SECTION IV. STANDARDS FOR CONTROL OF STORMWATER

The following section outlines the standards, methods of implementation, and justification for a watershed-level runoff control program for the Tohickon Creek watershed, to be implemented at the municipal level. The standards are a direct result of the watershed modeling. This plan also incorporates the benefits of recharge and water quality management. The standards reflect the cumulative process of managing stormwater runoff on a watershed-level basis, from the furthest upstream point to the lowest drainage point. Proper municipal administration and implementation of the standards will ensure an adequate level of control for all municipalities within the watershed.

A. Design Storm

Preliminary design storm analysis evaluated whether or not the range of storms (e.g., 2-year, 5-year, 10-year) could be managed efficiently by the use of hydrologic release rate controls for stormwater management facilities in this watershed. Table 5 shows the rainfall depths for a range of storm return frequencies for the watershed. The analysis showed that for design storm return frequencies up to and including the 10-year storm, the application of hydrologic release rate controls for stormwater management would help maintain existing peak flow rates in several interior subwatersheds throughout the main watershed. Therefore, where a hydrologic release rate is required in the Tohickon Creek watershed, it is only applicable for the 1-, 2-, 5- and 10- year frequencies.

The analysis also indicated that for design storms greater than the 10-year storm, the application of a hydrologic release rate less than 100 percent (pre-to-post control) had little or no positive effect on stormwater management. This is due in part to the relatively rural nature of the watershed, the existence of Lake Nockamixon within the watershed, and the proximity of the Delaware River. The latter factors would account for little benefit being gained by extended detention of runoff. This is because of the capacity of Lake Nockamixon to assimilate large volumes of runoff as compared to a smaller, interior stream or creek. However, it is a serious concern in this analysis as to the effect of increased runoff on the interior tributaries and drainageways conveying runoff to Lake Nockamixon and the Delaware River. These may not have adequate capacity to accommodate additional or increased flows. Therefore, all storms above the 10-year frequency storm should be released at 100 percent of the existing flow rate (i.e., pre-to-post control).

An important factor in developing consistent stormwater runoff values is the use of uniform, consistent design storm frequencies and runoff amounts. This report incorporates the use of rainfall depths taken from Intensity-Duration-Frequency (IDF) curves, found in PennDOT design manuals. The accepted values for differing storm events in this region and the associated rainfall amounts are shown on Table 5. It is recommended that these values be incorporated into the municipal ordinance as the standard values for any stormwater facility analysis or design done in the watershed.

Table 5. Rainfall Depths

Frequency of Storm Event (years)	Rainfall Depth (inches)
1	2.4
2	3.1
5	3.7
10	4.5
25	5.5
50	7.0
100	7.5

(Source PennDOT, Intensity-Duration-Frequency Tables for Region 4)

B. Calculation Methodology for Stormwater Management Planning

It is recommended that all stormwater runoff calculations and determinations shall incorporate the "Soil Cover Complex" (SCC) method developed by the Natural Resource Conservation Service (NRCS) in their Technical Release-55 (TR-55), titled *Urban Hydrology for Small Watersheds*. The SCC method is a standardized way to evaluate stormwater runoff conditions based on what type of covering is on the surface of the land. Calculations for the SCC should be made using the rainfall and curve number data supplied in Tables 5 and 6.

C. Curve Numbers To Be Used As A Standard in Design

For the development of existing and future runoff numbers in the modeling for the watershed analysis, consistent values for curve numbers had to be generated. As explained previously, this was done to calibrate the model and also to establish a baseline set of engineering standards for use by the watershed municipalities when implementing this plan. It is recommended that all watershed municipalities adopt the use of the Soil Cover Complex method in stormwater facility calculations and design.

The curve numbers used in this plan have been taken from the TR-55. The TR-55 curve numbers are found on Table 6. This information should be referenced in the municipal ordinance as the mandatory curve number values to be used in stormwater design calculations.

Table 6. Curve Number (CN) Values for Land Cover in the Tohickon Creek Watershed

Land Cover Type	Hydrologic Soil Groups			
	A	B	C	D
Residential				
Multi-Family	77	85	90	92
Single-Family (<1/2-acre lots)	57	72	81	86
Single-Family (1/2- to 2-acre lots)	51	68	79	84
Single-Family (>2-acre lots)	46	65	77	82
Commercial	89	92	94	95
Industrial	81	88	91	93
Paved	98	98	98	98
Agricultural*	61	73	80	84
Open Space/Lawn/Parks/Cemeteries	49	69	79	84
Mining/Disturbed Earth	77	86	91	94
Pasture/Grassland	49	69	79	84
Brush	35	56	70	77
Wooded	36	60	73	79
Water	98	98	98	98

Source: TR-55, June 1986.

* Average of Good Hydrologic Condition Values from Table 2-2.b of TR-55
Generally, CN values used assume fair hydrologic conditions

D. Hydrologic Release Rate Districts

Proposed development, when built, will impact the stormwater runoff throughout the watershed. The projected runoff from future development must be evaluated with an eye towards its location (upstream or downstream) in the watershed, the natural topography of the area, and the environmental features of the municipality. This is done to create a comprehensive watershed-level runoff control system, or stormwater management program. The runoff control aspect of the system proposed for the Tohickon Creek watershed can be achieved by regulating the runoff peak flow rate from each subwatershed, thereby slowing down the speed, or rate, that runoff exits it. This is done according to a hydrologic "release rate" method, or by reducing peaks of runoff entering the watershed drainage system to a percentage of its predevelopment peaks. The STREMTUL model utility calculates the appropriate percentage of runoff peak released from each subwatershed to the next.

The release rate areas for the watershed have been aggregated into "districts" or similar areas of hydrologic peak rate control standards. Several different appropriate release rate standards

became apparent as modeling was performed for the watershed. Three significant factors influenced the runoff controls prescribed for this watershed:

- Significantly large times of concentration throughout the watershed because of its rural nature;
- Relatively low level of development which will not dramatically increase flows;
- Rugged topography and a substantial amount of vegetation.

The Hydrologic Release Rate Districts and the subwatershed designations established for the Tohickon Creek watershed are shown in detail on Figure 8 and summarized by municipality in Table 7. The majority of the Tohickon Creek watershed will be regulated by a 100 percent release rate standard; that is, any stormwater management facilities built within new developments cannot release stormwater runoff at a rate greater than what was created from the site prior to development. This regulation will coincide with a great number of municipalities that already endorse the "pre-to-post" runoff control philosophy. There are also three other release rate districts associated with the watershed; a 90 percent release rate district, a 75 percent release rate district, and a conditional direct discharge district.

It should be noted that required recharge and water quality criteria are applied uniformly throughout the watershed and must be adhered to regardless of peak rate districts. Even in direct discharge districts the water quality and recharge volumes must be managed as outlined in the ordinance for this plan found in Appendix G of Volume II, and are at no times exempt from stormwater management

The release rate districts are defined as follows:

1. Conditional Direct Discharge (No Peak Rate Detention) District

Developments in the Conditional Direct Discharge district (subwatersheds 2, 3, 8-10, 18, 20, 21, 42, 43, 52, 54, 56, 57, 59, 61, 62, 67, 70-73, 76, 77, 81-83) may discharge peak flows of postdevelopment runoff directly into streams without peak flow detention facilities and not adversely affect the total watershed peak flow (Figure 8 and Table 7). Conditional Direct Discharge areas are limited only to locations or sites in the district adjacent to Lake Nockamixon or immediately upstream of the Delaware River, which are capable of assimilating undetained runoff without affecting the watershed level of runoff control. However, in certain instances, the conveyance capabilities of the local streams, detention facilities, or other drainageways may not be adequate to safely transport the increased peak flows from postdevelopment volumes or peak rates of undetained runoff. In these cases, the developer shall assure that a minimum 100 percent release rate control is applied to facilities discharging to these receiving stream(s) or tributaries, and/or the developer may provide increased capacity of those receiving stream or tributaries in order to ensure safe passage of any undetained runoff. The municipality prior to approval of development plans should determine the method of increasing capacity. The municipal

engineer should determine where direct discharge can be used and where a 100 percent pre-to-post runoff rate must be used.

It is important to note, based on the best interest of the municipality and downstream areas, the use of direct discharge without peak rate detention is conditional. This is because there may be sites within the district that are not well suited to direct discharge because of existing flooding or drainage problem areas. Therefore, if in the opinion of the municipal engineer or other responsible agency, a development is unable to safely use direct discharge without peak rate detention, then a minimum 100 percent release rate ("pre-to-post") standard applies. Before allowing the use of direct discharge, the burden of proof is on the applicant to show the municipality that "no detention" of the peak rate discharge will not create or exacerbate downstream problem areas or create an environmental hazard. The municipality reserves the right to require a developer to apply a minimum 100 percent release rate.

2. 100 Percent Release Rate District

Subwatersheds located in the 100 percent release rate district (subwatersheds 4-7, 11-17, 19, 22-28, 31-34, 41, 44-51, 53, 55, 58, 60, 63, 64, 66, 68, 69, 74, 75, 84-98, 101, 109, 111-114, 116, 118, 119, 121-126) are not expected to incur a great deal of development growth (Figure 8 and Table 7). This can be attributed to their location, topography, and soils, or a combination of all three factors within the watershed. Therefore, sites in these areas can release postdevelopment runoff from a stormwater management facility at a rate that does not exceed the predevelopment or existing rates of runoff ("pre-to-post" standard).

3. 90 Percent Release Rate District

Certain subwatersheds in the upper reaches of the watershed (subwatersheds 30, 35-40, 226) require release rate control that reduces stormwater runoff created by new development to a 90 percent release rate (Figure 8 and Table 7). This means the peak rate of runoff leaving the site after development is no more than 90 percent of the predevelopment peak rate of runoff that left the site in existing conditions. These areas are located in Bedminster Township, and the imposition of this release rate serves to address a number of storm conveyance problem areas, in addition to addressing future development pressures. The geographic location of these subareas magnifies the resultant flows to the Tohickon, and controls in these areas will benefit the downstream subwatersheds.

4. 75 Percent Release Rate District

Certain subwatersheds in the upper reaches of the watershed (subwatersheds 78-80, 99, 100, 102-108, 110, 115, 117, 120) require release rate control that reduces stormwater

runoff created by new development to a 75 percent release rate (Figure 8 and Table 7). This means the peak rate of runoff leaving the site after development is no more than 75 percent of the predevelopment peak rate of runoff that left the site in existing conditions. One area includes all of Quakertown Borough and the portion of Richland Township surrounding the borough. This area must also deal with existing inadequacies in storm conveyance facilities. The second area is comprised of three subwatersheds in the southwestern East Rockhill and northeastern West Rockhill townships.

Table 7. Release Rate Districts by Subwatershed and Municipality

Municipality	Subareas Contained in each Release Rate District			
	Direct Discharge	100%	90%	75%
Bedminster Twp.	18, 20, 21, 42, 43, 52, 54, 57, 59, 62, 70, 72, 76, 77	11-16, 22-28, 31-34, 41, 44-47, 50, 51, 58	30, 35-40, 226	
Dublin Boro.		32, 34	38-40	
East Rockhill Twp.	77, 81-83	92-97		78, 79
Haycock Twp.	62, 67, 70-73, 76, 81-83	64, 66, 74, 75, 84, 85, 87-92, 94, 95, 98, 109, 114, 117		
Hilltown Twp.		34		
Milford Twp.		101, 124		104
Perkasie Boro.				78
Plumstead Twp.	2, 3, 8-10	4-7, 11, 13, 14, 16, 32-34		
Nockamixon Twp.	56, 57, 59, 61, 67	60, 64, 68		
Quakertown Boro.				102-106, 115
Richland Twp.		92, 93, 95-98, 101, 109, 111-114, 116, 118, 119, 121-126		99, 100, 102-108, 110, 115, 117, 120
Richlandtown Boro.		111, 112, 116		110, 115
Springfield Twp.		63, 64, 66, 69, 83, 89, 91, 109, 113, 116, 118, 119, 124-126		
Tinicum Twp.	2, 9, 10, 18, 20, 21, 42, 43, 52, 54, 56, 57	17, 19, 53, 55		
Trumbauersville Boro.		101		
West Rockhill Twp.		97, 101		78-80
Upper Saucon Twp.		126		

(Please refer to Figure 8, Release Rate District Map, for the location of the numbered subwatersheds listed above.)

E. Water Quality

Water quality treatment of stormwater runoff is mandatory for all new and redevelopment sites in the watershed. Treatment will occur through control of a portion of runoff from the site that shall be known as the water quality volume. The volume of runoff required to be managed from the site is directly related to the amount of impervious cover created. Water quality volumes (WQ_v) necessary for control are site specific, and need not include offsite areas. The WQ_v is measured in acre-feet of storage.

The mandatory water quality standard is as follows:

$$WQ_v = \frac{(1.0)\,(R_v)\,(A)}{12}$$

WQ_v = Water Quality Volume required for each site to manage
A = Site acreage
R_v = The volumetric runoff coefficient = 0.05 + 0.09(I), where I = The impervious surface ratio for the site

The equation represents an inch of rainfall multiplied by a volumetric runoff coefficient (R_v) and the site area. For the purposes of management in this watershed, a consistent value of 1 inch of rainfall will be used to eliminate variations in the calculations. One inch represents the anticipated amount of rainfall that can be expected from 90 percent of annual rainfall events.

The water quality volume must be treated with the use of a BMP, as found on Table 3.1 of this plan, or in the Pennsylvania Handbook of Best Management Practices (DEP, 1998). The mandatory water quality volume may be incorporated with the recharge volume to eliminate the need for multiple facilities; however, under no circumstances is water quality volume exempt from management in this watershed. If infiltration facilities are used for the water quality volume management, then the mandatory recharge volume should be incorporated for a total water quality volume.

F. Combined Stormwater Management Facilities

Traditionally, the approach to stormwater management has been to control the runoff on an individual site basis. However, the interest of developers to find cost-effective comprehensive stormwater control techniques has increased. For example, two landowners 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. Table 8 shows the standards for control of stormwater required in this watershed, and gives an overview of how these standards work together to create a combined stormwater management approach. The goal should be the installation of environmentally sensitive