LU/SWC

Final Report

SPARKILL CREEK FLOOD CONTROL ANALYSIS

May 1999

Submitted to:
The Rockland County Drainage Agency
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FLOOD CONTROL ANALYSIS
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EXECUTIVE SUMMARY

This study addresses the Request for Proposals for Sparkill Creek Flood Control Analysis, prepared by Richard A. Cohen, P.E., Chief Engineer, Rockland County Drainage Agency. This study determines the 25, 50 and 100 year storm levels for Sparkill Creek from its confluence with the Hudson River in the Village of Piermont, to its crossing with Greenbush Road, located approximately 370 LF north of Hickory Street in the Town of Orangetown approximately 7.1 miles upstream. The flooding limits are shown on the Floodplain Maps and the flood elevations and cross section locations are shown on the Flood Profiles.

Alternatives to reduce flooding along Sparkill Creek were investigated. Specific improvements which were deemed beneficial are presented in the Report and are as follows:

1. Replacement of the Valentine Avenue Culvert and channel improvements upstream to William Street at an approximate cost of $540,000.

2. An additional culvert under the Palisades Interstate Parkway (PIP) upstream of Williams Street at an approximate cost of $800,000.

3. Elimination of the Railroad Bridge and portion of the embankment at the Orangetown Wastewater Treatment Plant at an approximate cost of $250,000.

4. Improvements to the Rockland County Sewer District Treatment Plant Number 1 Access Drive culvert off Orangeburg Road at an approximate cost of $100,000.

5. Replacement of the Orangeburg Road (Route 340) culvert at an approximate cost of $515,000.

By replacing and/or improving the culverts and adjacent channel approaches as described above, flooding will be reduced upstream. Floodplain delineations for existing conditions and the improved conditions are shown on the Floodplain Maps.

Non-structural measures such as land use controls, development policies, floodplain management and preservation of wetlands are addressed in the Report. Of key importance is sound floodplain management and preservation of the extensive wetland areas within the Sparkill Creek watershed.

Floodplain management is currently in effect on Sparkill Creek. All new developments are reviewed by the Rockland County Drainage Agency and compensating storage is required for any fill placed within the floodplain. Wetlands are currently regulated at the State and Federal level. While these wetland regulations are prohibitive to the filling in of large areas of wetlands, they do allow filling of small parcels (generally less than one acre). While the impact per project may not be significant under the current wetlands regulations, the cumulative watershed impact over time can be significant, as parcels develop along the wetlands fringes.

Field reconnaissance was performed to identify areas along Sparkill Creek requiring stream maintenance. Areas requiring significant maintenance and potential sources of pollution are as follows:

1. The reach of Sparkill Creek between Rockland Road and Paradise Avenue contains sections of retaining walls which have collapsed as a result of erosive forces causing roadway embankment erosion, pavement problems, leaning utility poles and guide rail, and cracks in the foundations of adjacent homes.

2. The pond upstream of the Mill Pond Dam in the Village of Piermont has filled in with sediments. While the sedimentation does not significantly effect flooding, the aesthetic and recreational value of the pond is affected.

3. Debris was observed at the upstream entrances to the following stream crossings:

   - Valentine Avenue
   - Erie Railroad Crossing
   - Livingston Avenue
   - Orangeburg Road/Route 340
   - Schoolhouse Lane
   - Access Road to Innovative Plastics off Route 303

4. Debris pile-ups were observed at the Creek bends along the reach between the Orangetown Wastewater Treatment Plant and the Rockland County Sewer District Wastewater Treatment Plant.

5. Just upstream of Williams Street, dumpsters located in the parking lot at Tony's Lobster and Steak House are a potential source of pollution.

6. The industrial park near Livingston Avenue (Sec. No. 17840), which includes adjacent parking facilities, is a potential source of pollution.

7. Between Route 303 and PIP there is a Woodstock Home Furnishing Warehouse with adjacent parking facilities which could be a potential pollution source.

8. Town Plaza II, just downstream of Route 303, also includes a large parking facility which could also be a potential pollution source.

9. The sand pits within the Graney Gardens residential subdivision, located approximately 1,000 feet south of the Williams Street crossing, are a potential source of sedimentation.

In order to remove sediment and other pollutants from storm water runoff a first flush basin can be utilized. A first flush basin will retain the storm water runoff long enough to allow these pollutants to settle out before they reach Sparkill Creek. However, existing development and adjacent land use along Sparkill Creek preclude the installation of a basin along the stream. Currently, storm water discharges directly into the creek along its entire reach.

This report incudes the text "Sparkill Creek Flood Control Analysis" dated February 1999 and Drawings which include:

1. Title Sheet;
2. Legend and Notes;
3. Structure Tabulation;
4. Floodplain Mapping (Total 12 sheets);
5. Flood Profiles (Total 3 sheets).

SCOPE OF STUDY

In January of 1993 the Rockland County Drainage Agency retained Goodkind & O'Dea to perform a hydrologic and hydraulic analysis of Sparkill Creek for the purpose of defining the existing floodplain, recommending specific improvements to reduce flooding, erosion, and siltation and identifying sources of point and nonpoint pollution into the stream. Maintenance items and locations for future gaging stations will also be identified. The primary tasks required as part of the study were as follows:

- Assemble pertinent and available information relative to Sparkill Creek.
- Perform a field reconnaissance of Sparkill Creek for the purpose of determining hydraulic characteristics, identifying sources of point and nonpoint pollution, maintenance needs, and obtaining additional information to supplement the existing topographic mapping provided by the Drainage Agency.
- Perform stream survey work necessary for preparation of the stream hydraulic model of Sparkill Creek.
- Perform a hydrologic and hydraulic analysis of Sparkill Creek to determine the existing 25, 50 and 100 year floodplain elevations.
- Analyze alternatives to reduce flooding.
- Delineate the floodplain limits on the mapping for existing and improved conditions.
- Provide a report summarizing the Study results including cost estimates for the recommended improvements.
- Provide a report and maps indicating stream maintenance recommendations.
- Recommend locations for future gaging stations.
- Identify locations of point and nonpoint pollution.
- Recommend locations for first flush basins and/or filter strips.
- Locate wetlands on floodplain maps.

DESCRIPTION OF STUDY AREA

Sparkill Creek is located in the southeast corner of Rockland County just north of the New York-New Jersey border (See Figure 1 for Sparkill Creek Drainage Basin). This study encompasses 7.1 miles of Sparkill Creek from Greenbush Road in the Blauvelt area of Orangetown to its confluence with the Hudson River in the Village of Piermont.

From Greenbush Road the Creek flows south parallel to Route 303 crossing Spruce Street, Route 303 and Mountainview Road at the new Town Plaza II Shopping Center. The Creek continues to flow south through the Orangeburg area crossing under Schoolhouse Lane, Orangeburg Road, Route 303 and again under Orangeburg Road. The Creek then traverses the eastern side of the Rockland County Sewer District Treatment Plant, crosses under an abandoned railroad bridge, and flows along the west side of the Orangetown Wastewater Treatment Plant before crossing under the Palisades Interstate Parkway (PIP).

Following the PIP crossing Sparkill Creek flows through the Tappan area, crossing under Kings Highway, Washington Street, through Tappan Memorial Park, under Oak Tree Road and into Northvale, New Jersey. After leaving Northvale, the Creek flows north under the Erie Railroad Bridge, joins with Sparkill Brook, and flows under Oak Tree Road again, and passes Rockaway Park Industrial Park before entering a large wetlands area at the second PIP crossing. Following the PIP crossing the Creek enters a narrow gorge flowing north parallel to Carteret Road.

The Creek continues to flow north entering the Village of Piermont crossing under Williams Street, Valentine Avenue, Highland Avenue and entering Mill Pond. After the Mill Pond Dam, the Creek becomes tidal flowing parallel to Piermont Road at Ferdon Avenue to a meandering confluence with the Hudson River.

Development within the Sparkill Creek drainage basin is typical suburban-type development including industrial, commercial and residential areas. There are approximately 29 structures along the banks of the 7.1 mile length of the Creek studied. The Creek's channel slope gradually diminishes from about 25 feet per 1,000 in the upper section to less than 5 feet per 1,000 in the central portion to 0.2 feet per 1,000 as the Creek approaches the Hudson River. There are significant flood storage areas along the Creek which act as natural detention basins. These areas are in the vicinity of both PIP crossings and the Town of Orangetown and Rockland County Sewer District Wastewater Treatment Plants.

The following table, which is based upon data from the U.S. Bureau of the Census, indicates population for the Town of Orangetown. Based upon historical trends, population growth in Orangetown can be expected to moderate. It should be noted that while the census indicates a decline in population between 1980 and 1990, an increase in housing units of approximately 9 percent was reported in the Census during the same period.

Based on past trends, the labor force can be expected to continue to shift from factory-type employment to service-type employment (office, store, etc.). Service-type jobs increased from

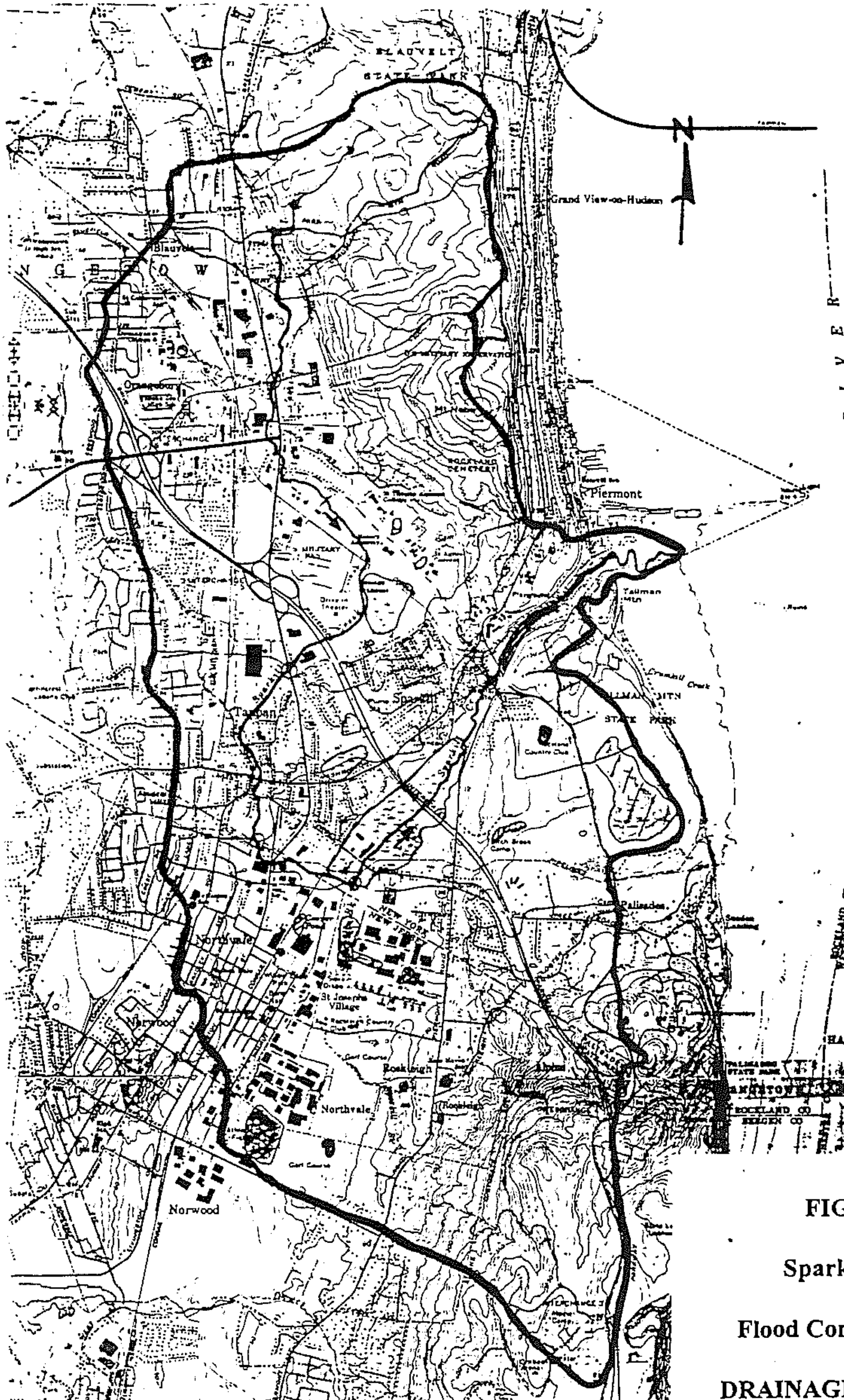

FIGURE 1

Sparkill Creek

Flood Control Analysis

DRAINAGE BASIN MAP

Scale: 1" = 4,000'

Source - USGS Nyack and Yonkers Quads

64% of the total in 1980 to 69% in 1990; factory jobs decreased from 21% in 1980 to 18% in 1990.

ORANGETOWN POPULATION Rockland County, New York 1960 - 1970 - 1980 - 1990 - 1996							
	Census April 1960	Census April 1970	Census April 1980	% Change 1970-80	Census April 1990	% Change 1980-90	Census July 1996
Orangetown Unic. (Not Including Villages)	31,813	41,443	36,697	-11.5	34,998	-4.6	36,577
Grandview Village	330	325	312	-4.0	271	-13.1	270
Nyack Village (part)	6,010	5,944	5,732	-3.6	5,958	3.9	6,076
Piermont Village	1,906	2,386	2,269	-4.9	2,163	-4.7	2,380
South Nyack Village	3,113	3,435	3,602	4.9	3,352	-6.9	3,207
Town of Orangetown Total	43,172	53,533	48,612	-9.2	46,742	-3.8	48,510

The topography of the study area can generally be characterized as rolling terrain with gentle ridges and hills. The study area is dominated by the Palisades ridge which rises sharply from the Hudson River and reaches elevations from 500 to 700 feet as compared with the Sparkill Creek Valley which generally lies below Elevation 100. The main source of the Sparkill Creek lies on the westerly slope of the Palisades and thence flows southwesterly across the New York-New Jersey boundary. The Creek then loops back across the same boundary in a northerly direction and drains to the Hudson River through a narrow gorge-like valley.

EXISTING FLOODING PROBLEMS

Currently both the Village of Piermont and Town of Orangetown experience flooding along Sparkill Creek. The flooding in the Village of Piermont downstream of the Mill Pond Dam is primarily tidal in nature and is due to tidal backwater effects from the Hudson River. Flooding along the remainder of the creek, i.e. beyond the limits of the Hudson River backwater, is riverine flooding caused by inadequate channel and/or structure (culvert, bridge) capacity. In these reaches, stormwater overflows the stream banks and affects structures, such as houses, which were constructed within the floodplain.

The Village of Piermont has flooded periodically due to storm tides on the Hudson River, normally associated with hurricanes, as far back as long time residents can remember.

While flooding on Sparkill Creek has increased due to the effects of urbanization, the majority of the chronically flooded structures were built within the naturally defined floodplain of the Creek. This, coupled with development within the watershed area, has resulted in an increase in the severity of flooding along the Creek.

Based upon historical records, the flood of record on Sparkill Creek, upstream of the Mill Pond Dam, occurred on election day in November of 1977. During this flood, approximately 5.6 inches of rainfall fell within a 24 hour period as measured at the gage located at Williams Street. Based upon rainfall only, this was approximately equivalent to a 25 year storm. More specifically, the total depth of rainfall that fell during the November 1977 storm (5.6 inches) is approximately equal to the 24-hour rainfall depth (6.0 inches) for Rockalnd County for the 25-year storm, obtained from Technical Paper No. 40 "Rainfall Frequency Atlas of the United States."

Goodkind & O'Dea, Inc. has compiled the following list of areas along Sparkill Creek which currently experience flooding on a regular basis:

Village of Piermont

Areas along Paradise Avenue, Main Street, Bridge Street at Piermont Avenue have been flooded due to tidal conditions on the Hudson River. The water has been seen up to the main floor level in the post office at the corner of Bridge Street and Piermont Avenue. The 25 year flood elevation is approximately 1.0' over the top of Bridge Street, and the 100 year flood elevation is approximately 1.5' above the top of the roadway.

Valentine Avenue and William Street

The existing twin-arch culvert under Valentine Avenue restricts the flow which results in flooding of Valentine Avenue, the St. Charles Church and some adjacent houses and buildings. The 25 year flood elevation is approximately 4.0 feet below Valentine Avenue although the 100 year flood elevation is approximately 1.5 feet above the roadway.

Carteret Road in the Vicinity of Van Terrace

Houses on the east side of Carteret Road flood due to Sparkill Creek and sheet flow coming off Van Terrace. Carteret Road has flooded to a depth of 1 to 2 feet at the intersection of Van Terrace. Some of the houses on the east side of Carteret are within the natural floodplain of Sparkill Creek.

Oak Tree Road

Flooding has been reported in the industrial area on the north side of Oak Tree Road. These industrial buildings were most likely constructed on fill placed within the natural floodplain of the Creek.

Livingston Avenue, Oak Tree Road Area, New Jersey Section (Northvale)

Flooding of the commercial areas adjacent to Sparkill Creek has occurred. The Creek is narrow in the Livingston Avenue area with parking lots and buildings built adjacent to the Creek. Sparkill Creek and Sparkill Brook join just upstream of Oak Tree Road resulting in flooding due to backwater effects on both the Creek and the Brook which flows out of the town of Northvale.

Oak Tree Road, Washington Street, Tappan Memorial Park

Both Oak Tree Road and Washington Street have been overtopped with the water reaching the first floor level of the Washington Street Firehouse. A recent flood was reported in July of 1994 which was attributed to heavy rains coupled with a debris jam at Oak Tree Road.

Orangetown and Rockland County Wastewater Treatment Plants

Relatively minor flooding from Sparkill Creek has been reported at both treatment plants with overtopping of the banks, but no flooding of the clarifiers or settling tanks has been reported to date.

Route 303

Flooding of Route 303 has been reported due to the inadequacy of the four barrel 60 inch CMP culvert under Orangeburg Road (Route 340.)

Spruce Street

Overtopping of Spruce Street has been reported during severe storms. Structural failure of the Spruce Street culvert prompted the agency to replace the aging, collapsed culvert with a new one. Although the maximum size culvert to fit the channel was installed and the flooding has been reduced as a result of this improvement, the major cause of flooding during severe storms is due to the inadequacy of the channel and relative elevation of the roadway.

Many of the above floods occur without much warning due to the steep terrain and floodplain characteristics.

PREVIOUS STUDIES

In July 1960, a report prepared by Nussbaumer, Clarke & Velzy, Consulting engineers, entitled "Sparkill Creek - Drainage Study" was submitted to the Supervisor of the Town of Orangetown. This report was a preliminary engineering study covering that portion of the Creek between the New York-New Jersey boundary and Mill Pond in Piermont. The Report concluded that the water level in Sparkill Creek should be lowered and that its carrying capacity should be increased by providing a new waterway at a lower elevation under the Palisades Interstate Parkway, removing the dam creating Mill (Boss') Pond, and improving the channel.

In December 1968, a report entitled "Sparkill Creek, Hydraulics - Hydrology" was submitted to the Rockland County Soil and Water Conservation District by Mr. Marion M. Weaver. The principal function of this report was to provide the District with the basic data needed for more extensive engineering studies. Data on rainfall and runoff were obtained and extrapolated to provide storm characteristics for the 2, 10, 20, and 100-year frequencies. Runoff data and water surface profiles were calculated for the various storm durations. The recommendations of the study included follow-up studies for evaluation of culvert enlargements, diking, channel improvements, diversion of flows at the Erie Railroad, and preservation of flood storage capacity in certain areas to prevent future flooding.

In September 1970 a report entitled "Sparkill Creek Flood Alleviation Study" prepared by Managanaro, Martin and Lincoln was submitted to the Rockland County Drainage Agency. This report was a follow-up to the Weaver Report and recommended extensive structural improvements to Sparkill Creek which would essentially result in a rechannelization of the Creek throughout its entire length. Diversion of the Creek at the "Erie Railroad" was also discussed.

In 1981 and 1982 the Flood Insurance Studies for the Villages of Piermont, South Nyack, and Grand View-on-Hudson and the Town of Orangetown were finalized. The hydrologic and hydraulic analyses for the four studies were performed by Goodkind & O'Dea, Inc. This set into process formal floodplain management, mandated by the Federal Government, establishing a 100 year floodplain, base flood elevations, stream encroachment boundaries and insurance zones for the purpose of flood insurance rating.

In 1983 studies entitled "Sparkill Creek Improvements - Valentine Avenue Reach" were completed by Garfinkel and Garfinkel Consulting Engineers recommending improvements to the Valentine Avenue and New (William) Street culverts and adjacent channel reaches. This Study concluded the following:

1. The project would reduce local flooding in the Valentine Avenue Area and immediately upstream.

2. The project would not have at an impact on the natural floodplain and wetland storage upstream.

3. Flooding downstream in Piermont would not be significantly increased (3 inch increase in water surface elevation for the 100-year flood) by opening up the Valentine Avenue culvert.

A report dated February 4, 1993, entitled "Preliminary Ecological Assessment of Sparkill Creek, Town of Orangetown, Rockland County, New York," prepared by Hudsonia, was submitted to the Rockland County Drainage Agency. The purpose of this Report was to conduct a preliminary ecological assessment of Sparkill Creek, examine the existing conditions along the Creek, identify environmental problems and make proposed recommendations. The Husdonia Report identified problems typical of streams which transverse suburban centers:

- Existing development constructed up to stream banks, thus preventing treatment of runoff water by flow across vegetated buffer areas.
- Discharge of untreated stormwater i.e., stormwater from parking lot and roadway catch basins outfall directly into the Creek.
- Deposition of sediments into the Creek from construction activities.
- High chloride concentrations, most likely from road salt.

The reports recommends formulation of a comprehensive stormwater management program to address water quality throughout the basin.

In 1987 the Chief Engineer of the Rockland County Drainage Agency recommended the County stream be flown to update all recent development within the basin and that the major, often conflicting, capital improvements recommended in the previous studies be put on hold until detailed hydrologic and hydraulic analyses of the entire basin be conducted and said improvements and stream maintenance issues be addressed concurrently with flooding remediation measures. This report is the reply to the Agency's Request for Proposal for this assignment.

STUDY METHODOLOGY

Hydrology

Peak discharges for Sparkill Creek were calculated based upon U.S. Geological Survey Water-Resources Investigation Report 90-4197, "Regionalization of Flood Discharges for Rural, Unregulated Streams in New York, excluding Long Island" by Richard Lumia, 1991. The regional analysis by Lumia utilized streamflow data from 313 gaging stations throughout New York and adjacent states to develop regression equations for each of eight hydrologic regions in New York State.

Multiple regression analysis is used to develop the relations between peak discharges of selected recurrence intervals (dependent variable) and drainage-basin characteristics (explanatory variables). Previous regression analyses for New York used ordinary least squares (OLS) methods (Zembrzuski and Dunn, 1979). The OLS estimates are appropriate when all onsite flow estimates are equally reliable, the natural variability is the same for each site, and observed concurrent flows at every pair of sites are independent. In practice, the analyst usually does not have such a uniform set of data with which to work.

Recent research by Stedinger and Tasker (1985) and Tasker and Stedinger (1989) indicates that generalized least squares (GLS) may be more appropriate for hydrologic regression than OLS. In this approach, the regression coefficients are estimated by taking into consideration the time-sampling error (length of record at each site) and the cross correlation of annual peak-discharges between sites. The above research has shown that the GLS technique was superior to OLS when streamflow data were cross correlated and (or) of differing record lengths.

In GLS regressions, each watershed in the analysis is weighted in accordance with the variance (time-sampling error) and spatial correlation structure of the streamflow characteristic (annual peak discharges). In addition, the time-sampling error in the streamflow characteristic is accounted for when the accuracy of the regression equation is evaluated. The prediction error for ungaged sites is partitioned into model error (error in assuming at an uncomplete model form) and sampling error (including both time- and spatial-sampling errors). The model error cannot be reduced by additional data collection, but the sampling error can be reduced through extended operation of existing stations or installation of new stations, or some combination of both.

For the GLS regression analysis used in this study, logarithmic (base 10) transformations were made on all streamflow and basin characteristics to obtain a constant variance of the residuals about the regression line, and to linearize the relation between the dependent variable (peak-discharge) and explanatory variables (basin characteristics) for linear least-squares regression techniques. The multiple-regression equations based on logarithmic transformation of the variables are of the form:

$$\log_{10}Y=b_0+b_1\log_{10}X_1+b_2\log_{10}X_2+....+b_n\log_{10}X_n$$

or, after taking antilogs,

$$Y = 10^{b0} (X_1^{b1}) (X_2^{b2})....(X_n^{bn}),$$

where:

Y	=	dependent variable (peak-discharge for selected recurrence interval)
X_1 to X_n	=	explanatory variables (basin characteristics)
b_0 to b_n	=	regression model coefficients estimated through GLS procedures

Selection of final explanatory variables for each model was based on stepwise regression algorithms and all-possible-subsets regression (SAS Institute, 1982; Minitab, 1985). Final regression equations were selected on the basis of several factors, including: standard error of the estimate, Mallow's Cp statistic, statistical significance of the explanatory variables, r^2 (coefficient of determination), ease of measurement of explanatory variables, and the PRESS statistic (at an index of the prediction error associated with the regression equation). Multicollinearity in the regression models was assessed by the VIF (variance inflation factor) and the correlation between explanatory variables.

Sparkill Creek falls within Hydrologic Region 3, the region in which drainage area, basin storage, precipitation and basin shape were found to be the determining factors in predicting runoff flows. The data from the Sparkill Creek Gage at the William Street Bridge was utilized in development of the Region 3 regression equations. The Sparkill Creek gage, USGS Gaging Station #01376280, recorded rainfall and runoff data from 1975 to 1979 at 15-minute intervals on an automatic-digital recorder. Lumia therefore had Sparkill Creek gage data for several years which was utilized, along with data from other gages in Rockland County, in the development of the regression equations. A total of twelve (12) gaging stations were installed in Rockland County between December 1974 and April 1977 by the U.S. Geological Survey.

An additional study performed by Richard Lumia, published in 1982 (Reference 7), involved the evaluation of rainfall-runoff data collected during 1975-1979 from 12 gaging stations on 10 streams in Rockland County, which included the Sparkill Creek gaging station. Using the gage data, hydrologic models were developed for each site (using the Army Corps of Engineers HEC-1 Flood Hydrograph Package) to simulate observed peak discharges at each gage. With minor loss rate parameter adjustments for seasonal effects, the models adequately reconstituted historical floods at each site.

It can therefore be concluded that the use of the Region 3 regression equations in Report 90-4197, which were developed using the gage data, to determine the theoretical 2 through 500-year storm peak flow rates yielded the most accurate theoretical peak discharges in the Sparkill Creek watershed to date.

The Region 3 regression equations for the 2 through 500 year floods are as follows:

$$Q_2 = 45.6(A)^{0.723} (ST+1)^{-0.390} (P-20)^{0.491} (SH)^{-0.273}$$

$$Q_5 = 33.0(A)^{0.718} (ST+1)^{-0.405} (P\text{-}20)^{0.806} (SH)^{-0.347}$$

$$Q_{10} = 29.2(A)^{0.717} (ST+1)^{-0.424} (P\text{-}20)^{0.977} (SH)^{-0.401}$$

$$Q_{25} = 27.4(A)^{0.717} (ST+1)^{-0.452} (P\text{-}20)^{1.155} (SH)^{-0.470}$$

$$Q_{50} = 27.5(A)^{0.717} (ST+1)^{-0.475} (P\text{-}20)^{1.263} (SH)^{-0.521}$$

$$Q_{100} = 28.5(A)^{0.718} (ST+1)^{-0.499} (P\text{-}20)^{1.354} (SH)^{-0.571}$$

$$Q_{500} = 33.1(A)^{0.722} (ST+1)^{-0.557} (P\text{-}20)^{1.529} (SH)^{-0.682}$$

The variables defined in the regression equations are as follows:

Drainage Area (A) - Area of basin upstream from the gage or a point of interest on a topographic map and then calculated by planimetering the basin outline (square miles).

Basin Storage (ST) - The percentage of the total drainage area shown as lakes, ponds, and swamps.

Mean Annual Precipitation (P) - The average value of mean annual precipitation over the basin (inches).

Basin Shape Factor (SH) - The calculated ratio of the square of the main channel stream length, in miles, to the drainage area in square miles.

For this study the regression equations for the 25, 50 and 100 year floods were utilized to calculate discharges at key locations, such as drainage structures, gaging stations, and upstream and downstream of a confluence with a tributary, along Sparkill Creek.

The peak discharges calculated for Sparkill Creek are shown in Table 1.

TABLE 1 - SUMMARY OF PEAK DISCHARGES

Location	Drainage area (mi^2)	Peak Discharges (cfs)		
		25-yr	50-yr	100-yr
Greenbush Road Station 392+70	0.70	312	405	513
D/S of Tributary Station 363+75	1.31	550	721	951
Route 303 Station 314+50	2.11	800	1052	1339
Route 303 Station 217+60	4.51	1071	1364	1732
U/S of Sparkill Brook Station 158+70	5.23	1192	1518	1926
D/S of Sparkill Brook Station 139+60	9.33	1658	2150	2677
Gaging Station at Williams Street Station 82+60	11.13	1426	1785	2252
Mouth (Hudson River) Station 4+10	11.70	1472	1855	2336

Variables for the regression equations including Drainage Area, Storage and Shape Factor were calculated using USGS quadrangles. The mean annual precipitation was obtained from USGS data and is included in Appendix “A”. The peak flow calculations are included in Appendix “A”.

It should be noted the flows decreased downstream of the Sparkill Brook confluence due to storage provided in the wetland area near the Palisades Interstate Parkway.

A comparison of 100 year discharges computed for this Study and discharges published in previous studies is shown in Table 2.

TABLE 2 - COMPARISON OF 100 YEAR PEAK DISCHARGES (cfs)

Location	Drainage Area (Sq. Mile)	Goodkind & O'Dea 1999 Study[1]	USGS 84-4049[2]	Flood Insurance Studies[3]	Flood Alleviation Study - 1970[4]	Weaver Report[4,5]	
						1968 Peak Discharges	Future Peak Discharges
Greenbush Road	0.7	513	-----	126	340	288	340
D/S of Tributary	1.3	951	-----	825	-----	-----	-----
Route 303 (North Crossing)	2.1	1,339	-----	1,010	1,234	991	1,137
Route 303 (South Crossing)	4.5	1,732	-----	1,126	-----	1,479	1,817
New York - New Jersey Border	5.2	1,926	-----	1,204	-----	-----	-----
D/S of Confluence with Sparkill Brook	9.3	2,677	-----	980	2,826 (At Oak Tree Road)	1,606	2,084
USGS Gaging Station (#01376280)	11.1	2,252	1,680	980	3,355 (At Route 9W)	1,831 (At Route 9W)	2,247 (At Route 9W)
At Mouth	11.7	2,336	-----	980	3,532 (At Bridge Street)	1,944	2,363

1 As previously stated, the peak discharges for this study were calculated using regional regression equations as set forth in U.S. Geological Survey Water Resources investigation Report 90-4197.

2 Peak discharges for U.S.G.S. Report 84-4049 shown in this table were calculated using regional regression equations developed by Stankowski (1974), as described in Special Report 38 (SR38).

3 SR38 regression equations were used to calculate peak discharges used in the Flood Insurance Studies (1982).

4 Peak discharges for this study were calculated using Soil Conservation Service (SCS) methodology which determines runoff by means of a runoff curve number which is function of soil cover, soil type, land use type, and antecedent moisture condition.

5 Future peak discharges were based on full development of the watershed, i.e. covered by roadways, industrial sites, residential areas, and cemeteries, as described in the Weaver Report.

The methodology used for USGS 84-4049 and the Flood Insurance Studies was Special Report 38 (SR38), as described in Reference 16. While SR38 is still used as an acceptable method to determine peak discharges for drainage areas greater than one square mile, regulatory agencies in New Jersey currently prefer the SCS method over SR38 because the SCS method more accurately models a watershed, as described in Reference 17. It should be noted that SR38 was developed to determine the magnitude and frequency of floods in New Jersey; however, the SR38 regression equations were used in the aforementioned studies because of similar storm and geological parameters in Rockland County and northern New Jersey.

The accuracy of the SCS method, which was used in the 1970 Flood Alleviation Study and the Weaver Report, can be seen in Table 2. At most locations, the peak discharges from this study correlate closely with those from the 1970 study and the Weaver Report's future peak discharges. However, the regression equations used in this study more accurately incorporate the attenuation of peak flows downstream of the Sparkill Brook confluence resulting from overbank storage provided between the confluence and the gaging station. This effect is illustrated by a decrease in peak flows at the gaging station and at the mouth.

The selection of the Region 3 Regression Equations to calculate peak discharges for this study is further substantiated by the comparison of measured data, i.e. rainfall and flow rate, from a historical storm to the calculated theoretical values. More specifically, the recorded rainfall depth of the November 7, 1977 (Election Day) storm was 5.65 inches and the observed peak flow rate at the Sparkill Creek gaging station was 1,040 cfs.

Since the rainfall depth of 5.65 inches, which fell over approximately a 24-hour period, is approximately equal to the 24-hour rainfall depth for a 25-year storm (6.0 inches) as described in Technical Paper No. 40, it is expected that the observed peak flow rate would correlate with the calculated theoretical 25-year peak discharge at the gaging station. From Table 1, the theoretical 25-year peak discharge at the gaging station was calculated to be 1,426 cfs.

It is our opinion that this is an acceptable margin of error between the observed and theoretical values given the variability of hydrologic parameters such as the pattern of rainfall, antecedent moisture condition, etc. that exist throughout the entire drainage basin.

__Hydraulics__

Existing condition hydraulic profiles for Sparkill Creek were calculated for the theoretical 25, 50 and 100 year peak discharges utilizing the U.S. Army Corps of Engineers HEC-2 computer program. The computational procedure utilized by HEC-2 is based upon the solution of the one-dimensional energy equation with energy loss due to friction evaluated with Manning's equation. This method is known as the standard step method. HEC-2 calculates water surface profiles considering the effect of channel variations and obstructions such as bridges, culverts and dams.

In order to formulate the HEC-2 model, the following information was utilized:

1. Topographic mapping at a scale of 1" = 100′ with 2′ contour interval prepared by the Rockland County Drainage Agency, from 1987 aerial photogrammetry the agency conducted.

2. Field survey of the bridges and culverts performed by Goodkind & O'Dea, Inc. in 1979 for the Village of Piermont and Town of Orangetown Flood Insurance Study.

3. Additional field reconnaissance and surveys obtained by Goodkind & O'Dea to update the topographic mapping and Flood Insurance Study data, and obtain wet cross sections of the Creek.

4. Manning's "n" values, i.e. roughness coefficients that vary along the creek, were determined from field reconnaissance and survey along the Creek.

Cross sections for the HEC-2 model were taken at representative locations throughout Sparkill Creek including locations where changes occurred in discharge, slope, shape, roughness, culverts and bridges, and other control structures such as dams. Cross section plots are provided in Appendix 'C'. The HEC-2 model was developed by inputting all cross-section, structure, flow and hydraulic data into the program. Following data input, numerous runs were performed to verify input data and flow consistency at hydraulic structures. The existing conditons HEC-2 model is included in Appendix 'B'.

Model Verification

For model verification, high water marks and flooding limits were obtained through conversations with local residents during the field reconnaissance phase of the Study and checked against the theoretical flood profiles. A summary of the high water marks is shown in Table 3.

TABLE 3 - HIGH WATER MARKS

Location	Approximate Stream Station	High Water Mark Elevation	Theoretical 25-Year Storm Elevation
Piermont Post Office	38+50	7.0±	6.0
Carteret Road at Van Terrace	106+00	29.0±	27.5
Tappan Wire & Cable Co. (Oak Tree Road)	147+00	28.0±	30.6
Washington Street	209+00	42.0±	40.5
Town of Orangeburg Sewer Treatment Plant	280+00	60.0±	60.0
Route 303 at Orangeburg Road	340+00	72.5±	75.4

Based upon conversations held with local residents, the high water marks at Carteret Road and Washington Street occurred most likely during the November 7 and 8, 1977 (Election Day) storm which, as previously stated, approximated a 25-year storm based on the total depth of rainfall. For this reason, the theoretical 25-year storm elevation from the HEC-2 model at the location of each high water mark is also included in the table for comparative purposes.

As illustrated in Table 3, it appears that the high water marks obtained at the Piermont Post Office and the Town of Orangetown Sewage Treatment Plant also occurred during the Election Day storm. The four aforementioned high water marks fall between 0 and 18 inches of the theoretical 25-year storm elevations. This verifies the accuracy of the hydrology and hydraulic model and indicates that no further calibration of the model is required.

The high water mark at Tappan Wire and Cable was obtained after the Election Day storm and therefore cannot be compared to the theoretical 25-year storm elevation. It is also unknown when the mark at Route 303 was obtained but based on the significant deviation from the theoretical storm, it can be concluded that it was also obtained after the Election Day storm.

HEC-2 model runs for proposed conditions were performed by inputting the geometry for the improvements, debugging and running profile runs for the 25, 50 and 100-year storms. The final HEC-2 run for the recommended improvements reflects the improvements discussed in the Flood Control Alternatives section of the Report. The improved conditions HEC-2 model is included in Appendix 'B'.

Using the HEC-2 computer output, flooding limits for the three storm events were delineated on the topographic mapping based upon the contour lines and spot elevations shown. The delineations are shown on the plans. Locations where stream cross sections were taken are shown on the stream profiles, which are part of the Drawings.

FLOOD CONTROL ALTERNATIVES

Structural Flood Control Measures

The following structural flood control measures were investigated:

- On-stream Detention
- Channel Modifications
- Culvert and Bridge Modifications

On-Stream Detention

There are currently two extensive floodplain/wetland areas along Sparkill Creek which provide natural on-stream retention during storm events: the area between Williams Street and the New York/New Jersey border; and the area upstream of the northerly Palisades Interstate Parkway crossing. Both areas currently provide significant flood attenuation. Elimination of these wetland areas alone would increase downstream discharges by approximately fifty percent. These wetlands are protected wetlands regulated by the New York State Department of Environmental Conservation (NYSDEC) and/or the Army Corps of Engineers.

In order to provide additional flood attenuation the flood storage in these areas would have to be increased by either widening the floodplain, or providing control structures such as dams or weirs to raise the flood level resulting in additional flood storage. Widening the floodplain would be cost prohibitive due to construction and right-of-way acquisition costs. As an example of volume requirements, to provide additional floodplain storage to reduce the 1977 Election Day Flood, which was approximately equal to the 25-year storm and the most recently recorded sizable storm event, discharge by 20%, approximately 500,000 cubic yards of excavation would be required.

Raising the flood level to provide additional on-stream detention in the areas discussed above, and any other areas along Sparkill Creek, would result in additional flooding adjacent to the impoundment areas. In order to reduce the Election Day Flood discharge by 20% at the Valentine Avenue Culvert, approximately 350 acre-feet of additional storage would be required. This would necessitate raising the flood levels in the two primary wetland areas by approximately 2.5 feet and would result in flooding of additional residences off Carteret Road, businesses off Oak Tree Road and Livingston Avenue, and the Orangetown Wastewater Treatment Plant. This would also result in higher flood elevations in Northvale, New Jersey, as a result of Sparkill Creek backwater.

The prohibitive cost, potential induced flooding impacts, and adverse environmental impacts preclude these improvements given the relatively minimal benefits.

Channel Modifications

In order to significantly reduce flooding along Sparkill Creek rechannelization of the entire Creek from Valentine Avenue to Greenbush Road would be required including replacement of all of the structures along the Creek. The Manganaro, Martin and Lincoln Report entitled "Sparkill Creek Flood Alleviation Study" details the improvements that would be required. The cost for the improvements outlined in the Manganaro Report was 10 million dollars in 1970.

In addition to being cost prohibitive, extensive channel modifications (rechannelization) would result in the destruction of wetland areas along with the natural stream environment by eliminating the high water table and frequent flooding which are necessary for wetland growth. Rechannelization would also result in increased flood discharges downstream as any reduction in flooding results in a loss of flood storage and a corresponding increase in flood discharges downstream. For these reasons, this alternative is also not recommended.

Bridge and Culvert Improvements

Based upon the HEC-2 computer runs conducted for existing conditions and evaluation of the water surface profiles and culvert velocities, 11 of the Sparkill Creek crossings were found to be hydraulically restrictive, i.e. caused pressure or pressure and weir flow conditions for the 100-year storm, or if replaced with a larger structure would reduce flooding impacts. In order to determine the optimum hydraulic opening for the restrictive culverts, an analysis was performed using Hydraulic Engineering Circular Number 5 "Hydraulic Design of Highway Culverts". The existing and preliminary (optimum) size of the restrictive culverts as sized using HEC#5 are shown in Table 4 below.

TABLE 4 - EXISTING AND PRELIMINARY CULVERT SIZES

Stream Crossing	Existing Structure & Dimensions	Preliminary Culvert/Bridge Dimensions
1. Valentine Avenue	Twin-Arch Culverts 5'H x 12'W	Twin 7'H x 20'W
2. Williams Street	Bridge 7.5'H x 34'W	Bridge 7.5'H x 39'W 7.5'H x 39'W
3. Palisades Interstate Parkway (South Crossing)	Bridge 8.5'H x 22'W	Addition of 8.5'H x 18'w culvert
4. Route 303 (South Crossing)	Bridge 5'H x 22'W	4.5'H x 50'W
5. Oak Tree Road	Bridge 4.4'H x 17.5'W	4.0'H x 40'W
6. Washington Street	Bridge 4.5'H x 19'W	4'H x 40'W
7. Kings Highway	Bridge 5.5'H x 28'W	5'H x 50'W
8. Abandoned Railroad	Bridge 6.5'H x 12'W	Remove complete structure and portion of embankment
9. Rockland County Sewer District Access Drive	Bridge 9'H x 10'W	9'H x 30'W
10. Orangeburg Road (Rt. 340)	(4) 60" CMP Culvert	5'H x 40'W
11. Spruce Street	Twin - 3'H x 6'W CMP arch culvert	4'H x 30'W

In order to evaluate the effect of the preliminary culvert bridge sizes on the water surface profiles for Sparkill Creek, a new HEC-2 model was created which included the 11 preliminary culvert sizes as shown in Table 4. Numerous HEC-2 runs were made incorporating the calculated preliminary culvert/bridge data for each structure. Structures were tested independently and with other improvements to assess flood reduction potential of each structure.

Culvert/bridge improvements which did not show a significant reduction in flooding included Williams Street, Oak Tree Road, Kings Highway and Spruce Street. Improvements at the lower Oak Tree Road crossing did not impact flooding as Oak Tree Road is overtopped. If the Oak Tree Road roadway profile were raised, the hydraulic opening would require significant enlarging. The Washington Street and Kings Highway crossings are influenced by the upstream Oak Tree Road culvert and channel alignment in Tappan Memorial Park. In order to reduce flooding impacts in this area, the channel would require realignment and widening through the park resulting in severe impacts to the park. Therefore, improvements to the upper Oak Tree Road and Washington Street crossings were deemed infeasible due to social and aesthetic impacts.

The following improvements resulted in a reduction in upstream flooding and are therefore recommended:

1. Valentine Avenue - The existing 5'H x 12'W Twin-Arch Culvert was replaced by a twin 7'H x 18'W Box Culvert. The channel between Valentine Avenue and William Street has been improved to allow more flow to be conveyed.

2. Palisades Interstate Parkway - The existing 22 foot wide stone arch was supplemented with a 8.5'H x 18'W culvert.

3. Abandoned Railroad Adjacent to Orangetown Treatment Plant - Since this bridge is no longer in use it was removed from the model along with approximately 100 feet of the embankment. When the bridge is removed the existing aerial sewer crossing will require reconstruction.

4. RCSD Access Drive - An additional 9'H x 10'W box culvert was added alongside the existing 9'H x 10'W box culvert.

5. Orangeburg Road (Route 340) - The existing structure consists of four 60 inch diameter corrugated metal pipes. This was replaced with a twin 5.0'H x 18'W box culvert.

The final channel and structure sizing of the five improvements were determined using the HEC-2 model to achieve the most efficient size for the greatest reduction in water surface elevation. The results of the final HEC-2 run with the above improvements for the 25, 50, and 100 year storms are shown on the Profiles and Floodplain Maps.

A summary of structural flood control alternatives is shown in Table 5.

TABLE 5 - SUMMARY OF STRUCTURAL FLOOD CONTROL ALTERNATIVES

Location	Description of Movement	Benefit(s)	Adverse Impact(s)	Estimated Cost	Priority	Recommendation (Yes/No)
Area between New York-New Jersey border and William Street & area upstream of Palisades Interstate Parkway (north crossing)	Additional flood storage	Flood attenuation	• Induced flooding at Carteret Road, Oak Tree Road, Livingston Avenue, the Orangetown Waste-water Treatment Plant, and in Northvale, New Jersey • Adverse environmental impacts to wetlands	N/A	Low	No
Valentine Avenue to Greenbush Road	Rechannelization and structure replacements (as described in the 1970 Flood Alleviation Study)	Decreased flood stages within this reach	• Adverse environmental impacts to wetlands • Increase in peak flows at downstream reaches due to loss of storage	$10,000,000 (1970 price levels)	Low	No
Valentine Avenue	Replacement of existing culvert with a twin - 7'H x 18'W box culvert	Reduction in upstream flooding, i.e. 2.7 ft. decrease in upstream headwater for 100-year storm	• Loss of flood st[redacted]ge upstream of structure	$540,000 (1995 price levels)	Necessary	Yes
Palisades Interstate Parkway (south crossing)	Existing bridge supplemented with a 8.5'H x 18'W box culvert	Reduction in upstream flooding, i.e. 2 ft. decrease in upstream headwater for 100-year flood	• Loss of flood storage upstream of structure	$800,000 (1995 price levels)	Deferrable	Yes
Adjacent to Orangetown Sewage Treatment Plant	Removal of abandoned railroad bridge	Reduction of flooding at treatment plant	• Loss of flood storage upstream of structure • Reconstruction of aerial sewer crossing required	$250,000 (1995 price levels)	Essential	Yes
RCSD Access Drive	Existing culvert supplemented with an additional 9'H x 10'W box culvert	Reduction of flooding at treatment plant, i.e. 0.9 ft. decrease in upstream headwater for 100-year storm	• Loss of flood storage upstream of structure	$100,000	Essential	Yes
Orangeburg Road (Route 340)	Replacement of multi-CMP culvert with twin 5.0'H x 18'W bridge	Reduction of flooding at treatment plant, i.e. 4.1 ft. decrease in upstream headwater for 100-year storm	• Loss of flood st[redacted]ge up[redacted]am of structure	$515,000	Essential	Yes

TABLE 5 (Continued)

Location	Description of Movement	Benefit(s)	Adverse Impact(s)	Estimated Cost	Priority	Recommendation (Yes/No)
Williams Street Oak Tree Road Kings Highway* Route 303 (south crossing) Spruce Street Washington Street*	Replacement of culvert/bridge	Insignificant reduction in flooding impacts	* Channel relocations/improvements in Tappan Memorial Park would be required.	N/A	Low	No

Non-structural Stormwater Control Measures

Non-structural stormwater control measures are by definition those not requiring construction of remedial facilities.

The forms that non-structural control measures can take generally relate to land use management techniques in the form of zoning and other development regulations. The following are typical non-structural measures which can be implemented to manage by limiting future increases in runoff.

1. **Land Use Controls** - Stormwater runoff increases rapidly with the change of land from natural cover to other utilization by increasing impervious areas. It is clear that the limitation and/or control of land use can lessen increases in runoff by limiting the density and type of development.

   Means by which this can be accomplished include:

   - Land Acquisitions: Transforming ownership of lands from private to public by obtaining deed documents;
   - Easement Acquisitions: Imposing development and land use restrictions on privately-owned land by obtaining easement documents;
   - Erosion Prevention: Limit development on erosive soils and/or slopes;
   - Rezoning: Management by adjusting future land use plans and zoning ordinances;
   - Tax Incentives: Encouraging specific land use by offering tax incentives;
   - Development Policies: Controlling development by setting forth specific stormwater management development policies;
   - Amendments to Local Requirements: Waiving or amending local requirements that call for extensive pavement, curbing and storm sewers where smaller pavement areas and vegetated swales could be used just as effectively.
   - Cluster Developments: Proposing centralized, cluster development, perhaps coordinated with open space acquisitions.

   Floodplains are the main areas targeted for stormwater flooding protection and land use control. Remedial measures are needed to protect life and property for existing developments within flood-prone areas. Land and easement acquisitions, and other incentives can be used to gain public control of lands and consequently lessen potential flood damages. Existing land use controls would require strengthening and/or additional land use controls would require promulgation.

2. **Floodplain Management** - In addition to the land use control methods described in the above section for implementation at the County and local levels of planning, there exists the Federal program applicable to floodplain management known as the National Flood Insurance Program.

Under the National Flood Insurance Program, the Federal Emergency Management Agency (FEMA) delineates floodways and flood fringes, 100-year and 500-year flood boundaries. The Agency prepares maps in order to facilitate floodplain management activities. The program encourages localities to prudently utilize land resources and develop land use controls in the floodplain. As described in previous sections, the FEMA Studies for Sparkill Creek utilized lower flood flows than the flows used in this Study.

The Rockland County Drainage Agency currently provides nonstructural stormwater control by regulating the construction of structures and amounts of "net fill" within the Sparkill Creek floodplain.

U.S. Army Corps of Engineers and the NYSDEC Permit Division also help in floodplain management practice. This is accomplished via wetland programs and stream classifications. However vigil, these programs do not cover all cases and many streams are unclassified, leaving them open for mismanagement, or none at all.

3. **Conversion of Floodplain Lands to Stormwater Conservation Areas** -By limiting development and occupancy of the floodplain, and by adjusting the type of land uses, the impact experienced from flooding will be lessened.

Stormwater conservation areas are those areas designated to accept rising floodwaters. Certain areas are not usually in use during periods of precipitation, and the ponding of stormwater for short durations does not seriously impede their primary functions. Recreational facilities, community parks and parking facilities provide excellent settings for temporary storage of stormwater.

Land used for parks and passive recreational activities can provide stormwater conservation. If most of the existing vegetation is preserved in its original condition, runoff is buffered and water quality is maintained.

4. **Structural Measures Often Considered Non-Structural** - Measures associated with flood prevention that have been termed non-structural include:

- Installation of protective walls and levees around specified structures;
- Elevating existing structures above flood levels;
- Placing control devices on existing drains to prevent flood waters from backing up into developed areas;

Measures associated with new development that have been termed non-structural in some cases include:

- Curbless construction in conjunction with swale and vegetative control;
- Porous pavement;

5. **Non-Structural Operation and Maintenance Criteria** - These measures are primarily water quality oriented:

- Frequent inspection, cleaning and repair of drainage system components;
- Strong spill control countermeasure programs;
- Isolation of contaminant stockpiles from rainfall;
- Control of littering and frequency of street sweeping;
- Pavement maintenance;
- Maintenance of vegetation in park and public lands;

Presently, the Rockland County Drainage Agency, through its review and permit operations, recommends and requires for all permits it issues first flush basins and filter strips for projects under it jurisdiction. These devices filter out the first flush of runoff from parking areas before entering the stream.

It is recommended that implementation of non-structured measures be considered for Sparkill Creek on a case by case basis until a comprehensive stormwater management plan can be developed at a countywide level. Such a plan will provide uniform stormwater management guidelines and standards to be followed by developers when planning and designing development projects.

Cost and Implementation

The probable cost of the flood control improvements discussed in the "Structural Flood Control Measures" section of the Report are as follows:

1.	Valentine Avenue Culvert Replacement at Station 81+00± -	$540,000
2.	Additional Culvert under PIP crossing at Station 127+00± -	$800,000
3.	Removal of Abandoned RR and reconstruction of aerial sewer crossing at Station 286+00± -	$250,000
4.	Additional Culvert under RCSD Access Drive at Station 324+00± -	$100,000
5.	Orangeburg Road Culvert replacement at Station 331+00± -	$515,000

A breakdown of costs for flood control improvements are included at the end of this section. Costs are based on 1995 price levels.

Ranking the various flood control improvements in terms of priority results in the following:

PRIORITY 1

Removal of the abandoned railroad crossing and reconstruction of the aerial sewer crossing, replacement of the Orangeburg Road Culvert and Additional Culvert under RCSD Access Drive (Items 3, 4 and 5) as these improvements will reduce flooding of the Rockland County Sewer District Number 1 Treatment Plant.

PRIORITY 2

Replacement of the Valentine Avenue Culvert (Item 1) as the culvert is hydraulically restrictive and is in fair to poor overall condition. Replacement of the culvert will result in reduced flooding at Valentine Avenue, Williams Street and areas upstream. The downstream Village of Piermont has opposed improvements to the Valentine Avenue Culvert indicating that the increased waterway opening will allow more flow downstream thereby increasing flooding. This conclusion is not supported by this study or previous studies by Garfinkel and Garfinkel Consulting Engineers.

PRIORITY 3

The additional culvert under the Palisades Interstate Parkway crossing (Item 2) will reduce upstream flooding and may have limited effects on the Sparkill Brook backwater in New

Jersey. However, the culvert opening is only modestly restrictive and the cost is relatively expensive when compared to the benefit.

In terms of capital project classification, where the terms **essential, necessary, desirable** or **deferrable** apply, the priority's listed above should be classified as follows:

PRIORITY 1	Essential
PRIORITY 2	Necessary
PRIORITY 3	Deferrable

VALENTINE AVENUE CULVERT REPLACEMENT, STA. 81+00

Item	Cost
Clearing	$ 2,000
Removal of Bridge	20,000
Earthwork	2,000
Drainage and Channel Protection	10,000
Culvert/Bridge Cost	300,000
Pavement	10,000
Miscellaneous Items	8,000
Landscaping and Restoration	4,000
Maintenance and Protection of Traffic and Signing	10,500
Mobilization	38,000
Construction Layout	10,500
Sub-Total	415,000
10% Contingency	41,000
20% Engineering	83,000
TOTAL	539,000
SAY:	**$540,000**

REMOVAL OF ABANDONED RAILROAD BRIDGE, EMBANKMENT AND REPLACEMENT OF AERIAL SEWER CROSSING, STA. 286+00

Item	Cost
Clearing and Bridge Removal	$ 20,000
Earthwork	10,000
Channel Protection	8,000
Wetland Restoration	5,000
Aerial Sewer Crossing	125,000
Mobilization	18,480
Construction Layout	5,040
Sub-Total	191,520
10% Contingency	19,000
20% Engineering	38,000
TOTAL	248,520
SAY:	**$250,000**

ADDITIONAL CULVERT UNDER THE PALISADES INTERSTATE PARKWAY, STA. 127+00

Item	Cost
Earthwork	17,000
Pavement	23,000
Culvert	356,000
Landscaping	5,000
Incidental Items (sheeting)	90,000
Lighting, Striping, Signs and Delineators	15,000
Maintenance and Protection of Traffic	34,000
Mobilization	54,000
Construction Layout	15,000
Sub-Total	609,000
10% Contingency	60,000
20% Engineering	120,000
TOTAL	789,000
SAY:	**$800,000**

ADDITIONAL CULVERT UNDER ACCESS ROAD TO ROCKLAND COUNTY SEWER DISTRICT NO. 1 TREATMENT PLANT, STA. 324+30

Item	Cost
Earthwork	$10,000
Pavement	6,000
Culvert Cost	42,720
Railings	3,000
Landscaping	2,000
Channel Protection	4,000
Mobilization	7,450
Construction Layout	2,030
Sub-Total	77,200
10% Contingency	7,720
20% Engineering	15,440
TOTAL	100,360
SAY:	**$100,000**

ROUTE 340 CULVERT REPLACEMENT, STA. 331+00

Item	Cost
Clearing	$ 2,000
Removal of Bridge	10,000
Earthwork	18,500
Pavement	8,000
Culvert Cost	260,000
Guide Rail and Finishes	10,000
Landscaping	5,000
Channel Protection	4,000
Signing	9,500
Traffic Control	22,200
Training	3,200
Mobilization	35,000
Construction Layout	9,500
Sub-Total	396,900
10% Contingency	40,000
20% Engineering	80,000
TOTAL	516,900
SAY:	**$515,000**

STREAM MAINTENANCE RECOMMENDATIONS

Field reconnaissance was performed to identify areas along Sparkill Creek requiring stream maintenance. Areas requiring significant maintenance are as follows:

1. The portion of Sparkill Creek in Piermont from the Hudson River to Valentine Avenue, particularly the reach between Rockland Road and Paradise Avenue, is in need of significant maintenance. Collapsed retaining walls, eroding and unstable embankments, and pavement problems (predominately in Piermont Avenue) together with leaning utility poles and guide rail adjacent to Piermont Avenue were observed. The majority of the stream banks in this reach are supported by hand-laid stone rubble retaining walls. Many sections of the walls have collapsed as a result of erosion behind the walls, a lack of footings, and general instability. Of particular concern is the section of embankment adjacent to the houses a 302 and 310 Ferdon Road. The embankment there is high and fairly steep, and the stone retaining walls have completely collapsed. The exposed embankment is unstable and some movement has occurred as evidenced by cracks in the house foundation walls. The other area of concern is the stability of the stream embankment adjacent to Piermont Road on the opposite side of Sparkill Creek. Piermont Borough officials have reported continual pavement problems in the section of Piermont Road closest to the Creek as a result of the embankment creep.

   It is recommended that a more detailed study, such as a Feasibility Study, be performed for the reach of Sparkill Creek within the Village of Piermont. The study should address methods and costs to stabilize the stream embankments, repair and replace the damaged and collapsed retaining walls, and remove the sediments from Mill Pond, as described in 2. below. It should be noted that there are houses adjacent to the creek that are experiencing foundation problems as a result of the unstable embankments.

2. The pond upstream of the Mill Pond Dam has filled in with sediments. While the sedimentation does not significantly effect flooding, the aesthetic and recreational value of the pond is affected.

3. Debris was observed at the upstream entrances to the following stream crossings.

   - Valentine Avenue (Floodplain Map 3).
   - Erie Railroad Crossing (Floodplain Map 5).
   - Livingston Avenue (Floodplain Map 8).
   - Orangeburg Road/Route 340 (Floodplain Map 10).

- Schoolhouse Lane (Floodplain Map 10).

- Access Road to Innovative Plastics off Route 303 (Floodplain Map 11).

4. Debris pile-ups were observed at the Creek bends along the reach between the Orangetown Wastewater Treatment Plant and the Rockland County Sewer District Wastewater Treatment Plant.

The stream maintenance items are shown on the Floodplain Maps and tabulated by station herein.

In addition to the repair of the collapsed retaining walls described in 1. above, a significant maintenance item is removal of the silt in Mill Pond. In order to increase the depth of the Pond by approximately 3 feet, excavation of approximately 18,000 cubic yards of excavation would be required. At a cost of $10.00 per cubic yard, this totals $180,000 (1995 price levels). Though the maintenance will not reduce flooding, it will enhance the aesthetic and environmental aspects of the area.

Tabulation of Stream Maintenance Items

Sheet No.	Station (left or right)*	Description.
1	21+00R to 21+50R	Timber walls and slips in fair condition.
1	31+00R	Low railings and deteriorated pier (potentially unsafe).
1	33+60R	Stone walls in fair condition.
1	0+00 to 35+00	Creek shallow at low tide varying in depth from 2 to 3 feet.
2	38+00L±	Oil spill at downstream corner of Paradise Avenue Bridge.
2	38+20L to 51+30L	Left bank, composed of hand-laid stone retaining walls, is eroding and collapsed in some areas.
2	47+00L	Debris piles along stream (dumping).
2	47+00 to 49+00L	Stonewalls along steep embankment have partially collapsed. House #310 foundation appears to be moving as embankment "creeps". Steep embankment is unsafe due to drop off.
2	51 + 50R	Some undermining of right abutment and right upstream wingwall observed.
2	49 + 50 and 50 + 50R	Buildings overhang streams.
2	52 + 50 (Mill Pond Dam)	Condition of dam is fair.

* Looking upstream

Sheet No.	Station (left or right)*	Description.
2	53+00 to 65+00	Pond is filled in with silt; water depths vary from 0.5 to 3′
3	66±00 to 74+00 (Mill Pond)	Pond is filled with sediment; water depths vary from 0′ to 2′.
3	81+00 (Valentine Ave.)	Stone Arch Culvert is in poor overall condition. Debris caught at upstream end of pier.
4	102+40R	Old 6" iron pipe in stream and abandoned pump adjacent to the stream should be removed.
5	164 + 50 Erie RR	Debris at upstream face of pier.
6	186+00±R	Small debris piles in parking lot.
7	201+00 to 202+00R (Oak Tree Road)	Dumping area adjacent to Creek including fill, clippings and tree branches.
7	202+50± (Oak Tree Road)	Debris at entrance to Culvert.
7	208+90R	Exposed footing along stone masonry wall.
7	213+50L	Stone rubble walls along Creek bank are in fair condition.
8	247+00 (Route 303)	Significant amount of debris at Culvert entrance pier.
8	250+00	Fallen tree across Creek.
8	264+00± to 268+00±L	Misc. debris in woods along edge of old drive-in theater parking lot.

* Looking upstream

Sheet No.	Station (left or right)*	Description.
9	270+00± to 274+00±L	Misc. debris along edge of old drive-in theater parking lot.
9	289+00	Debris jam in Creek (trees and branches).
9	291+00± to 295+00±	Piles of debris at stream bends.
10	330+00±L (Moore & Moore Real Estate)	Stone masonry retaining wall, which also serves as the building foundation, is in poor condition.
10	331+00± (Route 340)	Debris at culvert entrance.
10	333+10	Debris in Creek at bend.
10	340+60 (Orangeburg Road)	Debris at culvert entrance.
11	345+00 (I.P.C. Driveway)	Debris at upstream end of culvert.
12	393+00 (Spruce Street)	Sand and gravel in downstream end of culvert.

* Looking upstream

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