uses
- **Commercial:** local or regionally serving commercial and office uses
- **Public/Institutional:** Schools, community facilities, government services, libraries

Figure 3.7 Proposed General Land Use Map



3.3.1 Town Center

The Town Center concept is consistent with the goals of smart growth. Smart Growth encourages sustainable development that minimizes suburban and ex-urban sprawl and encourages higher density development in urban areas adjacent to transit or other exiting infrastructure systems. Principles of smart growth include:

- Mix Land Uses
- Encourage Compact Building Design
- Create a Range of Housing Opportunities and Choices
- Create Walkable Neighborhoods
- Foster Distinctive, Attractive Communities with a Strong Sense of Place
- Preserve Open Space
- Strengthen and Direct Development toward Existing Communities
- Provide a Variety of Transportation Choices
- Make Development Decisions Predictable, Fair, and Cost Effective
- Encourage Community and Stakeholder Collaboration in Development Decisions

The intention of the Town Center development is to create a highly desirable mixed-use area that includes a full range of residential, retail, office and public uses including parks and open space. Town Center is envisioned as a walkable village that includes retail uses facing key streets to create a lively and visually appealing community. The streets would have well proportioned sidewalks along small urban blocks along with parks and open space areas to help ensure a strong pedestrian ambiance. The Town Center core should be a safe, attractive, efficient, walkable area with convenient connections to residential neighborhoods and nearby transit. Although many people will still drive to the Town Center core, once there, they should be able to park once and walk to other destinations. The Town Center should create an environment that people will return to repeatedly for more than just shopping purposes. The Town Centers should satisfy everyday needs and provide enticements to linger and relax.

Multi-family housing
Source: EDAW

Single family housing
Source: EDAW

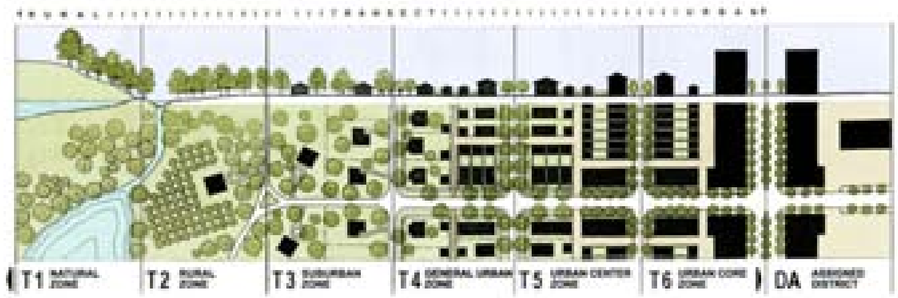
Mixed use development
Source: EDAW

Town center residential development
Source: EDAW

The Town Center should evoke special characteristics that set it apart from its surroundings and contribute to its individuality. The Town Center should strive to create community character with identifiable characteristics which can include:

- Preservation of environmentally sensitive areas
- Sustainable building practices and design
- Mixed uses both vertically and horizontally
- High density development in the core of the Town Center with transitions to surrounding lower density and existing development
- A broad range of housing types and price levels, bringing people of diverse ages, races, and incomes into daily interaction
- A variety of neighborhood to regional-serving commercial, office, and entertainment uses
- Well organized public spaces including parks, formal and informal spaces
- Incorporation of historic and cultural resources
- Regional stormwater facilities to protect water quality and enhance natural resources
- Community facilities and services
- Pedestrian orientated design
- Quality design and materials
- Access to existing and future transit opportunities

While the general land use plan illustrates a zone for the Town Center, it will likely include a mix of uses developed over time and through phases. The uses are envisioned to include residential, retail, commercial, office, institutional, park, and natural areas. Application of a concept termed ‘transect’ can help provide form for the town center and ensure the edges of the town center transition smoothly to less urbanized areas.



Transect Concept
Source: Smart Code Version 8.0

Planning Transect
"Transect" is a term and concept created by urban planner and architect Andres Duany to illustrate the effective transition from an urban core to a natural setting. This transition, which occurred organically and naturally in the past, now must be carefully considered since current zoning regulations have separated and segmented uses creating a disjointed landscape across urban, suburban and rural areas. Classified by zones, it is designed to allow for a seamless and orderly transition between urban and rural areas. By developing according to the transect model, single-use zoning is set aside, allowing for the appropriate mix of uses within each zone and encouraging a mix of design options. On the macro scale, the transect can be used to revise existing zoning codes and on the micro scale it can be used on large scale master plan developments.

The transect has six zones beginning with the Natural Zone that is conceived as permanently protected open space. This zone transitions into the Rural Zone which features large lot development on land that is environmentally sensitive and scenically valuable. The Suburban Zone consists largely of single family homes but can contain a mix of appropriate uses within walkable distances such as neighborhood retail, schools, and institutional uses. This mix of uses becomes richer as the transition continues into the General Urban Zone that features more residential density. The Urban Center and Urban Core Zones are the densest and most urban zones in the transect and have the largest mix of uses. The Urban Center Zone can be described as a neighborhood center or a town center, while the core is typically envisioned as a more regional center.

A transect concept should be applied to the Town Center to provide an acceptable transition from high density to surrounding rural developments. The urban core of the town center should gradually recede into more rural style development like conservation development and open space. Following a transect concept allows denser, concentrated development in the Town Center to coexist and seamlessly integrate with any existing development and environmentally sensitive areas.

To ensure a well planned and high quality town center is created, a more detailed Master Plan should be pursued as discussed in Section 5.0. Additional policies related to the mix of uses, design and character of the Town Center are described in Section 4.0

Density / Level of Development
The number of residential units anticipated to occur within the initial development of the Town Center is approximately 5,000 units, based on a sewer capacity analysis further discussed in Section 4.9. The total amount of development may increase depending on sewer service availability. Planning and design of the Town Center will be driven by the location of available utilities. Flexibility near the town center zone edges related to existing zoning, environmental features and the provision of services should be considered and addressed in the Master Plan process. Initial phasing should begin along West Broad Street.

To achieve a successful Town Center, a base level of density should be established within the core area of Town Center. This base level of density would allow for a mix of uses and encourage the creation of pedestrian friendly environment. Based on successful Town Centers both within central Ohio and from around the country, it is recommended that the core area be developed with a minimum of 8 units per acre to a maximum of 15 units per acre. Another approach to managing the density would be based on Floor Area Ratio (FAR). Floor Area Ratio is a method of calculating the building intensity allowed on a site. Floor Area Ratio is expressed as the gross floor area permitted on a site divided by the total net area of the site, expressed in decimals to one or two places. For example, on a site with 10,000 net sq. ft. of land area, a Floor Area Ratio of 1.0 will allow a maximum of 10,000 gross sq. ft. of building floor area to be built. On the same site, a FAR of 1.5 would allow 15,000 sq. ft. of floor area. To create a successful Town Center the FAR would likely be between 1.0 and 2.0.

These densities should be further explored and refined as part of the detailed Master Plan recommended for the Town Center.

3.3.2 Conservation Development

As Central Ohio has grown, people have migrated to what have become known as "subdivisions" located in more suburban or rural areas, including the Big Darby Accord planning area. Much of this type of development has followed a traditional design, which some have described as "checkerboard or cookie-cutter housing development." The residential zoning ordinances have encouraged such traditional designs by requiring minimum lot sizes, uniform road frontage and lot setbacks, specific road standards, and other standard requirements. In general, the only open space within such developments has been the yards between adjoining privately owned housing lots. In many cases, little planning went into preserving or improving the quality of the open-space areas or protecting natural features on the developed parcel.

Conservation development
Source: EDAW

Conservation development
Source: EDAW

Highlight on Conservation Development

Well-designed conservation developments may benefit the whole community in terms of stormwater management. These developments usually have less impervious surface cover and provide more open space for water infiltration. These two factors combined can help reduce the amount of stormwater runoff leaving the property and thus decrease the chances that the new development will cause flooding problems. Although traditional subdivisions may be required to build stormwater detention areas, these structures usually only reduce the flow rate of water, not the increased volume. Natural areas, such as wetlands or native plantings that are a part of the conservation development's open space can help manage stormwater by reducing the volume of runoff and cleaning the stormwater during the infiltration process.

Another advantage of conservation developments is that they generally use less mass grading of the parcel's soil surface. Such grading can compact the soil and increase runoff even on areas where there is no construction. Road ditches in cluster designs are often grass swales instead of curb and gutter. These grassy areas allow for more water infiltration and are often less costly for developers and require less maintenance from the homeowners' association or community (http://www.urbanext.uiuc.edu/lcr/LGIEN2000-0010.html).

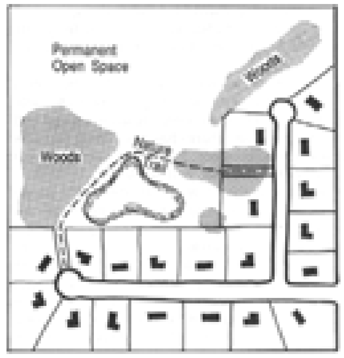
Conservation development is not a new concept to the Big Darby Accord planning area. Prairie Township is developing a planned residential conservation development overlay district to promote the creation of conservation developments. Brown Township's recently adopted Comprehensive Plan identifies conservation development as the preferred land use for a majority of the rural township. Policies must be adopted and in place to allow for conservation development, as described in Section 4.0. Developers often cite local regulations as the primary reason more innovative designs are not used. More flexible regulations does not mean "anything goes," however. Traditional codes must be replaced with new design standards that address the goals of conservation development, such as open space preservation, etc.

This pattern of land use and land consumption has resulted in many people asking the question of whether we are creating a high quality of life in our communities. Conservation development, also sometimes referred to as cluster development, is an approach to development that allows residential development while still protecting the area's environmental features, allowing for more open space, and protecting the rural character of the area.

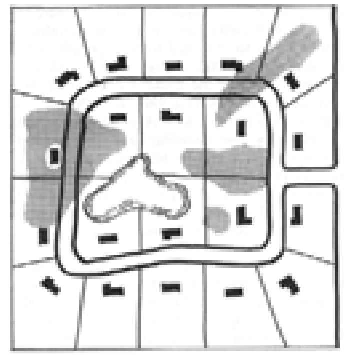
The rural character of western Franklin County is a contributing factor to the quality of life enjoyed by residents who live in the area. Rural character within the Big Darby Accord exists due to the predominance of open space, natural landscape, vegetation in the area and the emphasis on traditional land-based uses like agriculture. Other rural characteristics include significant park lands and equestrian activities. Several small communities exist, such as Darbydale and Georgesville, that provide concentrations of businesses and homes;

however, a large amount of homes are located on isolated parcels. Typically, rural communities maintain a limited expectation of urban services and infrastructure such as sewer, water, urban roads, curbs and sidewalks Conservation development is a design strategy for residential development that can lead to increased protection of existing natural resources on and off-site. Conservation developments incorporate open space as part of the design with consideration of existing site topography, soils, vegetation, natural drainage patterns, and other sensitive or unique landscape features. Protected natural areas provide wildlife habitat, protect biodiversity, and can contribute to improved water quality, regional greenways and natural area networks. Like other land use types, conservation developments integrate stormwater Best Management Practices (BMPs) throughout the site, utilizing the site's natural features to protect and restore natural hydrology, habitat and water quality. Development costs for site preparation and stormwater management infrastructure is often reduced since only a portion of the site needs modification.

Conservation developments differ from traditional developments in several ways. Conservation developments usually site homes on smaller lots with less emphasis on minimum lot size. The same number of homes is clustered on a smaller portion of the total available land. The remaining land, which would have been allocated to individual home sites, is now converted into protected open space and shared by the residents of the subdivision and possibly the entire community.



20 lots
25 acres open space
Pond access for all residents



20 lots
No open space
No pond access except from four lots

These two plans provide the same number of dwelling units. The conservation develoment, left, uses smaller parcesl and a range of unit types on a much smaller footprint, allowing the surrounding area to be maintained as open space. The conventional development, right, more typical of current residential zoning, offers no open space and limits access to the pond to those homes which front along it. The amount of roads and infrastructure required for the conventional site development would most likely be greater than costs for the conservation development. Source: Arendt, 1994.

3.3.3. Other Residential Uses

Along West Broad Street, east of Hellbranch Run, residential development of 3 to 5 units per acre is identified. These areas are expected to have access to central sewer through the extension of the Big Run Trunk sewer line to the town center.

Another residential category, identified on Figure 3.7 as Special Pilot Leadership in Energy and Environmental Design (LEED) Residential, is located north of I-70, between Clover Groff and Hamilton Runs. Due to the sensitive nature of this location and gateway into the watershed, this area should serve as a model development for sustainable design through application of LEED principles. Application of LEED principles should be encouraged throughout the entire planning area. LEED is further described in Section 3.4.

3.3.4 Mixed Use

The mixed use areas identified on the general land use plan are intended to occur at key locations within the planning area. The Mixed-Use areas are intended to be neighborhood or community centers that provide a focus for locating uses that will support surrounding residential communities. The mixed-use designation provides some flexibility in what uses could occur in these areas, however, a blend of residential, retail, commercial, and institutional is recommended. The density of mixed-use areas should be slightly higher than the surrounding lower density residential areas they would serve. The overall density of the proposed mixed use areas is envisioned as 5 to 8 units per acre along with supporting commercial uses. The goal of these areas is to create a "village center" environment, encouraging development within a limited area that could support some commercial uses oriented toward the street and create an attractive pedestrian environment.

3.3.5 Agriculture

The Accord Plan recognizes that farming is an important local and regional industry. Development patterns, increased traffic, demand for higher yield crops and costs associated with farming have caused many local farmers to sell their land for development in order to realize a return on their investment.

Active agriculture uses are expected to continue within the planning area; agriculture is a permitted use within the proposed conservation development areas. Over time, it is anticipated that many of today's active farms will transition into conservation development and as a result active agriculture is not a dominating land use on Figure 3.7.

The Accord should work with local farmers to implement practical best management practices to reduce the impacts that farming practices have on local water quality. Many existing, local programs, such as agriculture easements, can result in tax savings for land owners. In cooperation with local organizations like Ohio State University Extension, FSWCD and NRCS, new programs should be promoted in the watershed that creates financial incentives encouraging farmers to reduce pollutant loadings.

3.3.6 Transportation Considerations

With I-70 and US Route 40 being major east-west arterials that traverse downtown Columbus and serve the overall region via interchanges with I-270, it is only logical that development will continue to progress westward along the US 40/I-70 corridor. Based on the general land use plan, the Town Center would have its primary access via a major gateway on US 40 and a new interchange on I-70. Murnan Road could provide access to the Town Center from areas south of US 40 while Feder Road could link the Town Center with Alton-Darby Creek Road.

Based on an initial 5,000 dwelling units, the Town Center could generate up to 10,000 work-related vehicle-trips during the morning and afternoon commuter peak hours. With the primary employment zones being to the north in Hilliard and Dublin, to the east toward downtown Columbus, and around the I-270 corridor, the majority of the drivers will desire to use Alton & Darby Creek Road (and Cosgray Road), I-70, and US 40.

As the primary east-west roadway providing direct access to developments along the US 40/I-70 corridor, steps should be taken to protect and improve mobility and traffic flow along US 40 – while at the same time balancing this regional need with proper access for major developments. A significant portion of US 40 east of Big Darby Creek to I-270 is under the jurisdiction of Ohio Department of Transportation (ODOT). Access points for new developments must adhere to the guidelines set forth in the State Access Management Manual. Unfortunately, much of the area east of Hilliard-Rome Road has been developed and numerous access points and intersections (together with excessive traffic demands) yield traffic delays and sluggish traffic flow.

In order to yield a successful Town Center development with appropriate access, considerations should be given to improving and enhancing the US 40 corridor.

As the Town Center continues to develop, consideration should also be given to the establishment of a new interchange on I-70. A new interchange will further improve accessibility for the Town Center and will relieve traffic demands on Feder and Renner Roads (as they feed the Hilliard-Rome Road interchange). This will also reduce traffic demands at the Hilliard-Rome Road interchange and create a more balanced regional roadway system.

As shown on the general land use plan, the proposed I-70 interchange would be "one-sided" and not have a roadway extending to the north. The intent is to primarily serve the Town Center to the south. However, it is recognized that any new interchange will provide the "opportunity" for drivers to access points to the north. The impact of this travel on the roadway systems to the north of I-70 will have to be carefully evaluated in an Interchange Justification Study that will need to be submitted to ODOT and the Federal Highway Administration.

The Interchange Justification Study will need to address the potential for new development within the interchange area. It is common for intense auto-oriented development to surround freeway interchanges. If proper land-use controls are not in place new development at the new interchange could quickly overwhelm the area. The Accord jurisdictions will need to work together to ensure that any development near the interchange is consistent with the Accord Plan and proposed Town Center Master Plan.

3.4 LEED Principles of Design

Another key concept that should be incorporated in site design and community planning in the Accord planning area is outlined by Leadership in Energy and Environmental Design (LEED). LEED is a rating framework that has been developed for buildings – also known as the Green Building Rating System. The general land use plan identifies an area of about 350 acres for residential development that is encouraged to develop using LEED techniques. Many communities and developers around the country are adopting LEED practices and seeking to have their buildings certified as LEED rated buildings. Arlington, Virginia for example requires all public buildings have a goal of achieving a silver rating for new buildings. For the purposes of a large planning area like Darby Accord, the focus is less on individual buildings and more on community and site planning. LEED is developing a new rating system called LEED ND (Neighborhood Design) that focuses on elements that bring the buildings together into a neighborhood and relates a neighborhood to its larger region. It is strongly encouraged that Accord jurisdictions incorporate these concepts into development – particularly the areas that include higher densities that can achieve the goals of LEED ND.

The LEED ND rating system is divided into “prerequisites” and “credits”. To achieve a basic LEED ND certification, a project must achieve all the prerequisites to achieve a higher certification such as silver, gold or platinum, a project needs to achieve a certain amount of the credits.

The categories included in this system are:

- **Location efficiency** which addresses the issue of development (or redevelopment) within the urban environment versus development on Greenfield areas at the edge of the region
- **Environmental preservation** which includes protection of ecological communities, sensitive environmental areas, and site design that supports protection and creation of high quality natural environments.
- **Compact, Complete, and Connected Neighborhoods** which includes providing for a diversity of uses, creating pedestrian friendly environments, and cluster of development

A goal of the Big Darby Accord should be to integrate the LEED ND standards into the day to day practices making the Accord area a leader in Central Ohio for sustainable design.

3.5 Water Quality

Water quality considerations of the land use plan have been addressed through a hydrological modeling exercise and an assessment of stormwater management policies and best management applications. The modeling process and outcomes are described in the following section, followed by a discussion of stormwater best management practices. Appendix A provides a more detailed discussion about the modeling process.

3.5.1 Water Quality Modeling

The purpose of water quality modeling was to determine the impact on water quality, measured in terms of pollutant loading, related to proposed land use changes within the planning area. Using the Soil and Water Assessment Tool (SWAT) software, a baseline condition model was created similar to the Generalized Watershed Loading Functions (GWLF) model established by the Ohio EPA (OEPA) for the Big Darby Creek TMDL analysis and report. The SWAT baseline model was calibrated for flow to the U.S. Geological Survey (USGS) gage along Hellbranch Run; the model was then calibrated to the EPA’s GWLF model results for Total Nitrogen (TN), Total Phosphorous (TP), and Total Suspended Solids (TSS).

Although the Ohio EPA did not publish calculated TN loadings in the TMDL report, the Ohio EPA provided detailed and summary model results that included those values for the Hellbranch Run watershed and other subwatersheds that are at least partially within the Big Darby Accord planning area. The final calibration model’s parameters were then used to analyze the effects of the land use plan,

Description	Volume (mm)	Q (cfs)	SF/BF (%)	TN (kg)	TP (kg)	Overland Runoff TSS (kg)	Construction/ Channel Erosion TSS (kg)
TMDL Existing	NA	NA	59/41	NA	16,359	3,051,200	17,594,074
TMDL Allowable	NA	NA	NA	NA	3,175	1,086,249	
SWAT Baseline model + PS	344.4	39.3	54/46	190,885	15,944	3,439,721	17,594,074
SWAT Final Land Use Scenario model + PS	369.8	42.2	62/38	113,617	4,517	1,023,087	17,594,074

Figure 3.8 Calibration and Final Land Use Model Results
PS – Point source loading
mm – millimeters
cfs – cubic feet per second
SF/BF – surface flow / base flow

comparing the pollutant loadings predicted by the SWAT model to the target water quality goals published in the Ohio EPA TMDL report. The model results were also used to evaluate the requirements for stormwater BMPs, in an effort to mitigate the impact of changing land uses and development on pollutant loadings.

Pollutant Loading Considerations
The pollutant constituents analyzed are those that are commonly considered and are most likely to be affected by changing land use conditions including TN, TP and TSS. Heavy metals, especially within the Big Darby Accord planning area, did not appear to be a significant consideration in the published TMDL. Furthermore, there are no anticipated future industrial land uses or other point source contributors within the planning area that would be a significant contributor of those pollutants.

Planning area
The modeling planning area is essentially comprised of two large sub-watersheds: the Hellbranch Run sub-watershed and all other areas within Franklin County that are directly tributary to Big Darby Creek. Each of these sub-watersheds was divided further into 51 sub-basins to allow for a more detailed analysis.

Calibration Model
The calibration model represents the existing land use condition within the planning area. The land use coverage used in the calibration model was provided by the Ohio EPA and is identical to that used in the TMDL analysis.

After all data input was completed, the SWAT baseline model was calibrated for flow to the USGS gage along Hellbranch Run; the model was then calibrated to the EPA's GWLF model results for TN, TP and TSS. All calibration operations were performed using data for the Hellbranch Run sub-watershed.

The results of the calibration modeling serve as the baseline for comparison to the final land use plan, described below. This comparison allowed for a determination of the changes in pollutant loading related to the changes in land use for the planning area.

Final Land Use Plan Model
The final land use plan model was established from the baseline (calibration) model by changing the land use coverage to reflect projected build-out conditions. The fundamental changes related to the final land use plan are described below.

1. Converting existing agricultural land uses to a variety of urbanized land uses, varying from a low density (conservation development) residential to a commercial level of development.
2. Converting existing agricultural land uses to preserved open space (conservation areas).

Pollutant	Percent Loading Reduction[1]	
	Hellbranch Run Watershed	Entire Planning area[2]
TSS[3]	70% (95%)	44%
TP	72% (81%)	65%
TN	41% (N/A)	40%

Figure 3.9
Comparison of Baseline Condition to Land Use Plan
[1]Compared to SWAT Baseline model
[2]Includes areas directly tributary to Big Darby Creek
[3]Pertains only to the overland runoff component of TSS
(%) – percent reduction prescribed in the TMDL; no value published for TN

Conclusions
The modeling analysis was successful in duplicating the results from the TMDL study, in particular for the Hellbranch Run watershed. With that modeling serving as a baseline for comparison, it has been determined that the general land use plan for the Big Darby Accord will ultimately reduce the level of pollutants that are contained in stormwater runoff and discharged to Hellbranch Run or directly to the Big Darby Creek main stem. The percent reduction in the various pollutants for Hellbranch Run and for the larger planning area is shown in Figure 3.10. As expected, the increase in impervious area associated with the urbanizing land uses contained within the land use plan will increase the calculated average annual flow rate and cause a re-distribution of the surface flow/baseflow relationship within the planning area.

The percent reductions noted in Figure 3.9 for the Hellbranch Run watershed are less than those specified in the TMDL to obtain the target levels for those pollutants (Note: TN is not presented in the TMDL). Furthermore, the comparison of TSS only pertains to the overland runoff component of that pollutant. The TMDL contains additional information relating the additional loading associated with construction activities and channel bank erosion. Considerations to reduce these individual components include comprehensive erosion and sediment control criteria and incentives to promote stream bank stabilization and/or restoration activities within the watershed.

It is important to note that the results represented by the SWAT modeling exercise represent and summarized within Appendix A are only an analysis of land use changes within the Accord planning area and do not account for stormwater BMP applications or specific site planning practices, such as low-impact design, that would further reduce pollutant loading or increase infiltration from urbanizing land uses. Other important observations regarding the modeling and the accompanying results are described below.

- The significant reduction in pollutants when comparing the final general land use plan to the baseline condition can be attributed to the replacement of agriculture with urbanizing land uses and the representation of conservation open space that replaces a considerable amount of land currently being used for agriculture.
- The analysis performed does not represent the presence of field tile that exists in conjunction with agricultural land uses. Eliminating field tile would likely reduce the change in flow rate and the surface flow/baseflow relationship.
- Stream restoration activities can have a beneficial impact on multiple facets of the modeling provided for this study. Stream restoration to add floodplain storage can mitigate the impact of increased flow associated with urbanizing areas and can increase the assimilative capacity of pollutants conveyed within the stream channel, particularly TSS.

Impervious Surfaces
The percentage of the total impervious area (PTIA), or the amount of the watershed covered by surfaces preventing water infiltration, has been found to be predictive of the amount of stress and degradation to streams. An estimate of impervious surfaces for the land use plan at build-out within the planning area indicates an increase from approximately 6 % (existing conditions) to approximately 10%.

While there is some degree of variability for threshold PTIA levels, ranging between 5% and 15% according to various studies, the goal of 10% is a commonly identified threshold for many

Researchers	State	PTIA Threshold
C. May (1997)	Washington	5-10%
R.D. Klein (1979)	Maryland	10%
E.J. Shaver, G.C. Maxted, D. Carter (1995)	Delaware	8-15%
T.R. Schueler & A. Gali (1992)	Maryland	15%
G.C. Maxted (1996)	Delaware	10-15%
R.C. Jones & C.C. Clark	Virginia	15-25%

Figure 3.10 Percent Total Impervious Area (PTIA) Variability
Source: Schueler, T.R. 1994. The importance of Imperviousness, Watershed Protection Techniques 1 (3): 100-111.

watersheds within the United States (Figure 3.10). It is also important to understand that 'imperviousness' is merely an indicator of various cumulative hydrological impacts to the waters and is not by-itself the cause of degradation. This concept is important within the context of the Darby Accord Plan which emphasizes best management practices and low-impact development to minimize effects of development with a comprehensive multi-strategy approach. The Appendix provides a more detailed analysis of water quality modeling efforts.

3.5.2 Stormwater Management

Stormwater management involves managing the volume, the intensity and the quality of stormwater discharges into receiving waters. Changes in land use and development can alter both the quality and quantity of stormwater runoff. To meet the water quality goals of the TMDL, application of a comprehensive stormwater management program will be required, incorporating various aspects of both structural and non-structural BMPs.

In areas undergoing new development, such as the Accord planning area, the most effective methods of controlling impacts from stormwater discharge are to limit the amount of rainfall that is converted to runoff and to capture and treat the runoff that is generated. By utilizing structural and non-structural techniques for achieving these goals, site development activities can be planned and designed in such a manner that the impacts on the watershed associated with development can be mitigated.

Structural BMPs are constructed features often included with or adjacent to a development site that receive, capture and provide some mitigating treatment for stormwater volume and pollutant constituency associated with runoff from that site. Non-structural BMPs are best represented by low-impact development techniques that are reflected in how a development site is planned to reduce the amount of impervious surface and/or the connection between impervious areas. The application of these different approaches to the site development process may depend on the type and density of development permitted by the land use zoning.

The Ohio EPA has released a draft permit for the Big Darby Creek watershed (Ohio EPA Permit No. OHC100001) related to water quality controls to be used during construction, titled *Authorization for Storm Water Discharges Associated with Construction Activity Located Within the Big Darby Creek Watershed Under the National Pollutant Discharge Elimination System.* The draft NPDES permit details the measures that developers must implement to control runoff during construction activities and provides criteria for post-construction water quality. Along with the guidelines of the Ohio EPA permit, several strategies have been identified to address water quality related to development in the watershed. Policies related to stormwater management are further described in Section 4.0

Low-Impact Development

Increased development typically brings increased stormwater runoff volumes in conjunction with an increased pollutant load from the runoff. The increased quantity of stormwater and the associated pollutants can lead to degradation of the stream channel, water quality and habitat, increased channel erosion and overbank flooding. The core principle of low-impact development is the planning and design of development projects that have a reduced impact on watersheds, accomplished through the basic principles listed below.

1. Reducing the amount of impervious cover within proposed developments.
2. Increasing the natural land set aside for conservation.
3. Using pervious areas for more effective stormwater treatment.

These practices, recommended for stormwater and stream protection by the Hellbranch Watershed Forum, result in the conservation of natural features and resources, reduction in impervious surfaces for roadway and parking lot areas, concentration of development in less sensitive areas and the use of natural areas for stormwater management. Better site design practices address both water quality and quantity management from developments. The practices result in a more natural and cost effective stormwater management system that reflects the natural hydrologic conditions of the site and can reduce long term maintenance.

A previous stakeholder initiative, referred to as Central Ohio Regional Forum Darby Watershed Advisory Group, developed twenty-two model development principles related to land use development and best management practices that are applicable to the Accord process. These model development principles can be found in the document entitled *Darby Creek Watershed Stormwater Management Strategies and Standards for New Development, 2001.* Many of the principles relate to site design recommendations to minimize stormwater impacts while others are more closely tied to treatment mechanisms. Those that directly reference BMPs (not including site design principles) have been listed below. In addition, principles adapted from the document entitled *EPA National Management Measure to Control Nonpoint Source Pollution from Urban Areas, 2002*, provide a solid foundation for future development policies regarding BMPs; these have also been included below. Together these principles provide a solid foundation to begin considering a BMP toolkit suitable for the Darby watershed that will provide a level of protection that promotes watershed stability.

- Incorporate landscaped areas with cul-de-sacs to reduce impervious cover and provide stormwater treatment (Principle 4, Darby Creek Watershed Stormwater Management Strategies and Standards, 2001).
- Where density, topography, soils and slope permit, vegetated open channels should be used in the street right-of-way to convey and treat stormwater runoff (Principle 5, Darby Creek Watershed Stormwater Management Strategies and Standards, 2001).
- Advocate open space development that incorporates smaller lot sizes to minimize total impervious area, reduce total construction costs, conserve natural areas, provide community recreational space, and promote watershed protection (Principle 10, Darby Creek Watershed Stormwater Management Strategies and Standards, 2001).
- Wherever possible, provide stormwater treatment for parking lot runoff using bioretention areas, filter strips and/or other practices that can be integrated into required landscaping areas and traffic islands (Principle 9, Darby Creek Watershed Stormwater Management Strategies and Standards, 2001).
- Reduce overall lot imperviousness by promoting alternative driveway surfaces and shared drives that connect to two or more homes together (Principle 13, Darby Creek Watershed Stormwater Management Strategies and Standards, 2001).
- Direct rooftop runoff to pervious areas such as yards, open channels, or vegetated areas and avoid routing rooftop runoff to the roadway and the stormwater conveyance system (Principle 15, Darby Creek Watershed Stormwater Management Strategies and Standards, 2001).
- Create a variable width, naturally vegetated buffer system along all perennial streams that also encompasses critical environmental features such as the 100 year floodplain, steep slopes and freshwater wetlands (Principle 16, Darby Creek Watershed Stormwater Management Strategies and Standards, 2001).
- The riparian stream buffer should be preserved or restored with native vegetation that can be maintained throughout the plan review, delineation, construction, and occupancy stages of development (Principle 17, Darby Creek Watershed Stormwater Management Strategies and Standards, 2001).
- Clearing and grading of forests and native vegetation at a site should be limited to the minimum amount needed to build lots, allow access and provide fire protection. A fixed portion of any community open space should be managed as protected green space in a consolidated manner (Principle 18, Darby Creek Watershed Stormwater Management Strategies and Standards, 2001).
- Conserve trees and other vegetation at each site by planting additional vegetation, clustering tree areas, and promoting the use of native plants (Principle 19, Darby Creek Watershed Stormwater Management Strategies and Standards, 2001).
- New development should not discharge unmanaged stormwater (Principle 21, Darby Creek Watershed Stormwater Management Strategies and Standards, 2001).
- Enclosing, straightening, and relocating streams should be discouraged during all new development (Principle 22, Darby Creek Watershed Stormwater Management Strategies and Standards, 2001).
- Clearly specify how community open space will be managed and designate a sustainable legal entity responsible for managing natural, recreational, and stormwater management open space (Principle 14, Darby Creek Watershed Stormwater Management Strategies and Standards, 2001).
- Incentives and flexibility in the form of density compensation, buffer averaging, property tax reduction, stormwater credits, and by-right open space development should be encouraged to promote conservation of stream buffers, forests, meadows, and other areas of environmental value. Off-site mitigation for open space, stormwater management and forest resources (excluding riparian buffers) within the same watershed should be encouraged (Principle 20, Darby Creek Watershed Stormwater Management Strategies and Standards, 2001).
- Maintain predevelopment site hydrology by using site design techniques that store, infiltrate, evaporate, or detain runoff (EPA National Management Measure to Control Nonpoint Source Pollution from Urban Areas, 2002).
- Use natural hydrology as a design element and avoid alteration, modification, or destruction of natural drainage features (EPA National Management Measure to Control Nonpoint Source Pollution from Urban Areas, 2002).
- Protect areas that provide important water quality benefits, habitat areas or are particularly susceptible to degradation (EPA National Management Measure to Control Nonpoint Source Pollution from Urban Areas, 2002).

- Site plan review and conditional approval should address and ensure that the integrity of environmentally sensitive areas and areas necessary for maintaining natural hydrology and water quality will not be lost (EPA National Management Measure to Control Nonpoint Source Pollution from Urban Areas, 2002).
- Limit land disturbance activities, such as clearing and grading and cut-and-fill, to reduce erosion and sediment loss and limit disturbance of natural drainage features and vegetation during site development (EPA National Management Measure to Control Nonpoint Source Pollution from Urban Areas, 2002).
- Protect and retain existing vegetation to help control erosion (EPA National Management Measure to Control Nonpoint Source Pollution from Urban Areas, 2002).
- Minimize imperviousness to the extent practicable (EPA National Management Measure to Control Nonpoint Source Pollution from Urban Areas, 2002).
- Incorporate open space and natural areas into site designs with an emphasis on creating an interconnected green infrastructure that has positive benefits to water quality and quality of life (EPA National Management Measure to Control Nonpoint Source Pollution from Urban Areas, 2002).

Approach to LID Site Design

LID site design should begin with an inventory of existing site conditions and natural features of the site to determine protection areas as well as what natural features can be incorporated into the LID stormwater management system. An inventory of natural features would likely include streams, floodplains, wetlands, groundwater recharge protection areas, soil characteristics, slopes and conservation areas. The inventory will reveal the overall development envelope, defining where development will have minimal impact on hydrology and other sensitive features of the site and surrounding area. Reducing the overall development envelope allows for a larger portion of stormwater to seep into soils gradually, removing contaminants, replenishing soil moisture, and recharging the shallow groundwater condition naturally without piping infrastructure leading to a centralized end of pipe approach to stormwater treatment.

Once site characteristics are inventoried, potential site development layouts can be configured. Site layouts should be designed to minimize impervious areas, retain natural topography and use existing natural drainageways, swales, depressions and storage areas, ultimately minimizing the volume of runoff that must be treated in a stormwater management system. Methods that will help reduce site coverage include clustering development, increasing building heights (within the allowable zoning regulations), building parking structures instead of lots, reducing road widths and using permeable paving and green roofs.

Conventional stormwater treatment systems use a piped system leading to a central stormwater treatment center. Low impact development takes advantage of a decentralized stormwater system that is integrated into site design for both the function of treating water and as a landscape amenity. The goal of a low impact system is to increase the time of concentration through stormwater retention close to the source, open drainage systems (vegetated swales and filter strips), long drainage paths and vegetated paths. Decentralized structures may include swales, bioretention areas, infiltration structures, and filter strips that can be dispersed throughout a site.

A variety of techniques can be used in low impact development, allowing for customization according to local codes and management requirements, site constraints and opportunities and topographic and climate conditions. Although low impact development techniques have become more common recently, codes and regulations may be outdated and may not allow for such practices. Zoning bylaws, site plan review, subdivision rules and regulations, wetland regulations and building codes should all be revisited. Some of the more prevalent site design techniques include (Whole Building Design Center):

- Minimizing imperviousness with permeable paving or landscaping to break up expanses of impervious surfaces;
- Directing runoff into or across vegetated areas to filter runoff and encourage groundwater recharge;
- Preserving or enhancing natural vegetation near parking areas, buildings, and other impervious expanses in order to slow runoff, filter out pollutants, and facilitate infiltration;
- Reducing street and sidewalk widths where appropriate;
- Removing curbs and gutters from streets, parking areas, and parking islands to allow storm water sheet flow into vegetated areas;
- Using devices such as bioretention cells, vegetated swales, green roofs, infiltration trenches, and dry wells to increase storage volume and facilitate infiltration;
- Installing vegetated roofs or garden roofs;
- Grading the site to encourage sheet flow and lengthen flow paths to increase the runoff travel time in order to modify the peak flow rate;
- Disconnecting impervious areas from the storm drain network and

maintaining natural drainage divides to keep flow paths dispersed;
- Disconnecting roof downspouts and directing storm water into vegetated areas or water collection devices;
- Installing cisterns or sub-surface retention facilities to capture rainwater for use in irrigation and non-potable uses;
- Using native plants (or adaptable species) to establish an adaptable and low maintenance landscape that requires less irrigation and are appropriate for the climatic conditions;
- Using naturally occurring bio-chemical processes in plants located in tree box filters, swales, planter boxes.

Minimize Impervious Surfaces
Although roads are a basic component of any development, minimizing the overall road network coverage can serve as a significant component to implementing low impact development practices. Streets comprise the largest share (40 to 50%) of impervious cover in residential developments. Narrower streets can result in an impervious cover reduction of 5 to 20% for a typical residential subdivision (Schueler, 1995). Residential streets rank as a major source area for many stormwater pollutants, including sediment, bacteria, nutrients, hydrocarbons and metals (Steur; Bannerman). The majority of pollutants deposited on or along street surfaces gets washed up during storm events into the storm drainage system. Reduction of impervious surfaces allows for increased natural filtration and less stormwater runoff and pollutant loadings.

Promoting the use of narrower streets will reduce the amount of impervious cover created by residential development, reducing associated stormwater runoff and pollutant load levels. Many residential streets can accommodate two travel lanes and two parking lanes. Streets can be narrowed without sacrificing emergency access, on street parking or vehicular safety. The applicability of requiring narrower residential streets may be dependent on the development size. According to the Stormwater Manager's Resource Center, narrower streets can be used in residential developments settings that generate 500 or less average daily trips (ADT) (generally about 50 single family homes) and may sometimes also be feasible for streets that are projected to have 500 to 1,000 ADT. Reducing road widths may not be suitable for roadways that carry greater volumes of traffic or are not expected to have a constant traffic volume over time. Implementation of narrowed road widths may require a revision to local road standards and zoning codes.

When laying out new roads, consideration should be given to existing natural drainage patterns, sensitive areas and surface waters. Road design should give consideration to natural features and post development conditions, including topography, natural drainage patterns, soils, climate, existing land use, estimated traffic volume and sensitive land areas. These factors all influence the impacts of nonpoint source pollution, erosion and sediment problems. Consideration for these natural features can greatly minimize erosion and sedimentation and prevent NPS pollutants from entering watercourses during and after construction.

Structural BMP Applications
Stormwater runoff generated from proposed development areas must be controlled before it is released from the development site. Stormwater controls will address both the quantity and quality of stormwater discharge from a development site in order to maintain and/or improve the quality of the streams and receiving waters within the planning area.

For new development that occurs within the planning area, the application of structural BMPs will be an integral component of meeting the water quality goals of the TMDL. The various aspects of structural BMPs associated with site development can be distinguished within the categories described below.

- Stormwater quantity control – the application of stormwater detention facilities to address the increase in the volume and peak rate of flow associated with runoff from a development site.
- Groundwater recharge – the application of infiltration practices to reduce the amount of surface runoff that is discharged from a development site and increase the contributions to groundwater that sustains stream baseflow.
- Stormwater water quality – the application of stormwater features that capture and may also treat pollutants captured within stormwater runoff. This approach applies to both construction and post-construction phases of a development site.

An increase in development and the associated impervious surfaces increases the volume of runoff from a development site and can, therefore, increase the quantity of physical and chemical substances that have a detrimental impact on the water quality of the receiving stream. The primary pollutants of concern within the planning area, identified in the TMDL, are TSS, TN and TP. All three of these pollutants have the potential to impact the aquatic health of the streams. Excess sediment within stormwater runoff can limit the areas in which certain species will locate, and can create many other problems. Nitrogen and phosphorous can lead to excessive algal growth, and a reduction in the available oxygen within a stream. As development occurs, there are two distinct periods of time where the control of water quality parameters must be considered: during construction and post-construction. Construction related water quality controls must primarily address the excess sediment that is present during construction activities, but are temporary in nature. By contrast, post development water quality controls must be able to control multiple pollutants over a long period of time. Considerations for both types of control are presented below.

Construction Phase Stormwater Control

The control measures included in the construction phase of development address runoff and sediment control.

Runoff control measures are applied to prevent or minimize the occurrence of erosion from disturbed areas. Acceptable BMPs recommended for use by the draft NPDES permit for the Big Darby Creek Watershed include rock check dams, pipe slope drains, diversion around exposed areas and protective grading practices.

Erosion control measures are applied to abate the release of eroded sediment from a disturbed area. Applications such as silt fence are significantly less effective at erosion control than sediment settling basins. The EAG recommends the use of sediment control ponds for all development sites, regardless of size. The current statewide NPDES permit (and the draft permit for the Big Darby Creek watershed) require that sediment basins be constructed for areas that receive drainage from disturbed areas of 5 acres or greater. At a minimum, the requirements of the Ohio EPA's permit must be followed within the Accord planning area, allowing for the use of silt fences and other erosion control BMPs to control sediment from sites less than 5 acres in size.

The draft NPDES permit for the Big Darby Creek watershed contains a target discharge of 45 mg/l TSS for up to a 0.75 inch rainfall in 24 hours that must be met for land area disturbances and is measured at the outfall of a sediment settling basin. The permit also requires the outfalls of such ponds be monitored initially and then quarterly through the project duration to insure compliance with the targeted sediment discharge limit from the basins.

More information regarding acceptable practices for both runoff and sediment control is contained within ODNR's *Rainwater and Land Development Manual.*

Post-Construction Stormwater Control

The unique sensitivity of the Darby watershed and particularly the Big Darby Accord planning area will require the application of techniques to ensure that the watershed is protected and that impacts of new development are minimized. Existing development and agricultural practices are already contributing to the impairment of streams including Clover Groff, Hamilton and Hellbranch Run and retrofitting existing development to address impacts may be beneficial and necessary to meet water quality goals.

The approach to developing within the Big Darby Creek Watershed will need to consider the unique environmental constraints and incorporate elements of good design and sustainability to ensure protection of important natural and biological resources, including water quality. Best management practices that incorporate innovative technologies are one mechanism available to assist with this effort. Best management practices are typically intended to control non-point source pollution on a development-site scale; however, their application can have positive watershed-wide impacts and can be applied to individual property owners, neighborhoods and municipalities.

Principles of Mitigating Water Quality Impacts

Information within this section is derived from the Northern Virginia Best Management Practices Handbook, prepared in 1992 by the Northern Virginia Regional Planning Commission and Engineers Surveyors Institute. The Northern Virginia BMP Handbook, which is a regionalized update of the nationally acclaimed BMP Handbook for the Occoquan Watershed, is intended for use by designers and reviewers of urban BMPs in meeting the water quality requirements and reflects initiatives related to improving water quality within the larger Chesapeake Bay watershed.

The basic mechanisms of pollutant removal operating in BMP facilities are the gravitational settling of pollutants, infiltration of soluble nutrients through the soil profile and, to a lesser extent, biological and chemical stabilization of nutrients, discussed below. Extended detention stormwater basins utilize settling as the primary removal process, with some nutrient uptake by the vegetative cover and soils. Wet ponds utilize settling as their principle removal method as well, but the existence of a permanent pool also promotes biological and chemical uptake and some infiltration through the soil horizon. Infiltration trenches rely heavily on filtration through the soil profile for pollutant removal with some biological and chemical stabilization of pollutants.

Settling
The establishment of a temporary or permanent pool of water, as is utilized in both extended detention dry and wet ponds, results in conditions which can settle out particulate pollutants between storms. The particulate materials settle into the pond bottom sediments while some of the soluble pollutants may pass through the sediment to the soil profile below by means of infiltration.

Biological and Chemical Processes
Removal of soluble pollutants is accomplished primarily through the mechanisms of chemical and biological stabilization of nutrients. The biological activities of some species of plants, algae and other aquatic organisms can serve as a mechanism for removing soluble nutrients from the water column. Dissolved oxygen levels, temperature, sunlight and pH affect the biological stabilization of a pond. The underlying soil has also been identified as contributing to chemical transformation of nutrients in wetlands and BMP facilities.

Soil Infiltration
Infiltration is usually achieved by lining a trench with a stone aggregate and a surrounding filter fabric to act as a filter medium and to remove much of the suspended sediments and attached contaminants before entering the soil horizon. Subsequent passage of water through the underlying soil column provides further filtering and pollutant removal through aerobic decomposition and chemical precipitation.

An important concern which arises from the infiltration process is the potential infiltration of polluted stormwater through the soil column to the water table. In some instances this could add contaminants to the underlying aquifer system. This is of special concern if the aquifer is to be used as a potable water supply in nearby areas. In addition, the contribution of nutrients to groundwater may affect local streams whose baseflow derives significantly from groundwater, thereby re-introducing nutrients into the surface water that the BMP was designed to protect.

Where soils are appropriate, infiltration provides substantial hydrologic benefits. Structural practices treat runoff, but more is needed to effectively prevent and minimize impacts. Therefore additional management practices are strongly encouraged such as stream setbacks or reduction of impervious areas that influence the layout and design of a development site so that important hydrologic areas are maintained and impervious surfaces are limited. (ODNR)

3.5.3 Performance Goals
The TMDL report for the Big Darby Creek defines the maximum loading for pollutants of concern within the Accord planning area to meet the objectives of water quality within the watershed. To achieve these maximum loadings values, the TMDL defines a percent removal for each of those pollutants from the existing conditions within the watershed. Within the Hellbranch Run watershed, the total allowable TSS load is 1,086,000 kilograms per year, which is a 95% reduction from the TSS load reaching the stream under existing conditions. Based on this information, the stormwater BMPs that will be utilized within the planning area will have to meet the removal requirements of the TMDL. Additional information regarding BMPs and their ability to remove pollutants from stormwater runoff is presented in Section 4.

It should be noted that discussions involving representatives of The Ohio State University, Ohio EPA, the Ohio Department of Natural Resources (ODNR) and other parties are on-going regarding the most appropriate measure of a performance goal that would meet the objectives for water quality suggested by the TMDL. These discussions are contemplating a numerical pollutant loading value (or concentration) requirement for release from a development site rather than a percent removal efficiency as currently defined in the TMDL. The numerical load number would allow developers to calculate an absolute pollutant load value, likely in milligrams per liter, which the development site could discharge to the receiving stream or downstream system.

Water Quality Volume
The pollutants of concern within the planning area are largely settle-able pollutants in that, if the velocity of the stormwater runoff is decreased to nearly zero, then the pollutants will settle out of the water column. This is true not only of the TSS components in stormwater runoff, but other pollutants that bind themselves to the solids and can then be captured through the settling process. Much of the pollution potential within a watershed comes from the most frequent rain events, which has been found to correlate to approximately the initial 0.75 inches of rainfall, often referred to as the "first flush" of stormwater runoff. The water quality volume is, therefore, that volume of water that is generated from a site during a 0.75 inch rainfall event. If the water quality volume is then captured within the limits of a development site for a certain period of time (usually varying from 24 to 48 hours) it is assumed that a large percentage of the pollutants of concern would be removed by the settling action that occurs during this time period.

The Ohio EPA has recognized the benefit that can be obtained by requiring a water quality volume draw-down time (the amount of time it takes for the water quality volume to be discharged from a development site), and within their draft permit include an equation to determine the actual water quality volume for a development site. In addition to the water quality volume calculation for all sites, the Ohio EPA includes draw-down times that are different for several different types of stormwater BMP applications.

BMP Pilot Study
A study of the application of various BMPs within a portion of the planning area was conducted to establish a scenario wherein the specified goals of the TMDL could be met. A summary report of that effort is provided in Appendix A.

Addressing Developed Areas
Many areas in the eastern portion of the planning area are already developed, especially in areas along Clover Groff and Hamilton Runs as well as Hellbranch Run. Similarly, these same areas are associated with declining water quality. As parts of the watershed develop, it will be equally important to identify ways to improve the conditions along these corridors. Developing areas typically provide considerably more opportunities to incorporate quantifiable land use-based and control-based structural and nonstructural BMPs. Once a landscape is firmly established, room may not exist to implement these techniques, or public reaction to change may prevent their implementation. In general, public education-style pollution prevention measures are the most applicable for "retrofitting" existing areas since they require no physical change in the landscape. However, these programs often do not result in quantifiable results. Street sweeping, as a control technique, is also highly applicable to existing urban areas and is often desirable for its positive aesthetic impact on the urban environment.

In agricultural areas, techniques to address water quality are also very important. Non-structural BMPs are more often associated with retrofitting an agricultural land use. Promoting stream setbacks as riparian corridors and filter strips are the most obvious and prominent techniques for addressing water quality impairments in these areas. A concept for "controlled drainage" has also been developed and promoted by individuals affiliated with The Ohio State University. This unique application utilizes control structures placed on-line with existing field tiles to create a mechanism for manipulating the ground water table within a agricultural field. The application promotes a higher groundwater table during the growing season when fertilizer and pesticide applications are most prevalent and impedes the release of the residual components of those chemicals to the receiving stream.

A major consideration will be the willingness of property owners, and the amount of adequate space and condition of the area. The identification of potential retrofit sites should be developed in cooperation with ODNR, Metro Parks, the local agricultural community and other key agencies that are already actively pursuing efforts in the watershed to improve water quality. Multi-agency pursuits often have added weight when it comes to funding priorities.

3.6 Stream Restoration

The TMDL for the Big Darby Creek watershed and other related Ohio EPA publications identify areas of impairment along the major watercourses within the planning area. The impairment constitutes a physical degradation of the stream channels that has led to a low or non-attainment of aquatic life use within the channel. Based on those findings, it is clear that the areas of highest degradation are along the upper reaches of the Hellbranch Run watershed, associated with Clover Groff and Hamilton Runs. The TMDL cites the conditions associated with an urbanizing watershed, as it impacts Clover Groff Run and is conveyed to Hellbranch Run. Other than the consequences of an urbanizing watershed, the most obvious component of impairment within both of these channels is that they have been hydromodified through the ditching process. The ditching process constitutes a widening and deepening of the channel and is most commonly associated with the drainage of adjoining agricultural fields. As an additional form of impairment, the riparian buffers along both Clover Groff and Hamilton Runs have been encroached upon by the practices of the adjoining urban and agricultural land uses.

A stream channel that has undergone the ditching process will most likely suffer from the significant impairments described below. In each case, it would take some physical correction to the channel morphology and/or adjoining buffer area to reverse the condition of impairment.

- A stream channel that is over-deep and over-side has a shallow gradient (slope) that reduces the ability of the channel to convey bedload materials that are a component of habitat within the stream. Low gradient streams are often characterized by a condition of aggradation, where sediment runoff from within the watershed accumulates within the channel, smothering substrate material and filling pools that are a source of habitat to the macro invertebrate and fish community, part of the overall ecosystem within a stream.

  The channel is often further impaired by the fact that it is now incised, meaning that it is disconnected from the natural floodplain. This disconnection leads to a condition where the channel now is required to carry a flow volume in excess of that associated with a stable channel condition. The resulting instability often leads to a higher rate of channel bank erosion that contributes more sediment loading to the stream system. The incised channel also loses the ability to utilize the floodplain for deposition of sediment and the other storage and filtering properties that could contribute to enhanced water quality.
- A stream channel with an impaired riparian buffer corridor loses a significant habitat attribute. The loss of the buffer removes a feature that provides several attributes. A vegetative corridor provides stability to channel banks while also enhancing the aquatic environment.

The findings of the TMDL are consistent in terms of the type and nature of the impairments to the stream channels within the Hellbranch Run Watershed. The TMDL indicates a large amount of the observed TSS within the watershed is attributed to channel bank erosion. Other collected information reveals a lower habitat value within segments of the channel system. These observations suggest that the conditions described above are associated with hydromodified stream channels, a leading cause of the degradation affecting the watershed. Based on the degree of degradation that has been documented for both Clover Groff and Hamilton Runs, and along the upper portions of Hellbranch Run, it seems unlikely that significant ecological benefit can be obtained by simply preserving those channels in their present conditions. In this case, stream morphology must be enhanced through some level of restoration to sustain a more desirable aquatic life use designation and to provide a meaningful contribution to the overall water quality within the watershed.

Although not the focus of any previous studies, there are numerous smaller tributary watercourses that discharge directly to the Big Darby Creek main stem. Observances of some of those stream channels suggest that they are also beginning to or are susceptible to degradation, due to either their position in the landscape (steep gradient) or because of adjoining land uses. Development within these smaller watershed areas can have an even more immediate impact to stream channel stability that would not only impact the tributary channel but also contribute sediment loading directly to Big Darby Creek.

3.6.1 Hellbranch Run Watershed Restoration Opportunities

The Hellbranch Run Watershed Forum (HWF) conducted an extensive investigation of restoration opportunities within the watershed, intending to identify a specific project to implement in cooperation with the U.S. Army Corp of Engineers under their Section 206 Ecosystem Restoration Program. Based on a specific and detailed evaluation process, the HWF has identified a stream restoration project in the vicinity of the confluences of Hamilton, Clover Groff and Hellbranch Runs. Further details regarding the nature and extent of the project and the program for implementation will be developed by the HWF.

The Accord general land use plan indicates a priority stream restoration zone for the entirety of the Clover Groff and Hamilton Runs. The degradation aspects noted previously are pervasive throughout this area. Meaningful restoration of these watercourses will likely require extensive physical alteration of the existing stream channels to provide for the appropriate morphology and habitat features, described later in this section. In identifying restoration opportunities within this watershed, the following should be considered.

- **Available land area along the stream corridor.** The width of the corridor needed to accomplish the restoration can depend on the restoration technique and should account for an adequate buffer area to allow for the vegetative corridor that is vital to the restoration goal. At a minimum, the width of that corridor should be the setback calculated in accordance with the criteria for the Stream Corridor Protection Zone (SCPZ), discussed in more detail in Section 4.0.
- **Position of the project along the watercourse.** From the standpoint of stream ecology, there is an added benefit to the restoration project if there is some connectivity to other areas of the watercourse where there is a sustained aquatic habitat condition. Considering this aspect, initial stream restoration activities should focus on areas in the lower portions of the both Clover Groff and Hamilton Runs to gain the benefit of the connectivity to portions of Hellbranch Run that have achieved a higher aquatic life use designation.

3.6.2 Other Restoration Opportunities

For the portion of the planning area that is directly tributary to the Big Darby Creek main stem, there is no specific priority for stream restoration. Opportunities should be identified in conjunction with development activities as they occur within the smaller watershed areas. Because of the small nature of these tributary channels, restoration should focus on channel stability to account for the changing watershed hydrology that may result from the pending development activities. Aquatic habitat use should also be enhanced but that consideration is on a different level of magnitude than the stream channels referenced within the Hellbranch Run watershed.

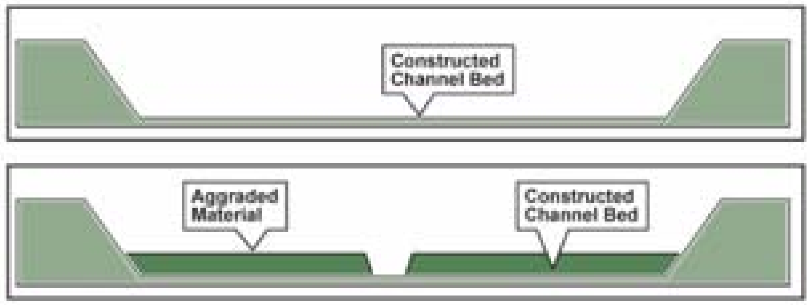


Figure 3.11 Over-wide Channel Design
Source: Attachment B, Ohio EPA Permit No.: OHC100

3.6.3 Stream Restoration Techniques

The approach to stream restoration depends on the objectives and goals that are being sought related to the ecosystem. The two approaches described below have different value in relationship to benefiting the aquatic life use attainment and water quality. The cost of stream restoration can vary depending on the technique applied; however, either approach can incur a significant cost. The majority of the costs are related to land acquisition, design and construction. It is foreseeable that stream restoration on a large scale can only occur if financial resources from a variety of sources are pooled together.

Over-wide Channel Technique
The over-wide channel technique is one that is often described by ODNR and has been developed as a concept specific to headwater streams that may develop a different ecosystem than expected in a typical stream system. The technique is defined by the excavation of the overbank area along an incised (over-deep) channel to bring the elevation of the floodplain down to or nearly to the flowline of the existing channel. The excavated floodplain is expected to be no less than 5 times and maybe up to 10 times as wide as a stable channel width for that stream. The result of the application of this technique is a valley that continues to have the shallow gradient (slope) of the impaired stream channel, as that is not adjusted through the restoration process.

Application of over-wide channel technique.
Source: EMH&T

The primary function of this restoration technique may be that it is now capable of assimilating a significant load of sediment transported through the stream system. The accumulation of sediment within the over-wide channel is expected, reducing the loading further downstream in the system, and can lead to the formation of a stable channel feature though the natural process of aggradation. Alternatively, portions of the excavated valley can take on the qualities of a wetland environment, due to the connection to groundwater and stream baseflow. The wetland environment, although not conducive to aquatic habitat conditions, can provide water quality benefits through the capture of sediments and the capture and treatment of nutrients that are processed by the evolving vegetative community.

Benefits
A simple design process that is also not complicated to construct. Since the flowline of the existing channel is not affected, this technique can either be applied on a large-scale or on a localized level. Water quality attributes are likely to occur related to the assimilation of TSS, TN and TP within the stream system.

Drawbacks
The resulting ecosystem within the stream channel may not facilitate the aquatic life use designations promoted by the Ohio EPA. There is some uncertainty regarding the formation of either a channel or functional wetland, which will be affected by the nature of pollutants being conveyed in the stream system and the watershed hydrology.

Natural Stream Channel Design Technique
Natural stream channel design follows the principles of conventional geomorphology, which identifies a fairly distinct structure related to a functional and stable stream structure. The Ohio EPA's Qualitative Habitat Evaluation Index (QHEI) is based on the physical components of a channel that are consistent with this technique. Essentially, this technique includes channel features such as functional pool (deeper water areas) and riffles (high-energy grade control features) and a substrate material consistent with the bedload capacity of the stream. All of these features are conducive to both macro invertebrate and fish habitat expected to achieve a certain aquatic life use designation.

The application of natural channel design requires the determination of stable channel geometry through the collection of data from an existing stable channel reach and the application of empirical design methods. Applied to channels within the Hellbranch Run watershed, this technique would likely involve both the excavation of the overbank area to establish the stable channel geometry and re-connect that channel to the floodplain, and the placement of in-stream material to accomplish the pool-riffle complex and to alter the gradient of the stream channel. Furthermore, the pattern of the stream channel would be altered to be less linear and have the characteristics of a meandering stream.

Benefits
A functional natural stream channel design will be more likely to attain the aquatic life use designations promoted by the Ohio EPA. The measure of a healthy stream, which relies on stable stream geomorphology and the success of macro invertebrates and fish, will more likely be met. A stream channel with the attributes described above is more likely to be a feature that is appreciated by the community and integrated as a passive recreational attribute.

Drawbacks
The complexity of design and construction may lead to higher overall project costs when compared to other techniques. Due to the likely alteration of stream flow line elevation and gradient, it is often not possible to apply this technique unless it is over a longer contiguous reach of channel, which would require that it be accomplished only as part of a large-scale project.

Stream Naturalization
The concept of stream naturalization is discussed in an article published in *Environmental Management, Volume 24, No.3*, entitled "Interaction Between Scientists and Nonscientists in Community-Based Watershed Management: Emergence of the Concept of Stream Naturalization". From that article, it is stated "that the goal of naturalization is to drive the (stream) system as a whole toward a state of increasing morphological, hydraulic and ecological diversity, but to do so in a manner that is acceptable to the local community and sustainable by natural processes, including human intervention". This approach to stream restoration is derived from the premise that restoration activities should consider both the social and ecological consequences of that activity. The social consequences are related to the perceptions of the residents of the watershed regarding the purpose and value of the watercourses,

particularly those who rely on them for agricultural drainage or flood control.

Stream naturalization includes natural stream channel design but allows for a departure from that approach, recognizing the fundamental limitations described below. The factors listed below are not intended to discount the growing and evolving body of knowledge and practice related to stream restoration using natural channel design. In recent years, considerable knowledge has been gained by the collective interests who continue to draw from experience and apply new solutions toward finding a correct balance that supports sustainable designs.

- Restoration of a stream channel to a "natural" state indicative of the pre-disturbed condition will be based on anecdotal references, influenced by changes in the environment that are a departure from the actual pre-disturbed condition of the watercourse that is being restored.
- The watershed associated with the stream channel may contain conditions, such as land uses, that are not conducive to sustaining a "pristine" restored channel. Altered hydrology and or the influx of sediments and other pollutants attributed to either agricultural or urbanized land uses are examples of these conditions.

The premise of stream naturalization is that a stream system may "passively recover from past channelization activities, eventually assuming a form and function generated by and compatible with the prevailing environmental conditions". This suggests that a watercourse, left alone, can regain ecologically sound characteristics; however, it also suggests that those characteristics will be influenced by the surrounding watershed. Given the substantial hydromodification along Clover Groff and Hamilton Runs and the mix of land uses anticipated within the watershed, it is reasonable to assume that the passive recovery of those channels will require an extended period of time, likely decades, and that the final outcome will be unpredictable. Conceivably, they may never fully recover. To address these shortcomings and accelerate the naturalization process, a variety of physical modifications that essentially de-channelize the stream can be performed. The predominant modification is to reestablish the stable bankfull condition and create an adequate connected floodplain to accommodate the dynamic condition that would allow for the naturalization process. In an incised channel, that typically means excavation of the overbank areas to an elevation consistent with the bankfull depth of the channel. From that point, it is anticipated that the on-going process of stream degradation and opposing aggradation will eventually begin to influence the pattern and profile of the channel, trending toward a point of morphological stability.

The benefits and drawbacks listed below assume that the stream naturalization technique is applied as a departure from the strict interpretation of natural channel design; otherwise, the benefits and drawbacks of that technique can be referenced from the earlier discussion. The assumption is that a more passive approach to stream naturalization is being considered that may include re-establishment of the bankfull condition and a connected floodplain.

Benefits

As with the over-wide channel technique, this stream restoration approach can involve a simple design and construction process, reducing costs associated with those activities. A stable bankfull channel dimension must be determined, but the other morphological parameters associated with natural channel design are not associated with this approach. Assuming the flow line elevation and gradient of the channel will not be altered, the stream naturalization process can be applied to shorter as well as an extended reaches of a watercourse.

Drawbacks

Similar to the over-wide channel technique, the outcome of stream naturalization may be difficult to predict. Whether a geomorphically stable channel evolves and whether that channel contains elements supporting a higher aquatic life use designation may only be determined over the course of time. That outcome is a common link between all of the stream restoration techniques described in this document. There can be no certainty on how each will perform in the long run when it comes to biological integrity; however, in this case, some of the known elements to support that condition are left to evolve over time.

3.6.4 Funding for Restoration Activities

Typically, funding for stream restoration must come from a combination of resources. Stream restoration can be identified as a priority when determining how funding from the general revenues generated by the Accord should be allocated. In doing so, the Accord could identify the stream corridors along Clover Groff and Hamilton Runs as priority areas for acquisition of open space. Where development is anticipated, the set-aside of that stream corridor will ultimately occur. Alternatively, the Accord revenue could be used to provide supplemental funding for the stream restoration activities in support of grant applications, described below.

There are grant funding programs that may be available to the Accord or other entities that would assist in funding stream restoration activities. Examples of these programs are the Clean Ohio Fund, administered locally through the Mid-Ohio Regional Planning Commission, and the 319 Grant program, administered through the Ohio EPA.

Another method of developing funding for stream restoration is through the process of mitigation. For the purpose of this discussion, mitigation is a process associated with impacts to stream corridors that may occur in conjunction with site development or public infrastructure improvements. The draft NPDES permit for the Big Darby Creek watershed stipulates mitigation for impacts to stream buffers, requiring restoration of other stream buffers or actual channel restoration. Furthermore, impacts that occur directly to existing stream channels must meet both state and federal permitting guidelines that also require mitigation. Typically, mitigation is in the form of an equal or greater amount of channel restoration and stream buffer preservation.

To apply this concept to stream restoration opportunities within the Accord planning area may involve a system that is based on an in-lieu fee payment whenever development activities impact stream corridors within the planning area. Fees collected for the purpose of mitigation would then be pooled and applied to stream restoration. This process requires a responsible entity to 'manage' the collection of mitigation funds and apply them to stream restoration opportunities that would meet he criteria of the NPDES permit and other state / federal permitting guidelines. There is a defined process for establishing this mechanism that would need to be followed by the Accord or some other designated entity.

3.6.5 Regional Planning for Stream Restoration

Numerous variables may influence stream restoration within the Accord planning area, including the chosen restoration technique and where and when restoration opportunities may arise based on future development. To establish more formal guidelines that promote uniformity and a coordinated approach to stream restoration, it is recommended that there be an oversight group responsible to the Accord Advisory Panel that is comprised of individuals knowledgeable in the field of stream restoration and connected to the implementation of the various components of the land use plan. The knowledge of these individuals should encompass the various sciences that deal with stream restoration, including geomorphology and ecology. The group should also contain non-scientists who are representatives of the watershed and can share the perspective of the individuals who will "use" the restored stream channels.

Section 5.3.1 discusses the formation of an Environmental Monitoring Group (EMG) to oversee the recommended water quality monitoring. This group would likely have the technical capabilities required for coordinated stream restoration oversight and should therefore assist with developing guidelines for stream restoration. A primary goal of this group should be to establish priority goals for stream restoration. Consideration should include demonstration of ecological integrity and achieving the aquatic life use designations in accordance with the TMDL.

3.7 Floodplain Management

Communities participating within the National Flood Insurance Program (NFIP) have adopted regulations that determine the extent to which encroachments can occur within the 100-year floodplain and floodway. The regulations must meet a minimum standard established by FEMA. Within the ten participating jurisdictions of the Big Darby Accord, there are some variations on what the standard is for floodplain management, but they are consistently applied in that all grading/filling activities within the 100-year floodplain require a permit from the local jurisdiction. Generally speaking, the NFIP-derived regulations create the restrictions listed below.

- Within the designated floodway, no activity shall occur that would cause an increase in the 100-year flood elevation, unless there is prior review and approval of the project by FEMA. The affirmative response from FEMA in this situation is a Conditional Letter of Map Revision (CLOMR) that must be issued to the local jurisdiction prior to the issuance of a permit for that project.
- Within the remaining portion of the 100-year floodplain, outside of the designated floodway, grading and filling activities may be permitted by the local jurisdiction without the benefit of a technical analysis to determine the impact to flood elevations. In this case, fill may be placed to remove areas from the 100-year floodplain, with the likely intent to change the land use in that area.

The regulations contain specific provisions that provide adequate protections for any development that would occur within the floodplain, requiring that any structures be properly elevated. Using the City of Columbus as an example of a higher standard with respect to floodplain management, they have adopted criteria requiring that structures be elevated at least 1.5 feet above the 100-year elevation and that there be a minimum setback of 20 feet from the revised limit of the floodplain. Due to the restrictions related to encroachment within the designated floodway, grading/filling within that area related to development is generally avoided. Encroachments within the floodway related to roadway crossings are common as a practical measure to avoid bridge or culvert designs that are excessively expensive to construct.

It should be noted that Brown Township has adopted a comprehensive plan recommending that no grading/filling occur within the 100-year floodplain. Furthermore, as one of Columbus' higher standards, their revised *Stormwater Drainage Manual* requires that any fill placed within the 100-year floodplain be mitigated with an equal volume of excavation, performed in such a manner that there is no loss of floodplain storage.

Stream restoration is an anticipated activity within a designated 100-year floodplain and floodway. Furthermore, referring to Section 4.2, there may be circumstances where fill is placed within the 100-year floodplain in conjunction with stream restoration. Policy recommendations for floodplain management pertaining to these circumstances are presented in Section 4.7.4.