Powder Mill Targeted Watershed Assessment

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August 2004

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POWDER MILL – TARGETED WATERSHED STUDY

1.0 STUDY OBJECTIVES

Baltimore City Department of Public Works (DPW) has requested a targeted watershed study of the Powder Mill subwatershed of the Gwynns Falls in order to meet the requirements of the City's NPDES permit. This study is a sub-study of the overall Gwynns Falls Water Quality Management Plan.

Components of this report include:

- Identification of Water Quality Problems within the Powder Mill watershed
- Identification and Mapping of Restoration Projects
- Restoration Project Analysis

Continuing the comprehensive watershed approach started in the Gwynns Falls Water Quality Management Plan, this study was conducted for the entire Powder Mill subwatershed including both the City and County portions of the watershed.

2.0 WATERSHED DESCRIPTION

The Powder Mill watershed is located partially in Baltimore City and partially in Baltimore County. Large tributaries in the County and City join together near Northern Parkway and Liberty Heights Road in Powder Mill Park. The Baltimore County portion runs through local neighborhoods and Power Mill Run Park. The Baltimore City portion runs through the Seton Industrial Park. Both portions of the subwatershed have a significant amount of urbanization (existing DCIA 34%). Residential land uses comprise approximately 59% of the subwatershed (and dominate the County portion) and commercial/industrial areas comprise 18% of the subwatershed and comprise a large portion of the City's part of the subwatershed. Table 1 summarizes the watershed characteristics for Powder Mill. It has a drainage area of 4.1 square miles. Figure 1 shows the location of the Powder Mill watershed within the Gwynns Falls.

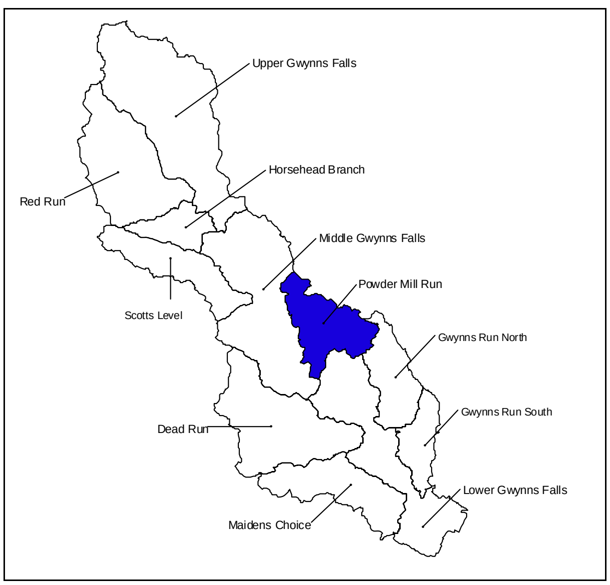

Figure 1: Powder Mill watershed within the Gwynns Falls watershed

Table 1: Powder Mill summary table

Drainage Area:	**4.09 square miles**	
Stream Length	**5.9 miles**	
Physiography:	**Piedmont**	
Soil Association(s):	**2% B, 86% C, 12% D**	
Dominant Bed Materials:	**Cobble**	
Dominant Flow Regime:	**Perennial**	
Dominant Rosgen Level II Classification:	**B – 47%, F – 20%**	
Average Unstable - Stable Reach Ratio:	**30%**	
Land Use	**Existing**	**Ultimate**
% Directly Connected Impervious Area	**33.8%**	**36.2%**
% Residential Development	**58.7%**	**63.4%**
% Commercial/Industrial	**33.5%**	**32.5%**
% Agricultural	**0.0%**	**0.0%**
% Forested/Wetlands	**7.8%**	**4.1%**

Stream Network

The Powder Mill watershed is composed of first, second and third order streams. Table 2 shows the breakdown of stream order within the City and County. 3.4 miles of stream are located in Baltimore County and 2.5 miles of stream are located within Baltimore City.

32 Corps reaches and 8 cruised reaches were assessed in the Powder Mill watershed. Figure 2 shows the breakdown of reaches assessed in this study. The Corps reaches were originally assessed by the Army Corps of Engineers study. PB verified the information obtained during the field assessment, but did not collect all of the data collected during the rapid cruise reach assessment study.

Table 2: Stream order in the Powder Mill watershed

Stream Order	Baltimore City	Baltimore County
First Order	**38.6%**	**28.6%**
Second Order	**55.5%**	**50.7%**
Third Order	**5.9%**	**20.7%**

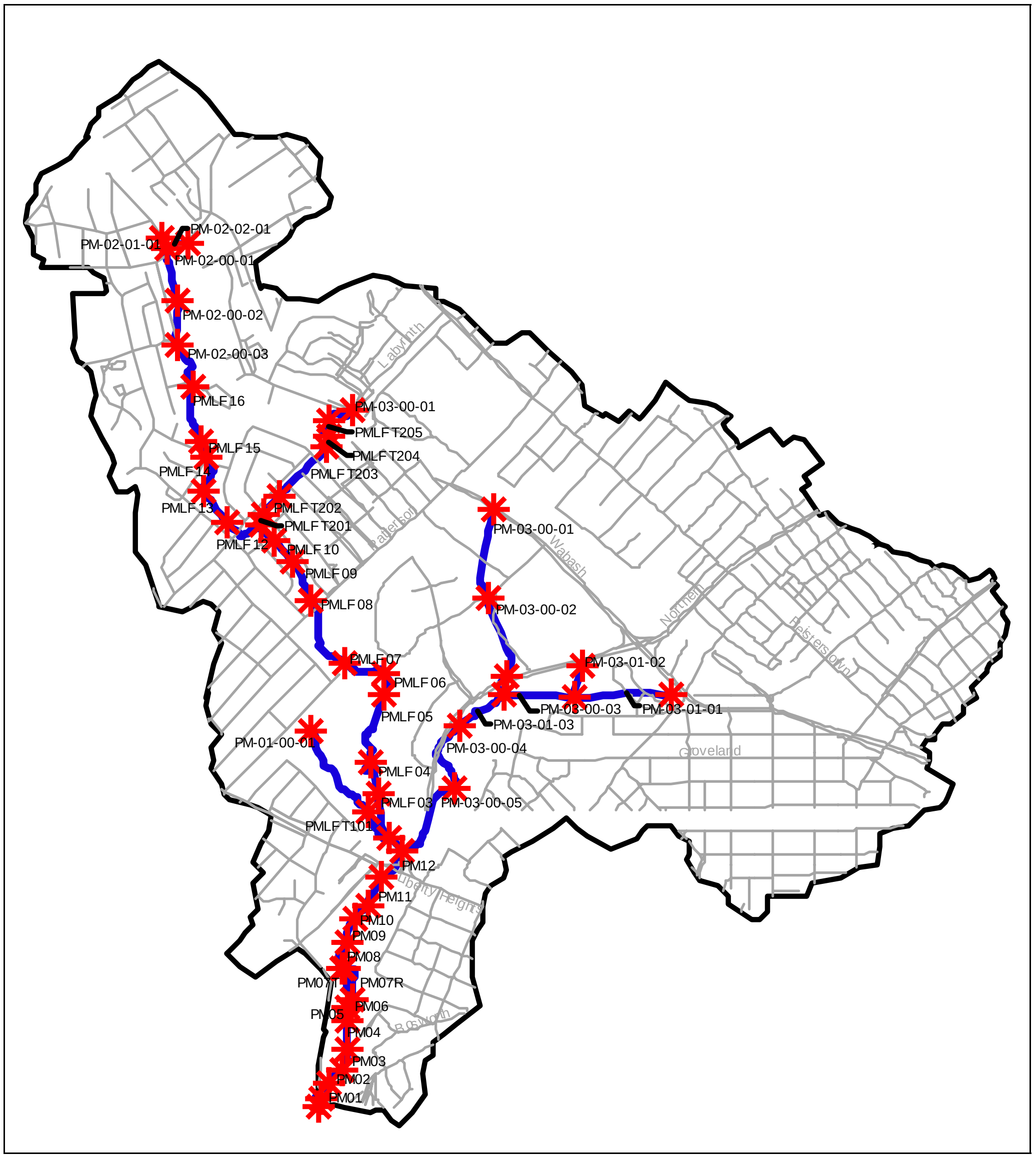

Figure 2: Powder Mill stream network and major roads.

Land Use

Land use information was taken from the Gwynns Falls Water Quality Management Plan. Two land use scenarios were analyzed. The existing condition was taken from the 2000 Maryland Department of Planning land use data. The ultimate development land use condition was taken from GIS Hydro 2000. GIS Hydro 2000 took current zoning data from Baltimore City and County and assigned each zoning classification into a land use category. The land use information is explained in detail in Chapter 1 of the Gwynns Falls Water Quality Management Plan (PB 2004). Figures 3 and 4 show the existing and ultimate development land uses respectively.

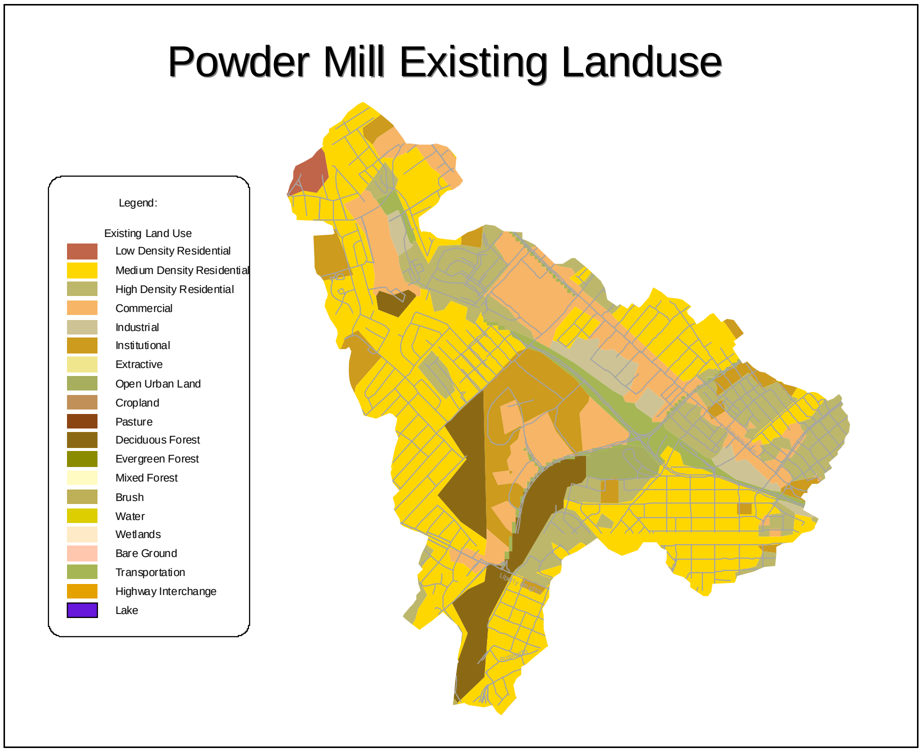

Figure 3: Powder Mill existing land use (MDP 2000)

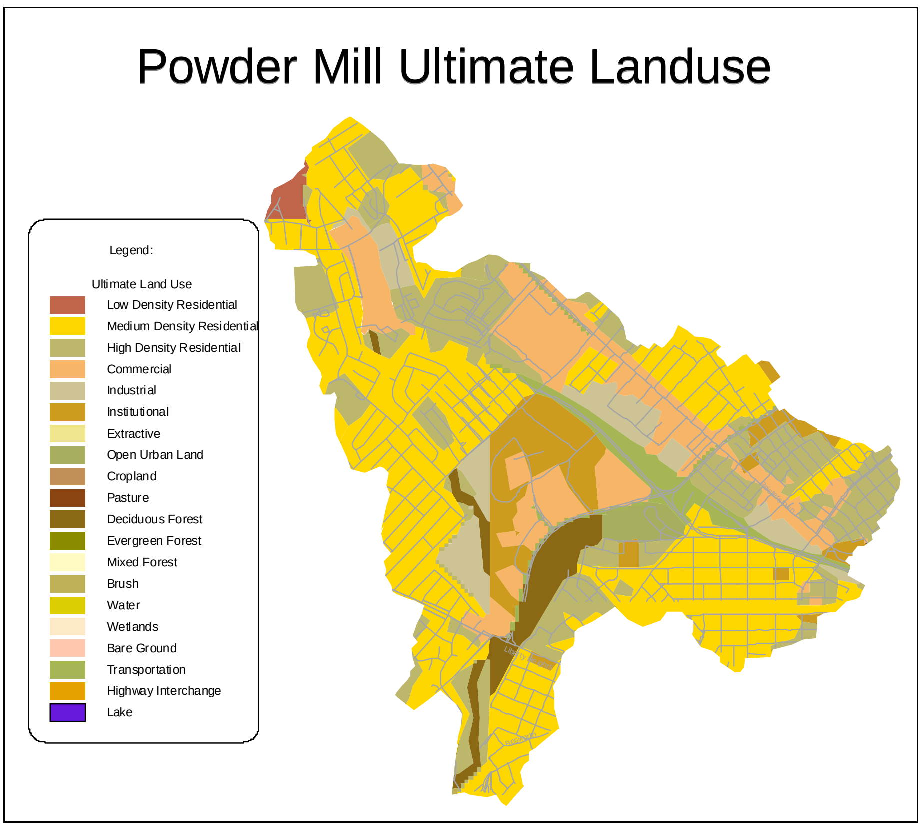

Figure 4: Powder Mill ultimate land use (GIS Hydro 2000)

3.0 FIELD EVALUATION METHODOLOGY

Channel Morphology

Flow Regime

Streamflow exhibits a strong influence on channel morphology, aquatic habitat and riparian vegetation. Flow regime categories were based on the Level III Rosgen Methodologies. Table 3 lists the categories used in this field assessment.

Table 3: Flow regime categories for the Powder Mill cruised reaches

Code	Flow Regime Category
E	Ephemeral stream channel, flow only in response to precipitation
S	Subterranean stream channel, flows parrallel to and near the surface various seasons
I	Intermittant stream channel, flow which exists seasonally or sporadic
P	Perennial stream channel, flow which exists year round

Stream Size

Bankfull width is often used to assess stream size because of the many hydrologic and geomorphic interpretations that can be derived from width measurements. Stream size can be used to provide prospective for interpreting hydraulic processes, sediment transport and biological processes. Table 4 lists the stream size categories based on Rosgen Level III classification that were determined from the measurement of bankful width for each stream reach.

Table 4: Stream size classification categories for the Powder Mill cruised reaches

Code	Stream Size
S-1	Bankfull Width less than 1 foot
S-2	Bankfull Width from 1 to 5 feet
S-3	Bankfull Width from 5 to 15 feet
S-4	Bankfull Width from 15 to 30 feet
S-5	Bankfull Width from 30 to 50 feet
S-6	Bankfull Width from 50 to 75 feet
S-7	Bankfull Width from 75 to 100 feet
S-8	Bankfull Width from 100 to 150 feet
S-9	Bankfull Width from 150 to 250 feet
S-10	Bankfull Width from 250 to 350 feet
S-11	Bankfull Width from 350 to 500 feet
S-12	Bankfull Width from 500 to 1000 feet
S-13	Bankfull Width > 1000 feet

Entrenchment Ratio Range

Entrenchment describes the relationship of a river to its valley and landform features. The entrenchment ratio describes the vertical containment of a stream. It has been defined by Rosgen to be the ratio of the width of the floodprone area to the surface width of the bankfull channel. The entrenchment ratio was computed for each stream reach and then divided into three categories: slight entrenchment, moderate entrenchment and entrenched. Table 5 shows the entrenchment characteristics of the Powder Mill Watershed.

Table 5: Entrenchment ratio ranges for the Powder Mill cruised reaches

Category	Entrenchment Range
Slight to No Entrenchment	**> 2.2**
Moderate Entrenchment	**1.41 to 2.2**
Entrenched	**1.0 to 1.4**

Sinuosity Range

Channel sinuousity is the ratio of stream channel length to down-valley distance. It is also defined as the ratio of valley slope to channel slope. Sinuosity is a primary indicator of Rosgen stream type and also provides an indication of how the stream slope has adjusted in comparison with the valley slope. The actual sinuosity was not field measured for each cruised reach, however, the sinuosity range was determined from the aerial photogrammetry and visually verified in the field. Table 6 shows the classification categories used in this analysis.

Table 6: Sinuosity range for the Powder Mill watershed cruised reaches

Code	Category
Low	**Sinuosity Ratio of 1.0 to 1.2**
Moderate	**Sinuosity Ratio of 1.2 to 1.5**
High	**Sinuosity Ratio of greater than 1.5**

Depositional Features

Depositional patterns are easily observed features that are beneficial in interpreting stream condition. Depositional patterns can be used to illustrate the effects of past land management on sediment supply and storage and the effects on channel form and stability. Table 7 lists the depositional features used to assess the cruised reaches in this study.

Table 7: Depositional features of the Powder Mill cruised reaches

Code	Category
B-1	**Point Bars**
B-2	**Point Bars with Few Mid Channel Bars**
B-3	**Many Mid Channel Bars**
B-4	**Side Bars**
B-5	**Diagonal Bars**
B-6	**Main Branching with Many Mid Bars and Islands**
B-7	**Mixed Side Bar and Mid Channel Bars exceeding 2-3 times the width**
B-8	**Delta Bars**
NONE	**NONE**

Channel Substrate

Channel bed and bank materials influence the cross sectional form, plan view and longitudinal profile of rivers. They also determine the extent of sediment transport and resistance to hydraulic stress. It is also important for addressing the biological function and stability of rivers.

Table 8 shows the channel substrate categories used in the cruised reach assessment. In addition to noting a primary channel substrate, bimodal channel substrates were considered and documented. There were no physical samples taken. The channel subpavement was not assessed.

Table 8: Channel substrate types for the Powder Mill cruised reaches

Category
Boulder
Cobble
Gravel
Sand
Silt and Silt/Clay

Stream Classification Type (Rosgen)

The cruised reaches were visually assessed and classified according to Rosgen's stream classification system. The entrenchment ratio, width to depth ratio and sinuosity were used in stream type selection. The majority of the watershed's streams can be classified as B, F or C stream types. Table 9 shows the breakdown of stream types within the Powder Mill Watershed.

Table 9: Rosgen stream classification for Powder Mill cruised reaches

Rosgen Classification	Stream Type Description
A	Steep, entrenched, cascading, step pool stream, high energy and debris transport, very stable if bedrock or boulder dominated channel
B	Moderately entrenched, moderate gradient, riffle dominated channel, very stable plan & profile
C	Low gradient, meandering, point-bar, riffle/pool
D	Braided channel with longitudinal and transverse bars. Very wide channel with eroding banks
E	Low gradient, meandering riffle/pool stream with low width to depth ratio, very efficient and stable, high meander width ratio
F	Entrenched, meandering riffle/pool channel on low gradients with high width to eepth ratio
G	Entrenched gully step pool and low width to depth ratio on moderate gradients

Channel Slope Range

The water surface slope is a major determinant of river channel morphology and of its related sediment, hydraulic and biological function. An average slope range was estimated for each stream reach. Detailed profile measurements were not taken for each reach. Table 10 shows the slope ranges used in the Cruised Reach assessment.

Table 10: Channel slope ranges for the Powder Mill cruised reaches.

Category
Channel Slope < 2%
2% < Channel Slope < 4%
Channel Slope > 4%

Width to Depth Ratio Range

The width to depth ratio is defined as the ratio of the bankfull surface width to the mean depth of the bankfull channel. The width to depth ratio is key to understanding the distribution of available energy within a channel and the ability of various discharges within the channel to move sediment. Of Rosgen's Level II parameters, the width to depth ratio is the most sensitive and positive indicator of trends in channel instability.

For channels with high width to depth ratios, the distribution of energy in the channel is such that stress is placed within the near bank region. As the width to depth ratio increases, the hydraulic stress against the banks also increase and bank erosion is accelerated. The accelerated bank erosion is usually the result of high velocity gradients and high boundary stress.

The actual width to depth ratio was computed using the field measured bankfull width and average bankfull depth. Table 11 summarizes the categories used in the width to depth ratio analyses. The categories for the width to depth ratio were taken from the Rosgen classification system. Cutoff values of 12 and 40 are used to distinguish between the various Rosgen stream types.

Table 11: Width to Depth ratio categories for the Powder Mill cruised reaches

Category
Width/Depth Ratio < 12
40 > Width/Depth Ratio > 12
Width/Depth Ratio >40

Meander Pattern

Channel meander patterns provide a plan view of lateral channel adjustments, meander width ratios and lateral containment characteristics for all of the stream types. The meander patterns provide insight into how the stream channel adjusts its slope in relation to the stream valley. Table 12 shows the Rosgen meander classification.

Table 12: Meander patterns of the Powder Mill cruised reaches

Rosgen Code	Category
M-1	Regular Meanders
M-2	Tortuous Meanders
M-3	Irregular Meanders
M-4	Truncated Meanders
M-5	Unconfined Meander Scrolls
M-6	Confined Meander Scrolls
M-7	Distorted Meander Loops
M-8	Irregular Meanders with Oxbows and Oxbow Cutoffs

Bank Failure Assessment

The bank failure assessment is based on a combination of field measured parameters:

- Length of bank instability
- Average height of bank instability
- Ratio of Unstable to Stable Bank
- Bank Height versus Bankfull Depth (low, medium or high erosion potential)
- Bank Angle
- Denisty of Roots
- Particle Size

AVERAGE BANK HEIGHT VERSUS BANKFULL DEPTH

Bank Erosion Potential was one of the key factors in the stream stability assessment. Varying erosion potential rankings were established based on the location of the bank height and the bankfull elevation. Low erosion potential ratios were between 1.0 and 1.19, medium erosion potential ratios were between 1.2 and 1.59, and high erosion potential ratios were greater than 1.6.

BANK ANGLE

The bank angle data was rated for erosion potential as follows: low potential was assigned to banks sloping away from the stream, medium potential was assigned to nearly vertical banks and high potential was assigned to undercut banks, sloping in towards the stream.

ROOT DENSITY

Root density was another factor considered in the bank failure analyses. Low erosion potential was given to banks with dense roots throughout the entire bank, medium potential was given to banks with dense roots in the upper half of the banks and high erosion potential was given to banks with minimal root density.

STREAMBANK SUBSTRATE

Streambank substrate was the fourth component of the bank failure analysis. Low erosion potential was given to banks composed of cobbles, boulders or bedrock. Medium erosion potential was given to sand banks and high erosion potential was given to silt and clay banks.

UNSTABLE TO STABLE STREAM RATIO (OR PERCENTAGE)

The final factor in the bank erosion analysis was the ratio of unstable stream length to total stream length. Low erosion potential was given to reaches with an unstable to stable length ratio of less than 25 percent. Medium erosion potential was given to reaches with an unstable to stable ratio between 25 and 50 percent. High erosion potential was given to any reaches that had more than 50% unstable to stable lengths.

Channel Stability – Vertical and Lateral

Each stream reach was assessed for its vertical and lateral channel stability. Table 3.12 was used to assist the field crews with the classification of aggrading or degrading. Watershed wide, 63% of the cruised stream reaches assessed were vertically stable. However, over 49% of the cruised stream reaches assessed were laterally unstable.

Table 13: Field Indicators to assess vertical and lateral stream stability.

Field Indicators for Stream Degradation or Aggradation		
Observed Condition	**Degrading**	**Aggrading**
Channel Form:		
Straightened Channel	**X**	
Active Head Cuts	**X**	
Active Meander Development		**X**
Channel Avulsions		**X**
Loss of Channel Bars	**X**	
Channel Bars Developing		**X**
Mass Wasting of Banks	**X**	
Vertical or Steepened Banks	**X**	
Tributary Stream Hanging or Steepened	**X**	
Hydraulic Conditions:		
Decrease in Energy Slope		**X**
Increse in Energy Slope	**X**	
Stage Control Downstream		**X**
Stage Control Upstream	**X**	
Dam or Reservior Upstream	**X**	
Hydrologic Conditions:		
Logging/Land Clearing		**X**
Watershed Urbanizing	**X**	
Clearwater Diversion		**X**
Drought Period		**X**
Wet Period	**X**	
Sediment:		
Reduction in Supply	**X**	
Increase in Supply		**X**
Alluvial Fan Downstream	**X**	
Alluvial Fan Upstream		**X**
Vegetation:		
Vegetation High Relative to Flow Line	**X**	
Trees Leaning into Channel	**X**	

Geologic Controls

Any geologic controls (bedrock) found in a reach were noted in the data collection forms. The results sections summaries any geologic controls found in Powder Mill reaches.

Channel Evolution Stage (Schumm, et al 1984))

The incised channel evolution model (Schumm et al, 1984) was used to classify each of the cruised stream reaches. The intent of the channel evolution model is to determine if the reach is in a stable, incising, widening or stabilizing state. The five stages are defined as follows:

- **Stage I**: Well developed baseflow and bankfull change; consistent floodplain features easily identified; *one terrace* apparent above active floodplain; predictable pattern and stream bed morphology; floodplain covered by diverse vegetation; stream banks less than 45 degree angle.

- **Stage II**: Headcuts; exposed cultural features; sediment deposits absent or sparse; exposed bedrock; streambank slopes > 45 degree angle.

- **Stage III**: Streambank sloughing sloughed material eroding; streambank slopes 60 degrees, vertical or concave.

- **Stage IV**: Streambank aggrading; sloughed material not eroded; soughed material colonized by vegetation; baseflow, bankfull and floodplain channel developing; predictable, sinuous pattern developing; streambank slopes less than or equal to 45 degrees.

- **Stage V**: Well developed baseflow and bankfull channel; consistent floodplain features easily identified; *two terraces* apparent above active floodplain; predictable pattern and streambed morphology; streambank angle less than 45 degrees.

Table 14 defines the channel evolution stages within the Powder Mill Watershed. Stages I and V were assumed to be stable, Stage II and III were assumed to be degrading and Stage IV was assumed to be aggrading.

Table 14: Channel Evolution Stage (Schumm et al) for the Powder Mill Cruised Reaches

Channel Evolution Stage	Short Description
I	**Stable**
II	**Headcuts, Degradation**
III	**Degradation**
IV	**Aggradation**
V	**Formerly unstable, returning to stable state**

Channel Disturbances

Bank Instabilities

Localized bank instabilities were recorded in each reach. The length and average height of unstable bank were measured in each reach. Separate values were recorded for the left and right bank. Bank instabilities that threatened private structures were also recorded. Additional information on bank instabilities can be found throughout the channel morphology and habitat section of the cruised reach assessment.

Altered Channels

Due to the large amount of urbanization that has already occurred within the Powder Mill watershed, many stream channels have been altered from their natural state. The field forms required the field crew to assess whether each of the stream reaches was impacted by the following:

- Channel Straightening
- Channel Widening
- Concrete Lining
- Riprap Lining
- Gabion Lining
- Relocation

- Piped
- Culverts

Table 15: Altered channels types in the Powder Mill watershed.

Altered Channels
Straightened
Manmade lining
Relocated
Piped

Debris Blockages

Debris blockages occurred on many of the stream reaches throughout the cruised reach assessment. The severity of the debris blockage was determined based on Rosgen's debris blockage description as described in table 16.

Table 16: Debris blockages in the Powder Mill Cruised Reaches

Rosgen Code	Description
D1	None
D2	Infrequent
D3	Moderate
D4	Numerous
D5	Extensive
D6	Dominating
D7	Beaver Dams - Few
D8	Beaver Dams - Frequent
D9	Beaver Dams - Abandon
D10	Human Influences

Utilities

Sewage leaks were a major problem throughout the Gwynns Falls watershed, but particularly in Baltimore City. During the utility assessment, any reaches with the following items were noted:

- Exposed Crossings
- Leaking Utility
- Exposed manholes in or near the channel

Channel Habitat

Fish Blockages

Stream reaches with fish blockages were noted during the field assessment. Each fish blockage was classified as having one of four causes as shown in Table 17.

Table 17: Fish blockage causes on cruised reaches

Causes of Fish Blockages
Debris Blockages
High Velocities
Excessive Height
Shallow Depth of Flow

Vegetation

Riparian cover on both the left and right overbanks of the stream was assessed. The width, composition and density of each riparian zone was collected. Density was classified as low, medium or high. Table 18 shows the vegetation categories that were used for the cruised reach assessments.

Table 18: Vegetation cover in the Powder Mill cruised reaches

Vegetation Categories
Bare
Forbs only
Annual grass with forbs
Brush
Deciduous overstory
Deciduous overstory with brush understory
Wetland vegetation

In addition to the adjacent riparian zone, the canopy cover immediately over the stream was assessed. Canopy cover was broken into five categories: less than 10% cover, 10 to 25% cover, 25 to 50% cover, 50 to 75% cover, and greater than 75% cover. Table 19 shows the results of the canopy cover analysis.

Table 19: Canopy cover in the Powder Mill cruised reaches

Canopy Cover Cateogries
0 to 10%
10 to 25%
25 to 50%
50 to 75%
75 to 100%

Forest Assessment

A forest patch assessment was conducted as part of the Gwynn's Falls Watershed Management Plan Study to investigate potential reforestation/conservation opportunities. Forest Patch selection was based on a 4 phase study. As part of that study, no forest patches were identified for assessment in the Powder Mill watershed.

Stormwater Management Facility and Outfall Assessment

Stormwater management facilities were selected by Baltimore City and Baltimore County for evaluation as part of the overall Gwynns Falls Water Quality Study. Sites chosen for inspection by the County were typically standard detention facilities that were providing no water quality treatment. The goal of the assessment was to identify facilities with conversion potential and to improve the control of stormwater, both quantity and quality, within the Gwynns Falls. Three stormwater facilities and seven outfalls were assessed in Baltimore City and none in Baltimore County.

4.0 FIELD EVALUATION RESULTS

Stream Stability

Thirty-two Corps reaches and eight cruised reaches were assessed in the Powder Mill watershed. Three of the cruised reaches contained predominantly piped reaches.

The combined cruised and Corps reaches were predominately classified as Rosgen type B and F streams. Refer to Table 20 for the complete stream type classification. The cruised reaches were classified into their Rosgen stream type and the stream types assigned in the Corps study were verified. 47% of the streams within Powder Mill are type B streams. Type B streams are moderately entrenched, have a moderate gradient and are a riffle dominated channel with infrequently spaced pools. Streambank erosion rates and aggradation/degradation rates are typically low for type B streams. Type F streams are typically entrenched, meandering, riffle/pool channels with low gradients and high width to depth ratios. Type F channels comprised 20% of the streams within the Powder Mill. Type F channels can develop very high bank erosion rates, lateral erosion rates, significant bar deposition and accelerated channel aggradation and/or degradation while providing very high sediment supply and storage capacities.

Table 20: Rosgen stream classification for Powder Mill streams

Stream Classification	% of Streams
A	0
B	47
C	13
D	7
E	6
F	20
G	6

The ratio of unstable to stable stream banks for the cruised reaches is 30% for the Powder Mill watershed. The most likely stream banks to have unstable banks are typically F and G channels. These stream types comprise approximately 26% of the cruised stream reaches.

Stages I and V of Schumm's channel evolution model indicate completely stable streams. 0% of the Powder Mill streams fit into these categories. 100% of the streams were classified as degrading. These results are slightly misleading however, because data was collected on channel evolution for the cruised reaches. Channel evolution was not collected for the Corps data and they comprised the largest number of reaches within this subwatershed. Table 21 shows the percentage of each stage found within the cruised reach assessment of the Powder Mill watershed.

Table 21: Schumm's Channel evolution stages, Powder Mill watershed

Channel Evolution Stage	Percent of Powder Mill Watershed
Stage I	0
Stage II	0
Stage III	100
Stage IV	0
Stage V	0

Three primary factors were used to assess bank stability in addition to the unstable to stable ratio described above: bankfull height to bank height, bank angle and root density. Tables 22, 23 and 24 show the detailed breakdown of each category for the cruised reaches. These tables do not tell the entire picture for the Powder Mill watershed because of the small sample size used to derive the tables.

The majority of streambanks in the Powder Mill watershed fall into the low to medium erosion potential category. Thus, a typical stream bank could be described as having its bankfull height found in the lower half of its banks, gently sloping stream banks and dense roots throughout the streambank.

Table 22: Erosion potential due to bank to bankfull ratio, Powder Mill watershed

Erosion Potential	Percent of Powder Mill Watershed
High, Bankfull in lower half of bank	80
Medium, Bankfull in upper half of bank	0
Low, Bankfull at top of bank	20

Table 23: Erosion potential due to bank angle, Powder Mill watershed

Erosion Potential	Percent of Powder Mill Watershed
High, Undercut banks	0
Medium, Nearly vertical banks	20
Low, Banks sloping away from stream	80

Table 24: Erosion potential due to root density, Powder Mill watershed

Erosion Potential	Percent of Powder Mill Watershed
High, Minimal roots	0
Medium, Dense roots in upper bank	40
Low, Dense roots throughout bank	60

Stormwater Management Facility and Outfall Assessment

Baltimore County selected the stormwater management facilities for inspection within the Gwynns Falls subwatershed. There efforts were largely focused in the upper portion of the Gwynns Falls watershed, therefore, no stormwater management facilities were selected for inspection within the Powder Mill subwatershed.

Baltimore City's stormwater management database was used to select the location of the stormwater management facilities within the City limits to inspect. Three facilities were originally selected for inspection within the City, however, only one facility was found at the addresses listed in the City's database. Inspection priority was given to standard detention ponds and extended detention facilities with maintenance issues. Any existing stormwater management facilities that are not currently extended detention should be considered for conversion in the future.

Seven storm drain outfalls were assessed in Baltimore City, two of which were not actually located in the field. Sites within Baltimore City were chosen based on outfall size. The inspections were geared toward outfalls that were 36” or greater and were at least 50 feet from the mainstem of the stream channel. The remaining five outfalls are all recommended for outfall retrofits including two potential BMP creation sites. Because Baltimore County focused the storm drain inspections for the Gwynns in the upper subwatersheds, no storm drain outfalls were assessed in Baltimore County.

Forest Assessment and Vegetative Stability

The forest patch assessment completed for the Gwynns Falls Study was based on a GIS analysis of the entire Gwynns Falls. It is a multi-phased assessment and only the highest priority sites were inspected in the field. No forest patches within the Powder Mill watershed were ranked high enough for a field inspection.

Instead, an analysis of the orthophotogrammetry was used to assess forest conditions. The aerial mapping identified four major forested areas within the Powder Mill watershed:

- Powder Mill Park
- Seton Industrial Park (Baltimore County Portion)
- Seton Industrial Park (South of Northern Parkway, includes Jewish Cemetary)
- Bedford Crossing (South of Metro Rail)

Powder Mill Park should be preserved as parkland. Seton Industrial Park is zoned as industrial land and Bedford Crossing is zoned as high density residential land except for the forest buffers. These losses of forested areas will account for the forested lands decreasing from 7% of the existing to 4% of the ultimate development land use.

The vegetative stability of the stream channel and buffer were defined in the cruised reach assessment in four primary categories. Because the stream channel may have different buffer characteristics on both stream banks, the data was collected for both the right and left overbank areas. Tables 25 through 28 summarize the vegetative data collected in the Powder Mill watershed. It is important to note that the small sample size of cruised reaches may skew the results of the data shown for this subwatershed. Only five cruised reaches were used in the data analysis below because the remaining study reaches in this subwatershed were Corps reaches. The important thing that these tables show is that for the cruised reaches assessed, the majority of them have ample riparian buffers. Although some of the major forested areas are zoned for development, current City and County regulations should protect the existing stream buffers in the watershed.

Table 25: Percent canopy cover, Powder Mill watershed

Percent Canopy Cover	Percent of Cruised Reaches in Powder Mill Watershed
0-10	0
10-25	0
25-50	0
50-75	0
75-100	100

Table 26: Riparian width, Powder Mill watershed

Riparian Width	Percent of Reaches (Left Bank)	Percent of Reaches (Right Bank)
< 10	20	0
10 < x <= 25	0	20
25 < x < = 50	20	20
50 < x < = 75	0	0
75 < x < = 150	20	60
> 150	40	0

Table 27: Riparian Composition, Powder Mill watershed

Riparian Compostition	Percent of Reaches Left Bank)	Percent of Reaches (Right Bank)
Brush	0	0
Deciduous w/brush grass understory	100	100
Deciduous overstory	0	0
Grass & forbs	0	0
Wetland Vegetation	0	0
Bare	0	0

Table 28: Riparian Density, Powder Mill watershed

Riparian Density	Percent of Reaches (Left Bank)	Percent of Reaches (Right Bank)
Low	0	0
Moderate	0	0
High	100	100

Stream Classification

Powder Mill, like the majority of other Gwynns Falls Tributary is classified as a Class I stream. The designated use of Class I streams is protection of fish and aquatic life and contact recreation (i.e. fishable/swimmable).

Habitat Condition

Three sets of data were used to characterize the habitat condition of the watershed: Save our Streams (SOS) Project Heartbeat data, Corps habitat rating and the fish blockage data from the cruised reach assessment.

There is one Save Our Stream monitoring site located in the Powder Mill watershed:

- Powder Mill Run at Gwynndale Avenue, 1990 – 2000

Table 29 shows the results of the monitoring history at this site. The results show that the habitat conditions have varied from fair to poor during this period.

Table 29: SOS data, Powder Mill Run watershed

POWDER MILL RUN			
STREAM AND ROAD CROSSING	**STATION**	**YEAR**	**HABITAT CONDITION**
POWDER MILL RUN AT GWYNNDALE AVENUE	**BCO091**	**1990**	**POOR**
		1991	**FAIR**
		1992	**POOR**
		1993	**FAIR**
		1994	**POOR**
		1995	**POOR**
		1996	**<60**
		1997	**ND**
		1998	**ND**
		1999	**POOR**
		2000	**<60**

The Corps study did not rate the ecological condition of the Powder Mill watershed based on macroinvertebrate and finfish sampling data.

No fish blockages were reported in the cruised reaches

Watershed Runoff

The Powder Mill watershed is already significantly urbanized. While there will be some additional residential and commercial development and redevelopment, the ultimate development discharges will be within 10% of the existing condition values. Therefore, since land development is not a major control within this watershed, other management practices will need to be used to improve water quality within Powder Mill. Table 30 shows the impact of ultimate development conditions on Powder Mill Run discharges.

Table 30: Discharge Estimates, Powder Mill Run waterdshed

Return Period	Discharge (cfs) at Subshed Outlet		
	Existing	Ultimate	% Increase
2 - year	759	794	4.4%
10 - year	6,303	6,678	5.6%
100 - year	44,710	48,154	7.2%

Water Quality

Powder Mill typically ranks within the middle third of the Gwynns Falls subwatersheds with respect to annual pollutant loadings. Table 31 shows the average annual pollutant loadings for each constituent for Powder Mill and Table 32 shows the percent exceedance of water quality criteria. The annual loadings for TP, BOD, COD, FCOL, OP, Zn, Pb, Cd and Cu are all slightly below the watershed average while NO3N is slightly above the watershed average.

Table 31: Average annual pollutant loadings, Powder Mill Run watershed

Constituent	Annual Loading (lbs/acre/yr)		
	Existing	Ultimate	% Increase
Total Suspended Solids (TSS)	43.81	45.18	3.1%
Total Kjeldahl Nitrogen	1.93	1.99	3.3%
Nitrate/Nitrite	1.56	1.53	-1.5%
Total Phosphorus	0.22	0.23	3.2%
Ortho-Phosphorus	0.11	0.11	3.3%
Biochemical Oxygen Demand (BOD)	7.33	7.59	3.5%
Chemical Oxygen Demand (COD)	75.05	78.30	4.3%
Fecal Coliform (col/acre/yr)	14403	13517	-6.1%
Cadmium	0.010	0.011	4.9%
Copper	0.056	0.058	3.3%
Zinc	0.064	0.068	5.6%
Lead	0.004	0.004	4.5%

Table 32: Percent events exceeding the water quality criteria, Powder Mill Run

Constituent	% Events Exceeding Chronic Water Quality Criteria		% Events Exceeding Acute Water Quality Criteria	
	Existing	Ultimate	Existing	Ultimate
Copper	**100.0%**	**100.0%**	**100.0%**	**100.0%**
Zinc	**19.6%**	**19.2%**	**19.4%**	**19.0%**
Cadmium	**100.0%**	**100.0%**	**100.0%**	**100.0%**
Lead	**100.0%**	**100.0%**	**36.1%**	**35.4%**

Threats to Private/Public Structures

There are no immediate threats to private or public structures within the Powder Mill Run watershed, however, there are numerous locations of bank erosion that are causing the loss of private land. This is particularly true in the Baltimore County portion of the subwatershed.

Subwatershed Summary

The Powder Mill subwatershed is largely composed of residential development (59%) and has a high percentage of impervious area (34%). There were a large percentage of Corps reaches in this subwatershed, so the results from the cruised reach analysis are slightly skewed due to the small sample size.

Streams

- All streams within the Powder Mill watershed are classified as Use I streams by MDE.
- The predominant stream type within the Powder Mill watershed is Rosgen type B. The watershed also contains 20% F channels and 6% G channels.
- Many of the unstable stream reaches occur in residents back yards due to poor management practices (i.e mowing to edge of stream bank). Education of residents is needed to encourage more healthy riparian buffers and to reduce stream bank erosion.
- 30% unstable to stable reach ratio (3^{rd} lowest in the Gwynns Falls)

Forest Buffer

- For the assessed cruise reaches, the majority of the stream channel has high density buffers with a width of between 75 and 100 feet.
- Based on aerial photogrammetry, potential for riparian enhancement exists among some of the Corps reaches

Water Quality

- The average annual pollutant loadings for this watershed are very near the overall watershed average.

- Significant reductions in pollutant loadings for TSS, TP, TN, Pb and Zn can be achieved by the construction of restoration opportunities.

5.0 PROPOSED IMPROVEMENT PROJECTS

Project Identification

The proposed projects were selected during the Gwynns Falls project assessment. Each site was reevaluated during the targeted watershed assessment. During the targeted project identification, field crews collected more detailed geomorphic information in order to provide details of the recommended improvements than in the original Gwynns Falls assessment. Projects were located in Baltimore City and County. Table 33 summarizes the proposed projects.

Table 33: Proposed project summary table

Project	Project Name	Estimated Cost (Design & Construction)	Annual Cost	Description
PM-01	Southern Cross Stream Restoration	$ 701,261	$ 51,600	Stream restoration, buffer enhancement, public outreach
PM-02	Parsons Ave BMP & Stream Stabilization	$ 526,171	$ 38,700	Stream restoration, buffer enhancement, BMP creation
PM-03	Powder Mill Run Park Stream Restoration	$ 305,500	$ 22,500	Stream restoration, utility protection, buffer enhancement, public outreach
PM-04	Seton Industrial Park Stream Stabilization	$ 1,481,361	$ 109,000	Stream restoration, utility protection, buffer enhancement, pollution investigation
PM-05	Metro Drive Stream Stabilization & Vegetative Enhancement	$ 92,000	$ 6,800	Buffer enhancement, utility protection
PM-06	Seton Industrial Park Outfall Retrofit	$ 250,000	$ 18,400	Storm drain outfall retrofit, bank stabilization
PM-07	Seton Industrial Park BMP Creation	$ 353,271	$ 26,000	BMP Creation
PM-08	Northern Parkway BMP Creation	$ 478,271	$ 35,200	BMP Creation
PM-09	Powder Mill Park Channel Daylighting & BMP Creation	$ 1,254,361	$ 92,300	Channel daylighting, stream restoration, BMP creation (2)
PM-10	Seton Drive Outfall Retrofit	$ 35,000	$ 2,600	Storm drain outfall retrofit
PM-11	MTA Park & Ride SWM Facility Retrofit	$ 228,271	$ 16,800	SWM Pond conversion

Project Costs

Cost estimates were developed for each project. Unit costs were developed based on type of project and project components. These unit costs are based on statistics of past projects and experience with stream restoration and stormwater quality retrofit projects conducted in Maryland. Because procurement costs differ between the City and the County, separate costs were used to estimate projects in each jurisdiction. The City's estimated costs for stream restoration projects and land acquisition are typically higher than the County's and this was accounted for in Table 34. Baltimore County DEPRM's stream restoration database was also used to compute stream restoration related costs based upon project size.

Particularly in Baltimore City, there are numerous stream reaches with exposed or leaking utility lines and manholes. The existence of these problems are noted in each project sheet, however, it is assumed that leaking utility lines will be repaired prior to the project's implementation and thus their costs are not included in the cost estimate. Costs for pro-active relocation and/or protection of manholes and utility lines were included as part of the project costs estimates.

Table 34: Project unit costs

Project Cost Description	Basis of Cost Estimate	Unit	Unit Cost (City)	Unit Cost (County)
Stream Restoration & Stabilization				
Stream restoration – small project (< 200 linear feet)	Length of reach (excluding land acquisition)	LF	$700	$500
Stream restoration – medium project (200 – 1,500 linear feet)	Length of reach (excluding land acquisition)	LF	$500	$300
Stream restoration – major project (> 1,500 linear feet)	Length of reach (excluding land acquisition)	LF	$350	$200
Stream stabilization with bioengineering techniques	Length of unstable reach (excluding land acquisition)	LF	$100	$80
Floodplain wetland creation (Small)	Excluding land acquisition	Each	$25,000	$25,000
Riparian buffer improvements (assume 100' width of new creation)	Length of reach (excluding land acquisition)	LF	$95	$75
Riparian buffer improvements – New forest creation	Area of improvement (excluding land acquisition)	Acre	$15,000	$15,000
Riparian buffer improvements - forest patch enhancement	Area of improvement (excluding land acquisition)	Acre	$10,000	$10,000
Stormwater Management				
SWM pond/ wetland creation - large	Cost excludes maintenance and land acquisition	Each	$375,000	$300,000
SWM pond/ wetland creation - small	Cost excludes maintenance and land acquisition	Each	$250,000	$200,000
SWM pond conversion to Extended Detention (medium pond, 20 - 80 acres drainage area)	Cost excludes maintenance land acquisition and/or access easement	Each	$187,500	$150,000
Outfall retrofit – large	Cost excludes maintenance land acquisition and/or access easement	Each	$100,000	$100,000

Project Cost Description	Basis of Cost Estimate	Unit	Unit Cost (City)	Unit Cost (County)
Outfall retrofit – medium	Cost excludes maintenance land acquisition and/or access easement	Each	$50,000	$50,000
Outfall retrofit - small	Cost excludes maintenance land acquisition and/or access easement	Each	$25,000	$25,000
Right of Way and Land Acquisition				
Land acquisition: riparian buffer	100 feet of each side of reach	Acre	$50,000	$30,000
Land acquisition: stream restoration	50 feet of each side of reach	Acre	$50,000	$30,000
Land acquisition: new SWM pond/wetland	Dependent upon drainage area to pond.	Acre	$62,500	$50,000
Riparian Buffer Enhancement/Stream Stabilization Easement	Cost to establish permanent easement along stream	Acre	$10,000	$5,000
Right of Way easement	Cost to negotiate easement and right of entry	LS	$10,000	$5,000
Maintenance Costs				
Maintenance: SWM pond	Annual cost per year	LS	$3,000	$3,000
Maintenance: stream restoration (includes monitoring)	Annual cost per year	LS	$4,000	$4,000
Other Costs				
Sewer/Manhole relocation	Excludes right of way easement	Each	$31,250	$25,000

Project Descriptions

A detailed project analysis was conducted for each proposed project site (Refer to section 7 of this report). This includes identification of the scope of work, photographs, preliminary cost estimate, water quality benefit, habitat benefit and impacts on the watershed and ultimately the entire Gwynns Falls. Notes on potential utility conflicts, property ownership and any unique permitting issues are also discussed. All mapping appears directly after the project description. Projects will then be prioritized and ranked.

Project Ranking

Ranking is performed of potential restoration and stabilization projects in order to determine recommended City and County actions. Rankings are inherently subjective. The value of the rankings is that they allow direct comparison of competing projects.

An initial ranking of water quality enhancement projects was prepared based on five different criteria. The criteria were selected to look at the water quality benefit, land availability and construction access, public acceptance and reduction of risk to public safety and infrastructure. The criteria are explained in more detail below and in table 35. Project rankings appear in Table 36.

1. Water Quality Benefit – This represents an assessment of a project's benefit to reducing pollutant and sediment loads and improving water quality within the watershed. A score of zero represents no benefit while a score of three represents a high benefit. Percent pollutant reductions were used to quantify the benefit. Scores were considered based on nutrients & metals. For nutrients, an average percent reduction greater than 4% received a score of 3; an average percent reduction between 1.5 and 4% received a score of 2; and an average percent reduction of less than 1.5% received a score of 1. For metals, an average reduction of metals greater than 4% received a score of 3; an average reduction of 1.5 to 4% received a score of 2 and an average reduction of less than 1.5% received a score of 1. The highest water quality score between the metals & nutrients was used for the final ranking.

2. Habitat enhancement – This criteria looks specifically at improvements to habitat within the watershed and the stream channel itself. Projects that are specifically designed for habitat enhancement are given a ranking of 3. Projects that include habitat enhancement features and forest patch enhancements are given a ranking of 2. Projects that improve a debris or fish blockage are ranked 1. Projects that have no habitat enhancement receive a score of 0.

3. Land availability & Construction Access – This category rates the ability for a project to be constructed and includes both land availability and construction access. For land availability, private land without access is given a zero while public land with good roadway access is given a 3.

4. Public Acceptance and educational opportunities – This category rates the public's willingness to support a project, its benefit to community aesthetics and potential for public education. A project with many public objections will receive a score of zero while a score of 3 represents a very visible project with strong public support and education opportunities.

5. Reduction of Risk to Public Safety or Infrastructure – This includes the threat of localized flooding, culvert failure and unstable stream banks along improved properties. A score of zero indicates no reduction of the risk of failure or that no risk exists and a score of three represents a high reduction in the risk of failure.

Table 35: Water quality enhancement project ranking scheme

Ranking Category	Numeric Ranking			
	0	1	2	3
1) Water Quality Benefit	None	Low	Moderate	High
2) Habitat Enhancement	None	Low	Moderate	High
3) Land Availability & Construction Access	Private land w/ no access	Private land w/ good access	Public land w/ fair access	Public land w/ good access
4) Public Acceptance & Educational Opportunity	Strong objections no educational opportunity	Some objections & minimal educational opportunity	Some desire & good educational opportunity	Strong desire & strong educational opportunity
5) Reduction of Risk to Public Safety or Infrastructure	No Impact	Low	Moderate	High

Table 36: Project ranking and cost benefit analysis

Project	Project Cost	Annual Cost	Water Quality Benefit	Habitat Enhancement	Land Availability & Construction Access	Public Acceptance & Educational Opportunities	Reduction of Risk to Public Safety & Infrastructure	Total Score	Cost Benefit Ratio
PM-09	$ 1,254,361	$ 92,300	3.0	3.0	3.0	2.5	3.0	14.5	6.4
PM-04	$ 1,481,361	$ 109,000	3.0	2.0	3.0	2.5	3.0	13.5	8.1
PM-02	$ 526,171	$ 38,700	3.0	2.0	2.5	2.5	3.0	13.0	3.0
PM-01	$ 701,261	$ 51,600	2.0	2.0	3.0	2.5	3.0	12.5	4.1
PM-03	$ 305,500	$ 22,500	2.0	2.0	2.5	2.5	3.0	12.0	1.9
PM-11	$ 228,271	$ 16,800	2.0	1.0	3.0	2.0	2.0	10.0	1.7
PM-07	$ 353,271	$ 26,000	3.0	1.0	1.0	2.0	2.0	9.0	2.9
PM-08	$ 478,271	$ 35,200	3.0	1.0	1.0	2.0	2.0	9.0	3.9
PM-05	$ 92,000	$ 6,800	2.0	2.0	0.5	2.0	1.5	8.0	0.9
PM-06	$ 250,000	$ 18,400	1.0	1.0	0.5	2.0	1.0	5.5	3.3
PM-10	$ 35,000	$ 2,600	1.0	1.0	0.5	1.5	1.0	5.0	0.5

Recommended Management Measures

It is recommended that the City and County undertake the following management measures:

Regulations:

- Follow current MDE Stormwater Design Manual, Volumes I & II. Minimize the number of waivers allowed, particularly in the Sensitive, Group I subwatersheds.

- Look for water quality treatment measures that will not cause increases in stream temperatures,

- Follow current Baltimore County DEPRM & City DPW regulations regarding forested buffers for wetlands, streams and floodplains. Minimize the number of waivers or exceptions permitted, Focus on incorporating water quality treatment in redevelopment projects in urbanized areas.

- Follow current erosion and sediment control guidelines, particularly for new construction. Maintain inspection program to insure that existing guidelines are being enforced.

Community education:

- Educate community on importance of stream buffers and what they can do to prevent stream bank erosion on their property

- Provide community demonstration projects where possible to show the community about the environmental benefits of various water quality projects. In addition, inform the community members about what they can do to improve the water quality of their local streams.

- Educate community on the importance of keeping their streets and neighborhoods clean. Make the connection that the debris that enters the storm drain systems will eventually enter the stream network and the Bay.

- Work with community watershed associations to improve riparian buffers and water quality within their local neighborhoods.

Stormwater Management Retrofits:

- Where possible, investigate conversion of all standard detention ponds to extended detention facilities.

- Consider low impact development solutions to stormwater management when possible. Look for opportunities to install bioretention basins, grassy swales, etc. throughout the watershed, but particularly in the area bounded by Patterson Avenue and Parr Avenue.

- Investigate new opportunities for BMP creation at existing storm drain outfall locations.

- In highly urbanized settings, consider the use of structural devices such as StormCeptors to help trap sediment and pollutants prior to being discharged into the stream/storm drain network.

6.0 TARGETED WATERSHED PLAN SUMMARY

11 projects have been identified as part of this targeted watershed study in Baltimore City and County. The total cost of projects in 2004 dollars is $5.5 million. The costs include construction and design, land acquisition, and access easements, public education and annual maintenance. (Table 37) Main project components include:

- Stream restoration (5,980 linear feet)
- Buffer enhancement (10,830 linear feet)
- BMP Creation (4)
- Channel daylighting (1)
- Stormdrain outfall retrofit (5)
- SWM pond conversion to extended detention (1)

Table 37: Summary of Project Costs

Project ID	Construction Cost	Land Acquisition Required (Y/N/E=ease-ment)	Land Cost	Maintenance Required (Y/N)	Annual Maintenance Cost	Life Cycle	Interest Rate	Present Worth of Regular Annual Maintenance P/A Present Worth	Total Present Worth Cost of Project	Total Annual Cost of Project A/P Capital Recovery
PM-01	$ 595,900	Y	$ 34,400	N	$ 4,000	20	0.04	$ 54,361	$ 684,661	$ 50,400
PM-02	$ 475,400	Y	$ 34,400	N	$ 3,000	20	0.04	$ 40,771	$ 550,571	$ 40,500
PM-03	$ 275,500	Y	$ 30,000	N	$ -	20	0.04	$ -	$ 305,500	$ 22,500
PM-04	$ 1,427,000	Y	$ -	N	$ 4,000	20	0.04	$ 54,361	$ 1,481,361	$ 109,000
PM-05	$ 82,000	Y	$ 10,000	N	$ -	20	0.04	$ -	$ 92,000	$ 6,800
PM-06	$ 240,000	E	$ 10,000	N	$ -	20	0.04	$ -	$ 250,000	$ 18,400
PM-07	$ 250,000	Y	$ 62,500	Y	$ 3,000	20	0.04	$ 40,771	$ 353,271	$ 26,000
PM-08	$ 375,000	Y	$ 62,500	Y	$ 3,000	20	0.04	$ 40,771	$ 478,271	$ 35,200
PM-09	$ 1,200,000	N	$ -	Y	$ 4,000	20	0.04	$ 54,361	$ 1,254,361	$ 92,300
PM-10	$ 25,000	E	$ 10,000	N	$ -	20	0.04	$ -	$ 35,000	$ 2,600
PM-11	$ 187,500	E	$ -	Y	$ 3,000	20	0.04	$ 40,771	$ 228,271	$ 16,800

Water Quality Benefits

The water quality benefits were computed in terms of the percent reduction of pollutant loadings compared with the overall pollutant loading in the Powder Mill watershed. Overall pollutant loadings were computed using the EPA SWMM model as part of the Gwynns Falls Water Quality Management Plan. Pollutant reductions were computed using Baltimore County Monitoring data and values from the Chesapeake Bay data. Table 38 shows the proposed project list and associated percent reduction in nutrient (TSS, TP, TN) and metals (Pb and Zn) loadings.

Table 38: Projects with the greatest reduction in nutrient & metals pollutant loadings.

Project	Project Cost	Average Nutrients	Average Metals
PM-04	$ 1,481,361	8.1%	5.9%
PM-09	$ 1,254,361	6.9%	32.3%
PM-02	$ 550,571	4.8%	16.8%
PM-07	$ 353,271	3.5%	16.1%
PM-08	$ 478,271	3.5%	16.1%
PM-01	$ 684,661	3.2%	1.6%
PM-03	$ 305,500	2.3%	1.1%
PM-05	$ 92,000	0.9%	2.3%
PM-11	$ 228,271	0.5%	2.4%
PM-06	$ 250,000	0.5%	1.2%
PM-10	$ 35,000	0.2%	1.1%

Table 39 shows the benefit for all of the proposed projects within the Powder Mill watershed. The key to achieving this targeted reduction is for the City and the County to work together to improve the water quality in this subwatershed.

Table 39: Overall project pollutant reductions for the Powder Mill Targeted Watershed

	TSS	TP	TN	Pb	Zn
Watershed Total Load Reduction (lbs)	78,648	173.5	1521.7	17.6	84.1
Percent Total Watershed Reduction (%)	64.6%	26.6%	12.1%	156.1%	37.9%