V. COMPREHENSIVE WATERSHED - WIDE WATER RESOURCES MANAGEMENT

A. Impact of Runoff on Watersheds

Stormwater runoff from developed areas has a direct influence on the quality of the Brodhead Creek and McMichaels Creek waters. This influence begins with the effects development have on the natural hydrologic cycle of the watershed. During development, trees, meadow grasses, open fields and agricultural areas which would have naturally intercepted or infiltrated a significant portion of the rainfall are cleared, graded, and compacted. Much of these natural areas are then covered with impervious surfaces, such as buildings or parking lots, which reduces the total amount of rainfall which would have infiltrated to groundwater sources under natural conditions. Rainfall which does not infiltrate into the subsurface is converted directly to surface stormwater runoff and typically conveyed quickly to a receiving body of water, such as a stream or lake. With this large conversion of rainfall to surface runoff, streams are required to convey much larger volumes and higher peak rates of runoff, which the existing drainage systems may not be capable of handling. This may lead to erosion and sedimentation problems which can be evident in downstream areas.

B. Five-Phased Approach

The goal of Act 167 and this Stormwater Management Plan is to encourage planning and management of stormwater runoff that is consistent with sound water and land use practices. In addition, the Act authorizes a comprehensive stormwater management program designated to preserve and restore flood carrying capacities of streams, preserve to the maximum extent practical the natural courses of stormwater runoff, preserve current cross sections of streams, and protect and conserve ground waters and ground-water recharge areas. Maintaining the existing conditions hydrologic regime in the watershed is the best means to accomplish these goals. The technical standards and criteria developed as a part of this task will be watershed-wide in their interpretation and/or application. To strive toward achieving this goal, and to address stream bank erosion, flooding, water quality, groundwater recharge, and stormwater management projects on development sites, the following five (5) objectives should be considered:

1. Maintain groundwater recharge
2. Implement non-point source pollution removal methodologies
3. Reduce channel erosion
4. Manage overbank flood events
5. Manage extreme flood events

These objectives can be accomplished under the following items, and are shown in Figure V-1.

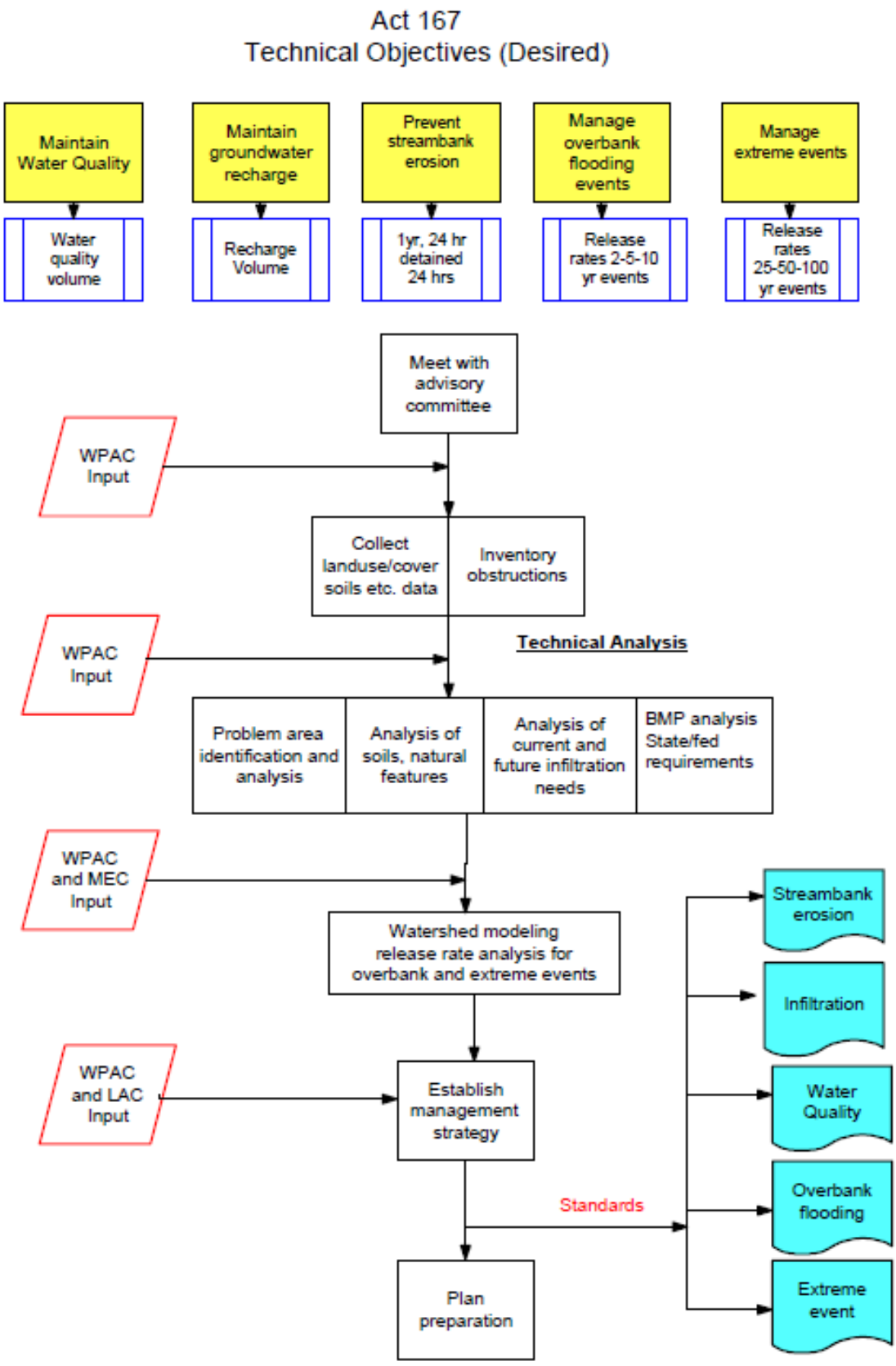


Figure V-1. Process utilized analyzing five comprehensive management objectives.

1. Groundwater Recharge/Infiltration

Recharging rainfall into the ground replenishes the groundwater that provides baseflow to streams, (a process that keeps streams flowing during the drier summer months), and maintains groundwater for drinking water purposes. As development occurs and the impervious area, increases, less rainfall reaches the groundwater systems and lower base flows and smaller groundwater supplies may result**.** Although detention basins can reduce the after development peak rate of flow to the existing conditions rate, the increased volume of runoff still gets passed downstream unless special provisions are designed into the basin to recharge this increase in runoff volume.

In highly developed watersheds, it is not uncommon to see dry streams during periods of drought, along with severely depleted groundwater drinking supplies. Stormwater management measures such as porous pavement with underground infiltration beds and infiltration/recharge structures, or Best Management Practices (BMPs) can be designed to promote groundwater recharge. These measures are encouraged, and should be utilized wherever feasible.

It is realized, however, that due to certain soils and topographic conditions, recharge may not be feasible on every site. It will be up to the design professional, therefore, to show that groundwater recharge cannot be *physically* accomplished. The infiltration criteria is therefore based upon a hierarchical approach, striving to achieve the maximum infiltration achievable, taking into account site limitations. Where infiltration is not feasible, other volume managing stormwater BMPs should be used such as Managed Release Concept BMPs or other BMPs developed to manage increased volume from development.

The size of the recharge facility shall be based upon the following volume criteria:

a. NRCS Curve Number equation.

The NRCS runoff equation is universally accepted to predict stormwater runoff from precipitation events:

Equation. V-1. $$Q = \frac{(P-0.2S)^2}{(P + 0.8S)}$$

where

Equation. V-2. $$S = 1000/CN - 10$$

Where:
Q = Runoff (inches)
P = Rainfall (inches)
S = Potential maximum retention after runoff begins (inches)
CN = The NRCS Curve Number

Setting Q to zero in the equation above would represent zero runoff from the site. Solving the equation above for P, while holding Q equal to zero, would provide an equation that represents the rainfall volume that would infiltrate from a site with a particular (or composite) CN under existing conditions. This equation would take the form:

For zero runoff: P = I (Infiltration) (in) = (200 / CN) – 2 Eqn. V-3

Where: CN = the existing condition curve number of the land area that will be converted to impervious surface. This equation can be displayed graphically as shown in Figure V-2.

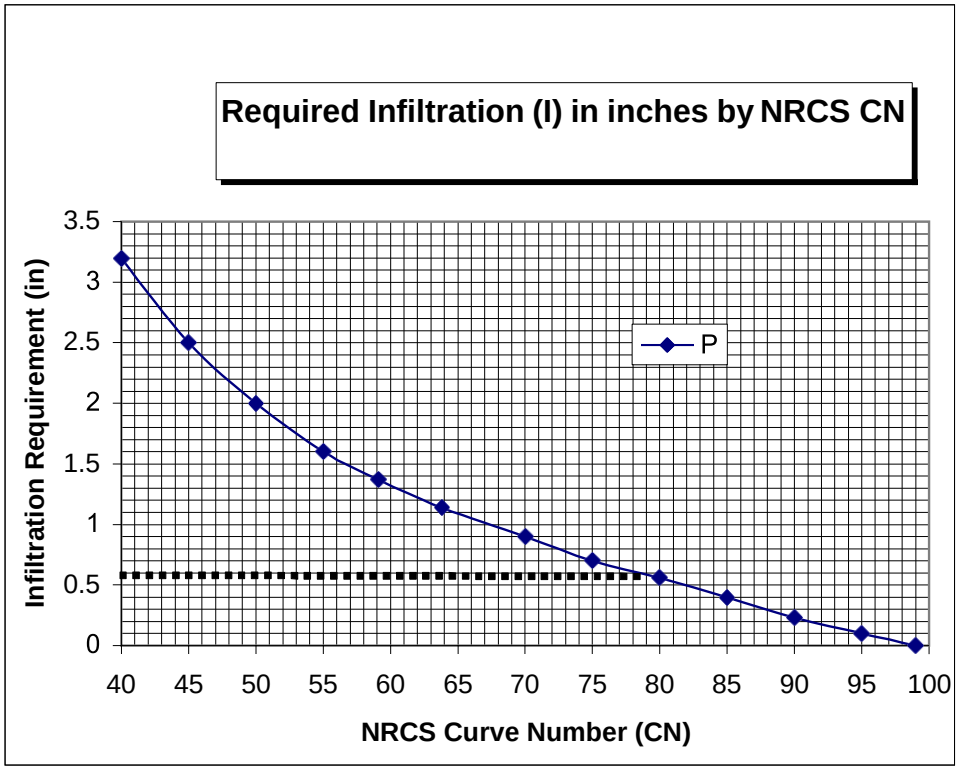


Figure V-2. Infiltration requirement based upon NRCS Curve Number.

To apply the above procedure, the infiltration requirement would be determined by finding where the existing condition CN intersects the curve. The goal then, is to maintain the natural existing hydrologic regime of a site by recharging that portion of rainwater that recharges under existing conditions. Therefore multiplying the infiltration requirement (I) by the site area would be the site's required recharge or runoff capture volume, Re_v.

In most cases, existing sites may have varying land uses and hydrologic soil groups (HSG). Obtaining a composite CN for the existing site conditions, and then obtaining the infiltration requirement, is not the proper way of determining the required recharge. One must determine the infiltration requirement for each unique land use/hydrologic soil group individually and then sum the infiltration values determined to obtain the recharge volume as shown in the example on the following page:

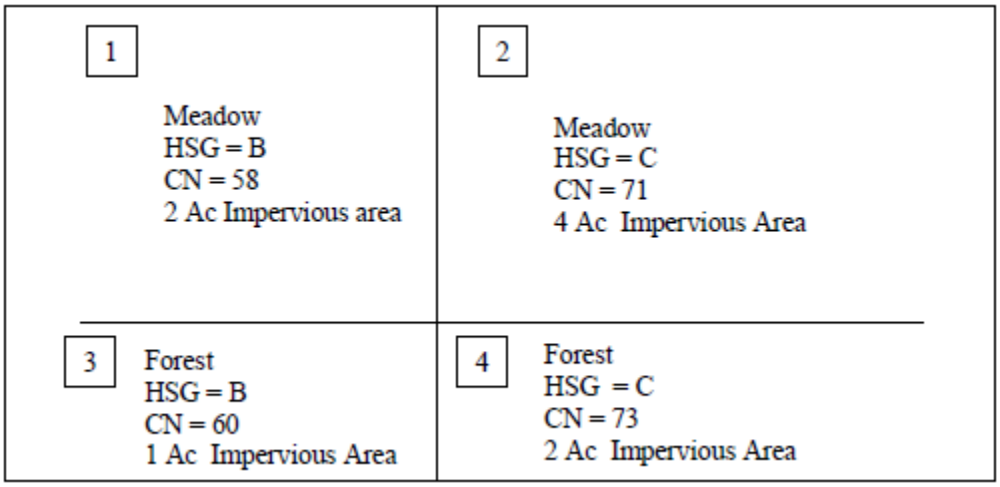


Figure V-3. Hypothetical Undeveloped Site:

From Equation V-3, or Figure V-2, the required infiltration (I) can be obtained:

1. I = 1.44 in. x 2 Ac. x 1 ft./12in. = 0.24 Ac-ft.
2. I = 0.82 in. x 4 Ac. x 1 ft./12in. = 0.27 Ac-ft.
3. I = 1.33 in. x 1 Ac. x 1 ft./12in. = 0.11 Ac-ft.
4. I = 0.74 in. x 2 Ac. x 1 ft./12in. = 0.12 Ac-ft.

Re_v = Total required recharge = 0.74 Ac-ft.

This process also advocates that the more permeable soils (HSG A and B), where the most rainfall would recharge the groundwater, be maintained in their natural condition. It is advantageous to develop on the less permeable soils (C and D) and keep the more permeable soils (A and B) as the recharge areas. If one were to run through the calculations, one would find that developing on or disturbing the permeable soils would require a lot more recharge volume than the other way around. This process therefore promotes the preservation of recharge areas.

b. Inability to Meet NRCS Curve Number Goals. Application of the Water Budget Approach.

It has been determined that infiltrating 0.6 inches of runoff from the impervious areas will aid in maintaining the hydrologic regime of the watershed. If the goals of Section a above cannot be achieved, then 0.6 inches of rainfall shall be infiltrated from all impervious areas, up to an existing conditions site conditions curve number of 77. Above a curve number of 77, Equation V-3 or the curve in Figure V-2 should be used to determine the infiltration requirement.

The requirements for recharge are applied to all disturbed areas, even if they are ultimately to be an undeveloped land use such as grass areas, since studies have found that compaction of the soils during disturbance reduces their infiltrative capacity.

c. Where an NPDES permit for stormwater discharges associated with construction activities is required, the volume control requirement of that permit should be met unless the volume control requirement in this plan is greater.

2. Water Quality

Pollutants accumulate on impervious surfaces between rainfall events or during dry weather.

Pollutant concentrations in runoff from developed land therefore, tend to be greatest at the beginning of the storm event, a phenomenon commonly known as the first flush. It has also been found that eighty to ninety percent of rainfall events are one inch of rainfall or less, storms that essentially simulate this "first flush". The majority of the non-point source pollutants, therefore, are being washed into streams during the smaller storms. Capturing this first flush and/or smaller storms will allow the stormwater to be detained and will allow pollutants to settle, thus allowing a "cleaner" outflow.

a. Buffers: Maintaining or restoring natural buffers has many storm water related benefits including aiding in groundwater recharge, improving water quality of runoff and protecting streambanks from erosion. A listing of 20 benefits of buffers is shown in Table V-1. Buffer requirements are therefore incorporated into the Ordinance.

TABLE V-1
Twenty Benefits of Buffers

1. Reduce watershed impervious area by 5%.
2. Maintain distance from impervious cover.
3. Reduce small drainage problems and complaints.
4. Stream "right-of-way" allows for lateral movement.
5. Effective flood control.
6. Protection from streambank erosion.
7. Increase property values.
8. Increased pollutant removal.
9. Foundation for present or future greenways.
10. Provide food and habitat for wildlife.
11. Mitigate stream warming.
12. Protection of associated wetlands.
13. Prevent disturbance to steep slopes.
14. Preserve important terrestrial habitat.
15. Corridors for conservation.
16. Essential habitat for amphibians.
17. Fewer barriers to fish migration.
18. Discourage excessive storm drain enclosures/channel hardening.
19. Provide space for stormwater ponds.
20. Allowance for future restoration.

b. Water Quality Requirements - The land developer SHALL comply with the following water quality requirements unless otherwise exempted.

For the water quality volume (WQv), the objective is to promote settlement of pollutants through detaining the proposed conditions' 2- year, 24-hour design storm to the existing conditions 1-year flow using the SCS Type II distribution. Additionally, provisions shall be made such as adding a small orifice at the bottom of the outlet structure so that the proposed conditions 1-year storm takes a minimum of 24 hours to drain from the facility from a point where the maximum volume of water from the 1-year storm is captured (i.e., the maximum water surface elevation is achieved in the facility. At the same time, the objective is not to attenuate the larger storms. This can be accomplished by configuration of the outlet structure not to control the larger storms, or by a bypass or channel to divert only the 2-year flood into the basin or divert flows in excess of the 2-year storm away

from the basin with the larger flows going to a storm water quantity control facility. Release of water can begin at the start of the storm (i.e., the invert of the water quality orifice is at the invert of the facility). The design of the facility shall consider and minimize the chances of clogging and sedimentation potential. Orifices smaller than 3 inches diameter are not recommended. However, if the Design Engineer can provide proof that the smaller orifices are protected from clogging by use of trash racks, etc., smaller orifices may be permitted.

Where an NPDES permit for stormwater discharges associated with construction activities is required, the water quality requirements of that permit should be used.

c. Innovative Design - To accomplish the water quality objectives, the land developer MAY submit original and innovative designs to the Municipal Engineer for review and approval. Such designs may achieve the water quality objectives through a combination of BMPs (Best Management Practices).

d. BMP Selection - In selecting the appropriate BMPs or combinations thereof, the land developer SHALL consider the following:

1. Total contributing area.
2. Permeability and infiltration rate of the site soils.
3. Renovative capacity of the soils
4. Slope and depth to bedrock.
5. Seasonal high water table.
6. Proximity to building foundations and well heads.
7. Erodibility of soils.
8. Land availability and configuration of the topography.
9. Peak discharge and required volume control.
10. Stream bank erosion.
11. Efficiency of the BMPs to mitigate potential water quality problems.
12. The volume of runoff that will be effectively treated.
13. The nature of the pollutant being removed.
14. Maintenance requirements.
15. Creation/protection of aquatic and wildlife habitat.
16. Recreational value.
17. Enhancement of aesthetic and property value.

3. Stream Bank Erosion

As storm flows increase, the velocities in streams also increase, thus exacerbating stream bank erosion problems. Stream bank full flow has been found to equate to approximately a 1.5- to 2-year storm. Theoretically, stream flows kept to near the one-year storm flow would minimize stream bank erosion. Detaining the smaller, more frequent events, where feasible, would therefore minimize the number of storms causing stream bank erosion.

Applying the water quality criteria above will also help the stream bank erosion problem. Thus, detaining the 2-year proposed conditions storm to the one-year existing conditions storm and detaining the 1-year proposed conditions storm a minimum of 24 hours would minimize the number of storms causing stream bank erosion. This is the same management criterion that has been recognized to also improve the water quality of stormwater runoff.

4. Overbank Events

Flooding and stormwater problems are caused by excess stormwater quantity. Storm events which result in water exceeding the natural bank of a stream are termed as "Overbank" events and are typically defined as an expected frequency of occurrence. Based upon the realization that most bankfull events occur at approximately the 1.5- to 2- year event, events greater than the 2-year storm generally result in overbank flooding. These "overbank" events typically range from the 2- year to 10- year events. Management of these "overbank" events requires a detailed knowledge of the interrelationship between all contributing areas of a watershed. Analysis of peak runoff, timing of runoff, and duration of runoff from the various areas of a watershed is critical for establishing this criteria. The result of this analysis is the Management District Concept, discussed below.

5. Extreme Events

"Extreme" flooding events are separated from "overbank" flooding events by the severity of damage which is incurred. Typically, events such as the 25-, 50- and 100- year events are labeled as "extreme" events.

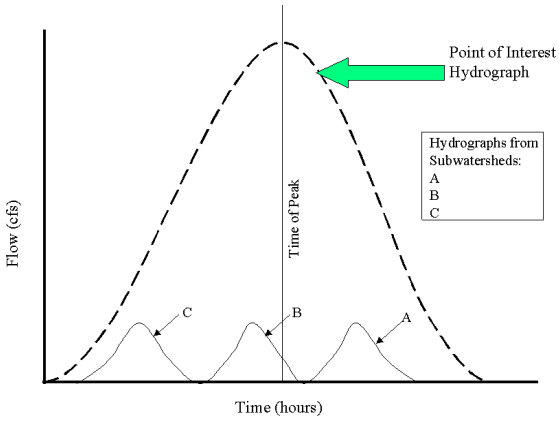
While some overbank and extreme flooding events are inevitable, the goal is to control the frequency of occurrence for such events such that the level of overbank flooding is the same over time, so that damages to existing infrastructure are not exacerbated by upstream development. Therefore, different management criteria are given for these "overbank" and "extreme" event floods. It must be recognized that there is a difference between the meanings of "storm" and "flood" when considering 5-year storms and 5-year floods. Although a certain quantity of rain may classify a rainfall event as a 5-year storm, this does not mean that same amount of rain will result in a 5-year flood. For example, if the event would occur during a drought, a 5-year storm may result in only a 2-year flood because of the capacity of the soil and ground to absorb water. However, if the same event occurred on top of a snow melt, then a 10-year flood may occur because of the extra water volume present in the melting snow. Similarly, the term "5-year flood" does not mean that this event will occur once every five years. Nor does it mean that once a 5-year event occurs, it will be another five years until that event may occur again. A 5-year event refers to the probability that the event will occur in any given year, which is the inverse of the frequency event. Therefore, a 5-year event has a 20% probability of occurring in any given year.

C. Management District Concept (Overbank and Extreme Event)

The original Act 167 plans for the Brodhead and McMichaels Creek watersheds were based upon the release rate concept where each subarea of the watershed was assigned a release rate (as a percent value). For any development scenario, the post development runoff rate must meet a percent (release rate) of the pre development runoff rate. These release rates were developed by analyzing the individual subarea contribution to the overall watershed runoff. The Management District concept uses the same idea as the release rate concept; however, it displays the final criteria by grouping subareas into "Management Districts" rather than assigning a release rate to each individual subarea. Each Management District contains specific criteria which are to be met in order to address "overbank" and "extreme" design events.

Figure V-4 shows a simplified version of how various subarea hydrographs would contribute to the peak flow at a particular point of interest (POI). As can be seen from Figure V-4, hydrograph "A" peaks after the point of interest hydrograph. In this case, standard detention or reducing post development flows to existing conditions rates would attenuate the flows past A's peak, but would minimally influence the peak of the POI. A development site in subarea B would contribute flow at a time between the start and end of that subarea's hydrograph. Standard detention would attenuate flow to a point where it is increasing flow at the POI; therefore, stormwater management controls would need to reduce the outflow to a higher frequency (smaller) storm. Flows in subarea C enter and exit the stream system before the peak flow occurred at the POI; therefore, if possible, it would be advantageous not to detain these flows. Subareas A, B, and C on the sample would fall into districts A, B, and C respectively as shown on the map in Figure V-5 of Appendix D. Development of the design storm criteria was based upon downstream obstruction capacities and problem areas identified in the study, as well as the overall goal of maintaining the existing condition flow at all points in the watershed in the future.

Figure V-4
Relative Timing of Subwatershed Hydrographs



In performing the tasks for the Brodhead / McMichaels Creek Watershed Plan under Act 167, a major goal was to determine where in the watershed stormwater detention was appropriate for new development and, just as importantly, where detention was not appropriate. It was also important to determine to what extent stormwater detention would be required in individual subareas as described above. In Table V-2, the peak rate of proposed conditions runoff would have to be reduced to the peak rate of existing conditions runoff for the design storms specified below. Individual subareas would fall into one of four districts:

Table V-2: Management District Peak Rate Requirements

District		Proposed conditions	(reduce to)	Existing conditions
A		2 – year		1 – year
		5 – year		5 – year
		10 – year		10 – year
		25 – year		25 – year
		50- year		50- year
		100-year		100-year
B-1		2 – year		1- year
		5 – year		2 – year
		10 – year		5 – year
		25 – year		10 – year
		50- year		25- year
		100-year		100-year
B-2		2 – year		1- year
		5 – year		2 – year
		25 – year		5 – year
		50- year		10- year
		100 – year		50 – year
B-3		50- year		10- year
		100 – year		50 – year
C		**Note: Section numbers provided herein refer to the Model Ordinance Sections.** Provisional Direct Discharge District - Development sites which can discharge directly to the main channel or major tributaries or indirectly to the main channel through an existing stormwater drainage system (i.e., storm sewer or tributary) **which meets the "Downstream Hydraulic Capacity Analysis" in Section 305.H and is shown by the design professional to not cause a downstream problem, may allow an increase in flow as long as no downstream harm is demonstrated.** However, sites in District C shall comply with the criteria for Water Quality and Streambank Erosion (Ordinance Section 303); and Groundwater Recharge (Ordinance Section 304). If the proposed conditions runoff is intended to be conveyed by an existing stormwater drainage system to the main channel, **assurance must be provided that such system has adequate capacity to convey the increased peak flows or will be provided with improvements to furnish the required capacity.** When adequate capacity of the downstream system does not exist and will not be provided through improvements, the proposed conditions peak rate of runoff must be controlled to the existing conditions peak rate as required in District A provisions (i.e.10-year proposed conditions flows to 10 year existing conditions flows) for the specified design storms.		

As in District C, development in those subareas designated on Figure V-5 of Appendix D must convey the generated stormwater runoff to a stream or watercourse in a safe manner. **The conveyance must manage the quantity, velocity and direction of resulting stormwater runoff in a manner that adequately protects health and property from possible injury pursuant to Act 167, does not overtax existing conditions drainage facilities and does not cause erosion or sedimentation.** Anyone who proposes no detention must comply with Section 305G, and H of the Model Ordinance. Acceptable velocities shall be based upon criteria contained in the DEP "Erosion and Sediment Pollution Control Program Manual**". A proposed**

flow that is greater than the existing flow can only be released if it would not aggravate a significant obstruction or existing problem area or overload existing storm sewer networks. If this condition could not be satisfied, proper stormwater management, obstruction replacement or standard detention would be required. Additionally, any flow from the 50-year storm not carried by downstream drainage facilities must be addressed and where necessary, additional controls must be installed to assure collection of this water by control facilities where required by the stormwater design.

When discharging peak flows greater than the existing peak flow rates, proper analysis of channel capacity downstream of a development site is essential to insure that the discharge is not creating any new problem areas or aggravating existing drainage problem areas. The analysis must include the assumption of complete build-out of the tributary areas to the channel being evaluated based upon the most current zoning requirements. The analysis must also analyze the future conditions assuming that stormwater detention on development sites is not implemented. In addition, stormwater control measures consistent with the Plan must be assumed in analyzing projected development upstream of the point of evaluation.

Stream channels, watercourses or other conveyance facilities may be improved to meet the above requirements and alleviate existing capacity deficiencies as long as local, state, and federal requirements are met and the applicable permits obtained. Any facilities that are subject to Chapter 105 criteria must be designed to be consistent with Chapter 105.

Culverts, bridges, stream enclosures or any other facilities must meet the criteria outlined in DEP Chapter 105 Rules & Regulations. Such facilities shall allow an unimpeded flow to be conveyed.

Table V-3 provides a process to accomplish the required standards and criteria, on a priority basis, looking at means other than detention to promote recharge, improve water quality and prevent streambank erosion and to reduce proposed conditions peak flows to the required existing conditions rate.

TABLE V-3
Process to Achieve the Standards and Criteria in Order of Required Consideration
(Ultimate Goal - Match Existing Conditions)

1. Maximize use of Nonstructural Stormwater Management BMPs
   - Minimize disturbance of natural features
   - Minimize grading
   - Minimize impervious surfaces, consider pervious surfaces
   - Break up large impervious surfaces
2. Satisfy water quality and streambank erosion requirements
   - Apply BMPs near the source of the runoff
3. Satisfy groundwater recharge (infiltration) / Volume reduction objective
4. Satisfy the runoff peak attenuation objective considering all measures other than detention basins.
5. After satisfying the above requirements, incorporate dual purpose detention measures, if necessary, to attenuate peaks. Dual purpose detention is recommended, e.g., recycling water, wetlands basins, water storage for fire flow, etc.
6. Maximize Nonstructural Stormwater Management Alternatives
   - Minimize disturbance of natural features
   - Minimize grading
   - Minimize impervious surfaces, consider pervious surfaces
   - Break up large impervious surfaces
7. Satisfy Groundwater recharge (infiltration) objective
8. Evaluate needs for treating runoff (water quality objective)
   - Apply BMPs near the source of the runoff
9. Satisfy the runoff peak attenuation objective considering all measures other than detention basins.
10. After satisfying the above requirements, incorporate dual purpose detention measures if necessary to attenuate peaks. Dual purpose detention is recommended (e.g. recycling water, wetlands basins, water storage for fire, etc.)

The required standards and criteria developed are summarized in Table V-4 while recommended standards and criteria can be found in Table V-5. The ultimate goal would be to match the existing conditions hydrograph, not just the existing conditions peak. Nonstructural stormwater management measures (or open space planning) should be evaluated to help achieve this goal. Section V of the Pennsylvania Stormwater Best Management Practices Manual should also be consulted to achieve these goals.

TABLE V-4
Required Criteria & Standards

REQUIRED STANDARD	BENEFIT
Stormwater Management A, B, and C Management Districts	No increase in runoff on a watershed wide basis, stormwater attenuation.
Calculations Methodology Standard parameters shall be set in the Model Ordinance.	Calculations for consistent stormwater management.
Existing Storm Sewers or Culverts Discharge into existing storm sewer networks or culverts will be based on system capacity or design storm(s), whichever is more restrictive.	Preserve sewer/culvert capacity thereby reducing Operation and Maintenance and replacement costs.
Discharge of Accelerated Runoff Only excess accelerated stormwater runoff (after all criteria has been met) shall be safely discharged into existing conditions drainage patterns and storm sewers without adversely affecting properties or causing channel scouring and erosion.	Safe conveyance, continued surface and groundwater quality, flow attenuation.
Inappropriate Outlets If outlet from stormwater conveyance systems from a development site to a stream, tributary, stabilized channel, or storm sewer is not possible, runoff shall be collected in a BMP and discharged at a non-erosive rate. Outlets discharging onto adjacent property owner(s)' properties must have appropriate easements for said discharge. Where an NPDES permit for stormwater discharges associated with construction activities is required, Refer to the DEP Guidance Document titled "Off-Site Discharges of Stormwater to Areas that are not Surface Waters", as amended, and the DEP FAQ titled "Chapter 102 Off-Site Discharges of Stormwater to Non-Surface Waters", as amended.	Safe conveyance, continued surface and groundwater quality, flow attenuation.
District C Those areas designated in Figure V-5 as being in District C shall safely discharge runoff directly into an existing conditions conveyance system with no detention or attenuation of greater than the 5-year storm, if the system has the capacity.	Allows excess runoff to exit watershed system prior to peak while still meeting water quality and groundwater recharge goals.

TABLE V-4 (cont.)
Required Criteria & Standards

REQUIRED STANDARD	BENEFIT
Wetlands Network with administrative and regulatory agencies involved with work within wetland areas to help promote the protection of those resources.	Infiltration, surface and groundwater recharge, stream baseflow, water quality, flow attenuation, detention.
Recharge/Infiltration/Retention Infiltration and retention BMP's are preferred over standard detention basins, where soil and physical conditions permit. Impacts on subsurface mine pools and Karst areas should be evaluated before recommending this type of practice.	Groundwater/stream baseflow recharge, flow attenuation.
Water Quality Provide adequate storage and treatment facilities necessary to capture and treat the Water Quality Volume (WQv). See Section V.B.2.b for calculation methodology for WQv.	Allows pollutants to settle thus providing improved water quality.

TABLE V-5
Recommended Criteria & Standards

RECOMMENDED STANDARD	BENEFIT
Erosion and Sediment Pollution Control Network with administrative and regulatory agencies involved with earth disturbance activities.	Infiltration, structure integrity, surface water quality, safe conveyance, stream, culvert, and channel capacity.
Floodplains Those floodplains in which the floodplain stores water shall not be filled nor covered with impervious surface which may reduce the storage capacity. Floodplains should be vegetated with native plants where possible.	Natural stormwater detention/flood control downstream.
Roof Drains, Residential/Commercial Prevent all roof drains from directly discharging into storm sewers, roadside ditches or channels. Discharge to lawn, recharge basin or storage facilities for re-use.	Promotes infiltration, flow attenuation and increases runoff time of concentration.
Pervious Surfaces The use of pervious materials will be encouraged for parking surfaces and sidewalks. Aquifer recharge beds are encouraged.	Infiltration, groundwater recharge.
Stormwater BMP's Concentrate on locating facilities within areas conducive to recharge and accommodate recharge to meet management district requirements. No stormwater structures are allowed in floodplains that would reduce the storage volume.	Infiltration, groundwater recharge, stream baseflow.
Steep Slopes Regulate activities in steep slope areas where management of stormwater by structure is inappropriate. Slopes should be vegetated with native vegetation.	Stream base flow, flow attenuation, conveyance integrity, surface water quality.
Stream Bank Protection Reduce 2-year proposed conditions flow to 1-year existing conditions flow.	Reduces the number of erosive flows thereby reducing stream bank erosion.
Green Roof Construct rooftop gardens	Flow attenuation and small storm retention

The references in the Reference Section of this Plan should be consulted to aid the design engineer in BMP selection and design. Riparian buffer width that is recommended is 150 feet of a vegetative mix measured from the top of bank on both sides of the stream.

Note: See the Model Ordinance for standards with more detailed criteria.

D. Alternative Runoff Control Techniques

Some runoff control techniques are "structural" stormwater management controls meaning that they are physical facilities for runoff abatement. Others are "non-structural" controls, referring to land use management techniques geared toward minimizing storm runoff impacts through control of the type and extent of new development throughout the study area. The Brodhead Creek and McMichaels Creek Watershed Stormwater Management Plan is based on the assumption that new development of various types will occur throughout the study area (except as regulated by floodplain regulations) and that structural controls will be required to minimize the runoff implications of the new development.

1. Nonstructural Runoff Controls - Non-structural methods of controlling stormwater runoff quantity and quality, such as innovative site planning, impervious area and grading reduction, protection of natural depression areas, temporary ponding on site and other techniques are recommended. Non-structural BMPs are increasingly recognized as a critical feature of stormwater BMP plans, particularly with respect to site design. In most cases, non-structural BMPs shall be combined with structural BMPs to meet all stormwater requirements. The key benefit of non-structural BMPs is that they can reduce the generation of stormwater from the site; thereby reducing the size and cost of structural BMPs. In addition, they can provide partial removal of many pollutants. The non-structural BMPs have been classified into broad categories including, but not limited to:

    - Natural area conservation
    - Limiting disturbed areas
    - Conservation design

A more detailed discussion on nonstructural Stormwater BMPs can be found in the Pennsylvania Stormwater Best Management Practice Manual.

2. Structural Runoff Controls - Structural controls for managing storm runoff can be categorized as either volume controls or rate controls. Volume controls are designed to prevent a certain amount of the total rainfall from becoming runoff by providing an opportunity for the rainfall to infiltrate into the ground. Greater opportunity for infiltration can be provided by minimizing the amount of impervious cover associated with development, by draining impervious areas over undisturbed areas or into specific infiltration devices, and by using grassed swales or channels to convey runoff in lieu of storm sewer systems. Rate controls are designed to regulate the peak discharge of runoff by providing temporary storage of runoff which otherwise would leave the site at an unacceptable peak value. Rate controls, much more so than volume controls, are adaptable to regional considerations for controlling much larger watershed areas than one development site.

   a. Innovative BMPs - The use of traditional and innovative Best Management Practices (BMPs) is encouraged to meet the recharge, water quality and quantity criteria established in this Plan. The Pennsylvania Handbook of Best Management Practices for Developing Areas prepared by the Pennsylvania Association of Conservation Districts, Inc., Spring, 1998, BMP Manuals referenced in or the PA PCSM BMP manual as revised and amended , should be used to design and maintenance of these practices/facilities.

   b. Temperature Sensitive BMPs – Runoff from blacktop during hot summer months can provide a "slug" of warm water into the streams, which could affect trout nd other orgnisms in the stream. Therefore, the temperature and quality of water and streams shall be maintained through the use of temperature sensitive BMPs and stormwater conveyance systems. Temperature sensitive BMPs are simply those BMPs which help reduce the temperature of the discharge of the BMP, typically by shading or by providing temporary underground storage. A list of some temperature sensitive BMPs and the source for further information on them can be found in Table V-6.

TABLE V-6
Temperature Sensitive BMPs
To minimize temperature increases caused by new development in watersheds Stormwater BMP designs should:

- Provide shading for pools and channels (particularly south side)
- Maintain existing forested buffers
- Bypass available baseflow and/or springflow
- Utilize underground storage where possible
- Utilize recharge

   c. Quantity Control - Post development runoff from a site must not exceed the applicable existing conditions rate applied to the subwatershed where the site is located. This runoff control can be obtained in a number of different ways. The applicant must select the technique that is the most appropriate to the type of project and physical characteristics of the site. Best Management Practices can be utilized to manage water quality, ground water, recharge, streambank erosion and quantity (peak and volume).The

runoff control(s) most applicable to a development site may vary widely depending upon site characteristics such as:

- Type of development proposed
- Soil characteristics (hydrologic soil group, etc.)
- Subsurface conditions (high water table, bedrock, etc.)
- Topography (steepness of slope, etc.)
- Existing drainage patterns
- Economics
- Advantages and disadvantages of each technique
- Applicable performance standard

A more detailed discussion on structural Stormwater BMPs can be found in the Pennsylvania Stormwater Best Management Practice Manual.

E. Sub-Regional (Combined Site) Storage

Traditionally, the approach to stormwater management has been to control the runoff on an individual site basis. However, there is a growing commitment to finding cost-effective comprehensive control techniques that both preserve and protect the natural drainage system. In other words, two developers developing sites adjacent to each other could pool their capital resources to provide for a community stormwater storage facility in the most hydrologically advantageous location.

The goal should be the development and use of the most cost-effective and environmentally sensitive stormwater runoff controls. These controls will significantly improve the capability and flexibility of land developers and communities to control runoff consistent with the Brodhead and McMichaels Creek Stormwater Management Plan.

An advantage to combining efforts is to increase the opportunity to utilize stormwater control facilities to meet other community needs. For example, certain stormwater control facilities could be designed so that recreational facilities such as ball fields, open space, volleyball, etc. could be incorporated. Natural or artificial ponds and lakes could serve both recreational and stormwater management objectives.

To take this concept a step further, there is also the possibility that the stormwater could be managed "off-site"; that is, in a location off the property(s) in question. These stormwater management facilities could be constructed in an offsite location more hydrologically advantageous to the watershed. These facilities could be publicly owned detention, retention, lake, pond, or other physical facilities to serve multiple developments. The design and release rate would need to be consistent with the Plan.

F. Regional Detention Facilities

Another aspect of the control philosophy is the provision for regional detention alternatives. The major advantage of a regional facility is the ability to control the runoff from large watershed areas with a single facility rather than one facility for each development site in the tributary area. A single facility may be more aesthetically acceptable than many smaller basins and would offer the benefit of much more efficient maintenance.

The potential for locating regional facilities within the Brodhead and McMichaels Creek Watershed was not evaluated as part of the plan. However, criteria to follow when investigating

the potential for a regional basin should include the following six parameters:

1. Site location's influence on the total watershed hydrology
2. Available undeveloped land
3. Ownership of the land
4. Topography
5. Environmental sensitivity of the locations
6. Total area and percent of the total contributing area to the basin location

While the feasibility of a regional basin was beyond the scope of this plan, the potential does exist for implementing regional detention alternatives within the Brodhead and McMichaels Creek Watersheds. In the original Brodhead Creek Act 167 Watershed Plan, locations of existing and proposed regional detention facilities were evaluated. Please refer to those Plans for locations and feasibility. The most likely alternatives would involve relatively small tributary areas representing several development sites. For the purposes of this Plan, any regional alternatives would require the initiative of a developer or group of developers to propose a regional facility. The funding, design criteria, maintenance provisions and other applicable considerations would be the product of Developer-Municipal-County discussions. There are no specific recommendations for locations of regional detention facilities incorporated in this Plan. However, since the Management Districts were developed based upon subarea delineations of tributaries to the Brodhead and McMichaels Creeks, the same Management District criteria would be applied to a "regional" facility controlling the entire subarea. Decisions between individual development detention facilities and facilities for entire subareas therefore depend upon the type of development(s) proposed conditions and the cost-effectiveness of each control alternative.

G. "No Harm Option"

A developer has the option to prove to the municipality that the increase in runoff generated from his site above the allowable release rate will cause "no harm" anywhere in the watershed. The No Harm Option is used when a developer can prove that the proposed conditions hydrographs can match existing conditions hydrographs, or if it can be proved that the proposed conditions will not cause increases in peaks at all critical points downstream.

Several developers within the same subwatershed could independently show that they would cause no harm. However, the cumulative effect of these contributions could significantly increase the flow. Therefore, proof of no harm would have to be shown if the entire subarea(s) within which the proposed development is located would be developed and the cumulative effect would not create a problem anywhere in the watershed. The impact of the increase in flow would have to be followed downstream until the increase diminishes due to additional flow from tributaries and/or stream attenuation.

H. "Hardship Option"

The plan and its standards and criteria were designed to maintain existing conditions peak flows throughout the Brodhead and McMichaels Creek watershed as the watershed becomes developed. There may be certain instances, however, where the standards and criteria established are too restrictive for a particular landowner or developer. The existing drainage network in some areas may be capable of safely transporting slight increases in flows without causing a problem or increasing flows elsewhere. If a developer or homeowner is not able to meet the stormwater standards due to lot conditions or if conformance would become a hardship to an

owner, the hardship option may be applied. The landowner would have to plead his/her case to the Governing Body with the final determination made by the Municipality. Any landowners pleading the "hardship option" will assume all liabilities that may arise due to exercising this option.

I. Exemptions

The following land use activities are exempt from the provisions of the Model Ordinance:

1. High Tunnels that meet the following three factors:

    a) Factor 1, Usage: High Tunnel structures must be used for one of the following purposes to be considered for exemption:
        - High tunnel systems that are used for the production, processing, keeping, storing, sale or shelter of an agricultural commodity. An agricultural commodity includes the production of plants used for human or animal feed, forestry, and horticultural purposes including the production and raising of livestock and poultry and the products they generate.
        - High tunnel facilities used for the storage of farm equipment and farm supplies

    b) Factor 2, Construction: High tunnel structures must be constructed following all of the following criteria:
        - Constructed using metal, wood or plastic frame;
        - The materials used for covering the frames of the high tunnels include plastic, woven textile or other flexible coverings; and
        - The floor of the high tunnel needs to be composed of soil, crushed stone, matting, pavers, a floating concrete slab or a combination of these materials.

    c) Factor 3, Siting: High tunnel structures must be sited following the following criteria:
        - High tunnel structures that result in an impervious area less than of equal to 25% of all structures located on the owner’s total contiguous land area; and
        - The high tunnel facility must meet at least one of the following criteria:
            - Must be located at least 100 feet from any perennial stream or other watercourse, public road, or neighboring property line; or
            - Must be located at least 35 feet from any perennial stream or other watercourse, public road or neighboring property line where the slope of the are where the facility is placed is not greater than 7 percent; or
            - There is a diversion system or buffer built and managed consistent with this plan that ensures that the runoff from the high tunnel does not directly drain into a stream or other watercourse.

The following land use activities are exempt from the Drainage Plan submission requirements of the Model Ordinance:

1. Use of land for gardening for home consumption.

2. Agriculture when operated in accordance with a Conservation Plan or Erosion and Sediment Control Plan (E & S) found adequate by the Conservation District.

3. Forest Management operations which are following the Department of Environmental Protection's management practices contained in its publication "Soil Erosion and

Sedimentation (E & S) Control Guidelines for Forestry" and are operating under an approved E & S Plan and must comply with stream buffer requirements and floodplain management requirements.

4. Impervious surface (See definition) - Any Regulated Activity that has less than 5,000 square foot of impervious surface and/or meets the following exemption criteria is exempt from the plan submittal provisions of the Ordinance. These criteria shall apply to the total development even if development is to take place in phases. The date of the original Brodhead McMichaels Stormwater Ordinance adoption shall be the starting point from which to consider tracts as "parent tracts" in which future subdivisions and respective impervious area computations shall be cumulatively considered.

Additional exemption criteria include:

5. Exemption responsibilities – An exemption shall not relieve the Applicant from implementing such measures as are necessary to protect the public health, safety, and property. An exemption shall not relieve the Applicant from providing adequate stormwater management for Regulated Activities to meet the purpose of this Ordinance; however, drainage plans will not have to be submitted to the municipality.

6. HQ and EV streams - This exemption shall not relieve the Applicant from meeting the special requirements for watersheds draining to high quality (HQ) or exceptional value (EV) waters, identified and Source Water Protection Areas (SWPA) and requirements for nonstructural project design sequencing, water quality and streambank erosion, and groundwater recharge.

7. Drainage problem - If a drainage problem is documented or known to exist downstream of, or expected from the proposed conditions activity, then the municipality may require a Drainage Plan Submittal.