FLOOD STUDY

FOR

THE VILLAGE OF IRVINGTON
WESTCHESTER, NY

PREPARED BY

HAHN ENGINEERING

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I. SUMMARY

Hahn Engineering was hired by the Village of Irvington to analyze the Village of Irvington's brooks/water courses, identify and evaluate specific flooding locations and recommend methods to alleviate the flooding conditions in accordance with objectives set by the Village.

The Sunnyside Brook, Barney Brook, and Riverview Road Brook (also known as High School Brook) were analyzed for this report. The channel along Main Street, located between the Riverview Road Brook and Barney Brook, was also studied to verify the capacity of the selected design storm. This area is referred to as Main Street Tributary.

As required by the Village, the past 10 years of storm data were used to determine the depth of rainfall for the tributary areas. A rainfall depth of 5.18 inches was used for the study. This rainfall depth occurred on April 15, 2007 and was the highest recorded rainfall in the past 10 years. This depth is 0.18 inches higher than the value used by the U.S. Department of Agriculture and used throughout Westchester County for a 10 year design storm.

A total of twenty-three areas were identified as problematic, potentially problematic, or require maintenance in the study area. Eleven areas are located on public property and the remaining twelve locations are on private property. The Village has identified five of the areas on public property that consistently flood, which the study has confirmed and are a high priority for remediation. To evaluate the feasibility of correcting the flooding problems, preliminary cost estimates and sketches have been provided. We recommend that the five public areas identified be surveyed, further evaluated, and preliminary plans be developed along with cost estimates of the work.

We also recommend that the Village determine the feasibility of remediating the other public areas identified in this study.

Other flooding occurs on private property, where individual homeowners will need to maintain or modify sections within the brooks. We recommend that a protocol be developed, to implement repairs or modifications to the stream on private property, to assist the homeowners in making improvements.

II. INTRODUCTION

This study was conducted on behalf of the Village of Irvington, in accordance with the Request for Proposals from the Village Administrator dated August 31, 2009 and November 6, 2009. The purpose of this report is to identify problematic flooding areas throughout the Village, provide recommendations for alleviating flooding conditions and develop preliminary estimates for repairs, and determine the impacts of flooding from public, private, and neighboring Village properties. Additionally, storm data from the past 10 years was obtained through the National Climatic Data Center which has been included in the study.

The study utilized Westchester County GIS topography and aerial imagery for determining watershed boundaries, flow paths, curve numbers, and other variables required for hydrologic analysis. The Federal Emergency Management Agency (FEMA) Flood Maps and stream profiles were used to determine slopes, inverts, culvers sizes, and floodplains. The Village identified areas that are prone to constant flooding and water damaged. Field inspections were performed to verify channel dimensions, pipe sizes, and other existing conditions. These areas should be surveyed and the design further detailed prior to construction.

III. BACKGROUND

The Irvington watersheds in this study consists mainly of forest and grassland, with mild to steep sloping hills. The coastal area along the Hudson River is a well developed urban area. A ridge exists along the east side of the Village which is parallel to the Saw Mill River Parkway and approximately 1,000 feet to the west of the parkway. Stormwater runoff west of the ridge flows towards the Hudson River and stormwater east of the ridge flows towards the Saw Mill River.

The Village of Irvington has two main bodies of water, the Irvington Reservoir and Halsey pond. The Irvington Reservoir and Halsey Pond both discharge into the Barney Brook that converge on Station Road west of Broadway. In addition to the Barney Brook and Barney Brook Tributary, Irvington has two streams that flow east to west. They include Sunnyside Brook and Riverview Road Brook (also known as High School Brook).

The Barney Brook originates to the east of the Irvington Reservoir as a small stream. From the reservoir, it flows through residential neighborhoods, west Broadway and the Old Croton Aqueduct, back through residential neighborhoods and into a culvert under

South Buckout Street to the Hudson River. The slopes vary throughout the entirety of the stream. Sections are relatively flat such as Dunham Place to Park Road.

The Barney Brook Tributary originates at Halsey Pond in the Village of Irvington. It flows through a residential area, under Broadway where it converges with the Barney Brook. The slopes throughout the stream are mainly moderate.

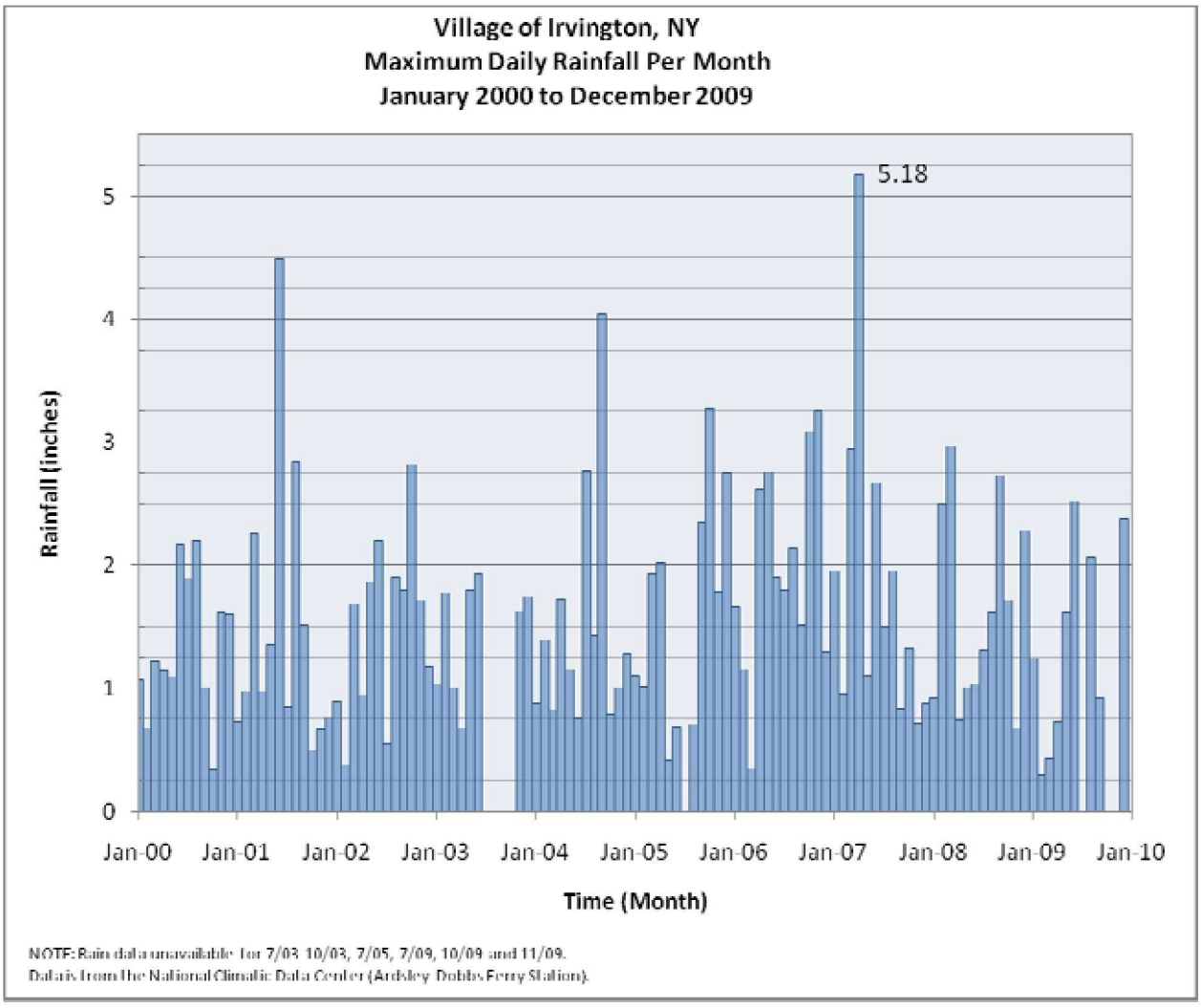
The Barney Brook and the Barney Brook Tributary comprises most of the tributary areas in the Village, which can be seen on the Stream and Tributary Area Map (provided in Appendix A). The combined area is over 764 acres. The contributing area is mainly residential with the exception of forest around the bodies of water and a couple of grass fields.

Sunnyside Brook originates in the Town of Greenburgh, flows beneath Taxter Road in the Village of Tarrytown, and through Irvington. West of Broadway, the stream flows back into Tarrytown and then Irvington before discharging into the Hudson River. Its tributary area is in both the Villages of Irvington and Tarrytown, and mainly residential. The slope is fairly steep with the exception of the section between Hudson View Park and Sunnyside Place.

Riverview Road Brook originates in the Village of Irvington at the High School track. It continues west through a residential neighborhood, across Broadway and the Old Croton Aqueduct and discharges into the Hudson River. The contributing area is mainly residential and also includes woods, open fields and roads. The slopes are mainly steep with the exception of the section from Circle Drive to Broadway.

IV. STORM CRITERIA

As requested, the past 10 years of rainfall was obtained to determine the amount of rainfall depth to use in the study. The data was collected from the National Climatic Data Center, Dobbs Ferry Station. April 15, 2007 had the highest recorded rainfall with a depth of 5.18 inches, as shown below (also provided in Appendix B).



Typically, pipe sizing/culvert sizing is based on a particular storm event. Storm events represent a depth of rainfall for a storm that occurs for a duration of time. As described in the FEMA FIS of 2007, "Flood events of a magnitude which are expected to be equaled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for flood plain management and for flood insurance rates. These events commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10-, 2-, 1-, and 0.2-percent chance, respectively, of being equaled or exceeded during any year."

Although this study is not being conducted to determine flood plains, the recurrence intervals are used for determining flows. Westchester County storm events are shown below.

STORM EVENT	RAINFALL DEPTH (INCHES)
1-Year	2.8
2-Year	3.5
5-Year	4.5
10-Year	5.0
25-Year	6.0
50-Year	7.0
100-Year	7.5

These storm events are used to calculate flows, which are required to determine pipe/channel sizes. The 500-year storm event is not typically used to size a channel. Depending upon the situation, road drainage is sized using a 10- or 25-year storm event. Culverts may be sized using the 10-, 25-, 50-, or even a 100-year storm event.

The maximum depth of rainfall that occurred on April 15, 2007, of 5.18 inches is similar to the 10-year storm event. Therefore, 5.2 inches will be used in the analysis and determining the preliminary size of the channels. This will be referred to as the design storm.

V. ENGINEERING METHODS OF STORMWATER ANALYSIS

Peak discharges for the 1-, 2-, 5-, and 10-year storm event and the design storm event were developed using Technical Release 20 (TR-20), with data derived from Technical Release 55 (TR-55). The computer program, Bentley Pond Pack V8i was used to model the streams and calculate flows and channel capacities. Hydraulic calculations can be found in Appendix C, D, E, and F.

VI. HYDROLOGIC MODELING

After evaluating the three streams, design points were chosen. They were located adjacent to major intersections or areas of reoccurring flooding that were identified by the Village.

Curve numbers were determined using the hydrologic soil groups, aerial photographic, and Village zoning maps. Soil groups used were identified using GIS Data from the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS). Aerial photographs were used to determine ground cover and the Village zoning map was used to determine the size of the lots.

The tributary area map used in this study is attached. It includes the tributary areas, flow paths, aerial photographs, Westchester County topography, FEMA FIS Flood Plains, Village parcels, and ridgelines. A soils map is also provided in Appendix H. Below are the soils and corresponding ground cover used in the hydrologic calculations.

Cover Type	A Soil	B Soil	C Soil	D Soil
Grass (good)	39	61	74	80
Impervious	98	98	98	98
Water Body	100	100	100	100
Woods (good)	30	55	70	77
1F-5 (1/8 Acre of less)	77	85	90	92
1F-10 (1/4 Acre)	61	75	83	87
1F-20 (1/2 Acre)	54	70	80	85
1F-40 (1 Acre)	51	68	79	84
1F-60 (1 1/2 Acre)	48	66	78	83

A summary of the tributary areas, curve numbers (CN), time of concentration (tc), and flows are provided below and also provided in Appendix F.

Design Point	Tributary Area (Acres)	Combined CN	Time of Concentration, Tc (min)	Flow (cfs)				
				1 Year	2 Year	5 Year	10 Year	4/15/2007
A1	42.2	57	31.08	2.1	7.1	18.7	25.8	28.9
A2	58.6	65	17.74	13.9	29.9	58.5	74.4	81.0
A3	141.6	66	30.15	31.4	64.3	121.9	153.8	167.1
A4*	169.6	68	23.47	51.1	98.1	178.1	221.9	240.0

*Peak flows provided do not reflect attenuation impacts of the bodies of water within the tributary area.

Design Point	Tributary Area (Acres)	Combined CN	Time of Concentration, Tc (min)	Flow (cfs)				
				1 Year	2 Year	5 Year	10 Year	4/15/2007
B1	106.4	64	17.68	22.0	49.7	99.9	128.2	139.9
B2	50.4	69	14.06	20.5	38.3	68.0	84.2	90.9
B3	47.2	63	18.76	8.3	19.6	40.6	52.6	57.6
C1	43.8	80	19.03	37.2	56.2	85.1	100.0	106.0
C2	18.5	74	12.21	12.1	20.1	32.8	39.4	42.2
C3	9.1	84	10.24	11.6	16.7	24.1	27.9	29.4
D1	59.8	74	18.18	34.4	57.1	93.5	112.7	120.6
D2	18.5	74	23.10	9.8	16.2	26.5	32.0	34.2
D3	86.7	73	19.45	45.0	76.3	126.6	153.4	164.4
D4	56.8	63	18.52	10.0	23.7	49.1	63.6	69.6
D5	47.1	63	23.25	7.8	18.1	37.4	48.4	53.0
D6*	87.0	66	26.13	20.4	41.9	79.5	100.4	109.1
D7	196.7	60	34.88	17.1	46.5	106.2	141.4	156.3

*Peak flows provided do not reflect attenuation impacts of the bodies of water within the tributary area.

Design Point	Tributary Area (Acres)	Combined CN	Time of Concentration, Tc (min)	Flow (cfs)				
				1 Year	2 Year	5 Year	10 Year	4/15/2007
E1*	121.6	64	20.55	24.0	53.9	108.1	138.6	151.4
E2*	89.8	65	16.23	21.8	47.3	92.5	117.6	128.1

*Peak flows provided do not reflect attenuation impacts of the bodies of water within the tributary area.

VII. CHANNEL MODELING

The variables used in modeling a channel are slope, roughness coefficient (Mannings Number, n), invert elevations, length, and dimensions. The roughness coefficients are derived using the TR-55 manual and are consistent with the FEMA Flood Insurance Study (FIS). The FEMA FIS provided stream profiles for Sunnyside Brook, Barney Brook, and Barney Brook Tributary, which were utilized in modeling the stream's slope and in some cases, culvert size (provided in Appendix I). Westchester County Topography was used for the channel section elevations of Riverview Road Brook and the drainage areas tributary to Main Street. Sections were determined in the field using a tape measure or visually, when field measurements were unobtainable. The channels and dimensions have been provided in Appendix J. The stream channels are known as "reaches" in the modeling program.

The program calculates the flow and channel capacities. When a channel is unable to convey the required flow, it is known as being "overtopped". Once a channel overtops the input parameters are revised until the channel can handle the flow. Usually the slope and roughness are constant, and therefore the cross section must change. The channels that are inadequate to convey the flow have been identified in section VIII of this report.

The Barney Brook and Barney Brook Tributary were modeled together. The Barney Brook has 43 reaches which total 7,440 feet. The maximum slope is approximately 11 percent. The portions of the stream, between Park Road and the north side of Dunham Place, flow through relatively flat areas. Additionally, low points and back-pitched pipes are shown on the FEMA FIS. The minimal or negative slope causes deposition of sediment and narrowing of the channels.

The Barney Brook Tributary has 18 reaches that total 4,030 feet. The slopes range from 13 percent to less than 1. The main area of flooding is approximately 200 feet from the convergence with the Barney Brook. Debris collects at the inlet of the culvert that lies

beneath the park. During large storms, the stormwater builds up and overtops the culvert, flooding the park.

Sunnyside Brook was modeled using 41 reaches that total 6,470 feet. The slopes varied from 13 percent to less than 1 percent. A section of the stream approximately 2,000 feet in length, between Hudson View Park and Sunnyside Place, is the main area of the stream subject to flooding. This is due to the slope and channel dimensions. These channels have a maximum slope of 2.5 percent and a minimum slope of less than 1 percent. The channels are narrow, shallow or both. The remainder of the stream in this section consists of a detention pond that was installed with the subdivision on Sunnyside Place. The pond and portions of the stream in this section are laden with sediment and vegetation. The channels and streams in this section are unable to convey stormwater for the larger storms, which flood the banks of the channels and streams. The FEMA flood maps also show the area inundated with water in various storm conditions.

The Riverview Road Brook was modeled using 8 reaches that total 3,950 feet. The slopes ranged from 3 to 20 percent. As described earlier, elevations and some sections were derived from the Westchester County topography.

VIII. PREVIOUS DRAINAGE STUDIES

Three drainage studies were reviewed. The main study utilized for this report is the FEMA FIS which was completed in September 2007 and is a study of all of Westchester County. The two additional studies completed by LAN Associates and Malcolm Pirnie, Inc., analyzed the Irvington Union Free School District's High School.

The FEMA FIS provides tributary areas and flows for the Sunnyside Brook and Barney Brook, which also included the tributary to Barney Brook. The report mentions the Riverview Road Brook (High School Brook) but does not provide areas or flows. This may be due to the stream not being in a flood plain. With the exception of the last section of stream, west of the Aqueduct during the 500 year storm event.

As shown below, the tributary areas are very similar to the FEMA FIS 10 Year Storm.

AREAS	FEMA	HAHN
Barney Brook Area (sq.mi.)	1.2	1.2
Barney Confluence with tributary (sq.mi.)	0.8	0.7
Barney Brook Tributary Area (sq.mi.)	0.3	0.3
Sunnyside Brook (sq.mi.)	0.7	0.7

As shown below, the calculated flows are higher than the FEMA calculated flows. This may be due to the flooding areas within the streams, which cause a reduction in peak flow. Undersized channels determined by our study were increased in size to allow the channel to convey the flow. This allows all of the stormwater to pass through the channels without any detention. The channels that were increased in size are noted in section VIII of this report. Additionally, the Halsey Pond, Irvington Reservoir, Sunnyside Place, and other miscellaneous bodies of water were not used for attenuation.

FLOWS (10-year storm)	FEMA	HAHN
Barney Brook (cfs) (Excluding tributary)	516	566
Barney Confluence with tributary (cfs)	430	471
Barney Brook Tributary (cfs)	221	261
Sunnyside Brook (cfs)	330	448

LAN Associates EPAS, Inc. (LAN), completed the first analysis for the high school, entitled Draft Drainage Report for Irvington Union Free School District and is dated October 29, 2007. Their objective was to analyze stormwater drainage conditions at the Irvington High School/Intermediate School (IMS/IHS) campus and also address conformance to the NYS stormwater regulations. Malcolm Pirnie, Inc. completed a second analysis of this area on November 14, 2008, as a review for the Village. The review was conducted after downstream land owners complained of an increase in stormwater runoff and degraded stormwater quality after improvements were made to the school property in 2003.

Since these analyses were performed, there has been further development within the tributary watersheds. A subdivision is being constructed east of the school's track. Two detention basins have been installed which direct the overflow of stormwater to the south towards Field Point Drive.

With the deviation in design points and areas, it is not reasonable to compare the results from the previous studies. However, Area C3 is comparable to Malcolm Pernie's Areas 1, 2, and 3, as shown below.

	LAN Ass.	Malcolm Pernie	Hahn Engineering (Area C3)
Area (ac)	10.7	8.3	9.1
CN	Unknown	77	84
tc (min)	Unknown	15	10
1-Year	4.6	7.8	11.6
2-Year	N/A	11.8	16.7
10-Year	16.2	20.1	27.9

Area C3 has a greater area, higher CN, and shorter tc, which all result in higher flows. The additional flow for the 10 year storm does not affect the results of the downstream channel calculations.

IX. RECOMMENDATIONS AND PRELIMINARY COSTS

The areas of concern have been broken into 3 categories which include primary Village, secondary Village, and private.

The primary Village areas have been identified by the Village as top priority. These are mainly Village owned properties, where flooding has been observed on the roadways. They are unsafe conditions and cause damage to the surrounding properties, both public and private.

The secondary Village areas are on Village owned property that either floods or appear to be undersized. This report identifies additional alternatives to reduce flows through the existing channels, areas that require maintenance, areas that flooding occurs but may not require immediate repair, or areas that the channels may be too small in size to convey the design storm.

The private areas identified are on private property where either flooding may occur, maintenance may be required, or the channels may be too small to convey the design storm.

Each location has been identified using a general description, FEMA station(s) or other designated station(s), and the reach identification number that coincides with the computer model. A location map of each area, which is labeled, Project Location Map (DR-4), has been attached. A brief recommendation to maintain, repair, or replace the channel sections throughout the streams is provided.

Conceptual plans and preliminary cost estimates can be found in Appendix K. The recommendations are subject to surveys that verify invert elevations and channel dimensions. If implemented, the remediations will not resolve all the issues associated with flooding in the Village. The recommendations, if implemented, will significantly ameliorate the areas of concern.

Primary Village Areas

AREA 1

Area 1 includes all areas tributary to the Barney Brook and is located east of the intersection of South Buchout Street and South Astor Street. The approximate FEMA station is from 0+00 to 3+00. The computer model identification for this section is Junction J01.

This section of stream is in a highly developed business and residential area. A bar screen has been installed upstream of the culvert headwall to collect debris and keep the culvert under south Buckout Street from clogging. Damage has been done to private and public property, including the Village's Department of Public Works' garage.

The FEMA study profile does not include the culvert beneath South Buckout Street. Therefore, the culvert inlet, outlet, and tidal elevations should be obtained and verified. Additionally, any other inlets to the culvert or change in culvert dimensions prior to discharging into the Hudson River should be obtained prior to further analysis of this area.

Alternative 1 is proposed to alleviate blockage and pipe clogging due to excessive debris. Alternative 2 is proposed if the existing culvert capacity is inadequate. This would be determined after surveys and calculations are complete.

Alternative 1 and Alternative 2 can be constructed independent of one another.

Alternative 1

Remove accumulated sediment and debris from stream bed. Remove piles of debris from the top of the slope. Install two sediment traps/energy dissipators to collect sediment and debris. The traps should include a solid bottom and access ramps for more efficient maintenance. Large rip-rap (12"–24") should be installed where soil has eroded, to reinforce the slope and reduce the amount of sediment being transported downstream. Additionally, we recommend a chain link fence be installed at the top of the slope to limit entrance by adjacent property owners and dumping of yard refuse.

The estimated cost is $294,500. Conceptual plans and preliminary cost estimates can be found in Appendix I.

Alternative 2

This alternative is proposed for future conditions, if flooding persists or further analysis determines the existing culvert is unable to handle the design flow.

A proposed control weir would be installed to split the flow and redirect a portion of the flow into a new piping installed along South Astor Street. The new piping would connect to an existing culvert downstream and ultimately discharge to the Hudson River. All items in Alternative 1 are also included.

The estimated cost is $800,050. Conceptual plans and preliminary cost estimates can be found in Appendix I.

AREA 2

Area 2 is located along Barney Brook and Station Road, approximately 1,700 feet east of the intersection of Station Road and Woodbine Road. The approximate FEMA station is from 16+50 to 16+85. The computer model identification is Reach R-06.

The existing culvert is undersized which causes overtopping and flooding to Station Road and the downstream residents.

The existing 4 foot diameter culvert is proposed to be replaced with a box culvert 6 foot wide by 4 foot high. The inlet and outlet should be stabilized with rip rap. Headwalls should be included for both the inlet and outlet. As discussed later in this section (Area 12), the channel directly downstream should be surveyed and further evaluated to determine if the channel can handle the design flow.

The estimated cost is $212,150. Conceptual plans and a preliminary cost estimate can be found in Appendix I.

AREA 3

Area 3 is within the Barney Brook Tributary and is located between Station Road and Dows Lane. The approximate FEMA station is from 0+00 to 8+00. The computer model identification are Reaches R-01T and R-02T.

This area experiences frequent flooding due to an existing bar screen which collects debris at the inlet causing overtopping of the headwall and flooding the park. Headwalls have not been properly constructed and erosion is occurring at both outlets. An existing bridge crosses the stream at Sta. 3+30. The bridge is damaged and is in poor condition.

The proposed work includes installing headwalls and rip rap at the existing culvert that converges with the Barney Brook, at both the inlet and outlet. The headwall on the existing inlet should be large enough to direct upstream stormwater to the culvert. A railing should be installed on the headwall for safety. A large bar screen should be installed with consideration to maintenance and to prevent clogging. Additionally, the existing 36 inch corrugated polyethylene pipe located north of Dows Lane should have a headwall installed at the outlet. The existing bridge between Dows Lane and Station Road should be removed and channel slopes stabilize. At this time, the channel capacities appears to be able to handle the flow, however the capacity should be verified to determine if it can pass the design flow.

The estimated cost of the improvements excluding replacing the 36 inch culvert is $154,800. If the culvert is replaced it could increase the cost by over $200,000. Conceptual plans and a preliminary cost estimate can be found in Appendix I.

AREA 4

Area 4 is within the Sunnyside Brook and is located at the intersection of East Sunnyside Lane and Hudson View Park. The approximate FEMA station is from 43+70 to 45+70. The computer model identification are Reaches R-33 to R-37.

Currently, two 24 inch Reinforced Concrete Pipe's are located beneath Hudson View Park and outlet to a channel located on private property beneath two residential driveways. The culverts frequently overtop, causing Hudson View and Sunnyside Lane to flood.

Alternative 1

The proposed work includes installing a 4'W x 3.5'H box culvert from the existing stream through Hudson View Park Road and East Sunnyside Lane, and outlet back into the Sunnyside Brook. A new inlet and outlet headwall should be constructed with rip-rap and an energy dissipater. The existing piping and channels would remain in place.

The estimated cost is $529,580. Conceptual plans and preliminary cost estimates can be found in Appendix I.

Alternative 2

Alternative 2 is less expensive, however, the proposed work requires replacing culverts through two private driveways. The two existing 24 inch pipes located under Hudson View Park should be replaced with a 4 foot wide by 3.5 high box culvert.

The estimated cost is $321,050. Conceptual plans and preliminary cost estimates can be found in Appendix I.

The culvert size for Alternative 2 and Alternative 1 are the same due to the various slope of each Alternative. The slope is much steeper in Alternative 2 which allows the same size culvert to convey a greater volume of stormwater. The downstream culvert under Broadway should be surveyed and analyzed to verify that can convey the additional flow.

AREA 5

Area 5 is within the Barney Brook and is located on Harriman Road between Parkside Way and Dunham Place. The approximate FEMA station is from 50+00 to 65+50. The computer model identification are Reaches R-24 to R-36 and R-1R to R-3R.

Sections of the stream throughout these areas are narrow, shallow and unable to convey flow for the smaller storm events. The channel from the north end of Dunham Place (FEMA station 62+00 to 65+50) has 2 back-pitched pipes and a minimal slope. A 36 inch Corrugated Metal Pipe directs the stream down Meadow Way, and across Harriman Road, where it runs through a resident's yard and across Park Road. The control structure does not function properly and flooding occurs in this area. The culvert under Harriman Road (FEMA station 59+10) has less than 2 percent slope and sediment has deposited at the outlet. The channel through the residential property (FEMA station 56+00 to 59+00) is undersized and has low spots adding to sediment deposition. This is a major area of flooding. Stormwater ponds on the property and floods Harriman and Park Road.

<u>Alternative 1</u>

The proposed improvements include installing a control structure to split the flow in the stream before the culvert under the private driveway at the north end of Dunham Place. A 42 inch pipe should be installed from Dunham Place and connected to the catch basin in Harriman Road approximately 120 feet east of Cedarlawn Road. A box culvert 5'W x 3.5'H should be installed from the existing 42 inch pipe to Parkside Way. The streams throughout these areas should be graded to provide positive pitch. Additionally, surveys must be completed to verify inverts and slopes. Since there is limited slope, the culverts must be larger to convey the design storm. The culvert size may be reduced once surveys are conducted. Additionally, a larger amount of stormwater may be redirected to the existing channel which will reduce the size of the proposed culvert in the roadway.

The estimated cost is $1,316,300. Conceptual plans and preliminary cost estimates can be found in Appendix I.

Please note, the location of the control structure may need to be installed on private property.

Alternative 2

The proposed improvements involve re-routing the flow through Harriman Road. The work includes reconstructing the control structure on Meadow Way and installing a box culvert (5'W x 3.5'H) from Parkside Way up to Harriman Road, between Cedarlawn Road and Meadow Way. The sediment located at the outlet should be cleared from culvert below private driveway and the channel should be graded to ensure positive pitch.

The estimated cost is $684,000. Conceptual plans and preliminary cost estimates can be found in Appendix I.

The areas and preliminary measures to rectify the condition as described above are conceptual and should not be constructed without surveys of utilities, topography, etc. The grades should be checked and the design and details finalized.

Secondary Village Areas

AREA 6

Area 6 is within the Barney Brook and is located at the outlet of Irvington Reservoir on Field Point Drive. The approximate FEMA station is 74+65.

The proposed improvements include raising the outlet weir and replacing low flow pipe with a larger pipe. This improvement would provide additional storage and reduce peak flows.

AREA 7

Area 7 is within the Barney Brook watercourse and is located on Harriman Road.

The proposed improvements include installing a bypass culvert from the Irvington Reservoir to the drainage channel past Sycamore Road. This would relieve the existing drainage infrastructure and channels by reducing the volume of flow. Maintaining some flow though the streams is possible. Further analysis is required.

AREA 8

Area 8 is within the Barney Brook and is located at the north end of Dunham Place. The approximate FEMA station is 65+00. The computer model identification is Reach R-35.

The proposed improvements include removing sediment from the channel and re-grade the road turnout. Additional work includes stabilizing the channel once cleaning and grading are complete.

AREA 9

Area 9 is within the Barney Brook and is located in Meadow Way. The computer model identification is Reach R-M1.

The existing culvert that conveys stormwater from Area D5 on the tributary area map is unable to convey the design storm event. To convey the design storm, the 36 inch culvert would need to be replaced with a 42 inch culvert.

AREA 10

Area 10 is within the Sunnyside Brook and is located at the intersection of North Broadway and Sunnyside Lane. The approximate FEMA station is from 30+10 to 31+00. The computer model identification is Reach R-25.

The existing culvert dimensions of the inlet and outlet do not appear to be the same. The analysis of the culvert cannot convey the design storm. The dimensions and slope should be verified to determine the channel capacity.

AREA 11

Area 11 is within the Barney Brook and is located from Sycamore Lane to Harriman Road. The approximate FEMA station is from 40+10 to 41+40 and 43+70 to 46+30. The computer model identification are Reaches R-16 and R-18.

The culverts located between Sycamore Lane to Harriman Road appear to have less capacity than the calculated upstream flow. They have not been identified as problematic flood areas and no proposed remediations are recommended at this time. However, the dimensions in the computer model were revised to keep the channels from overtopping. According to the model, the 42 inch diameter culvert beneath Sycamore Road should be replaced with a 48 inch culvert. In addition, the 4 foot wide by 2 foot high culvert beneath Harriman Road should be modified to a height of 3.5 feet.

Private Areas

AREA 12

Area 12 is within the Sunnyside Brook and is located between Hudson View Park and Sunnyside Place. The approximate FEMA station is from 46+00 to 60+00. The computer model identification are Reaches R-38 to R-40.

Section of the existing channel is narrow, shallow or both. Additionally, the slope is minimal. The adjacent areas along the stream were used to model this section. As shown on the FEMA FIS Map, the area is inundated in the larger storms. This area and the channel should be surveyed to determine the required channel dimensions to ensure the channel can convey the design flow.

AREA 13

Area 13 is within the Barney Brook and is located east of Brook Place (private drive). The approximate FEMA station is between 14+00 to 16+50. The computer model identification is Reaches R-04 and R-05.

Channels overtop in computer model due to minimal slopes. Stream dimensions and adjacent topography are required for additional recommendation of channel. The existing three 36 inch CMP pipes appear to have a minimal slope which may not be able to handle the design flow.

AREA 14

Area 14 is within the Barney Brook and is located between Meadow Way and Daisy Lane. The approximate FEMA station is between 62+50 and 65+45. The computer model identification are Reaches R-33 to R-36.

The existing channel is narrow with minimal slope which has a negative slope in two locations. The proposed improvements are to reshape channel and provide positive pitch. Reinstall culverts beneath private driveways to provide positive pitch.

AREA 15

Area 15 is within the Barney Brook and is located between Station Road and Barney Park. The approximate FEMA station is 10+00. The computer model identification is Reach R-03.

Remove blockage from stream and install large rip rap where needed.

AREA 16

Area 16 is within the Barney Brook and is located on Daisy Lane. The approximate FEMA station is between 67+00 to 68+00. The computer model identification are Reaches R-38 and R-40.

Remove sediment from the existing culverts and repair channel walls. Approximately 90 percent of the culverts are filled with sediment.

AREA 17

Area 17 is within the Sunnyside Brook and is located at Sunnyside Place. The approximate FEMA station is between 60+00 to 65+00. The computer model identification is Reach R-41.

Remove sediment and vegetation that is restricting the flow. Installing a forebay should be considered to help maintain pond and remove larger sediment.

AREA 18

Area 18 is within the Barney Brook and is located between Woodbine Road and the Old Croton Aqueduct. The approximate FEMA station is between 17+00 to 21+90. The computer model identification is Reach R-07.

This section of stream appears to be too narrow to convey the design flow. Consider widening channel.

AREA 19

Area 19 is within Riverview Road Brook and is located at 24 Riverview Road. The approximate FEMA station is 35+80. The computer model identification is Reach R-06.

The culvert dimensions and slope should be verified to determine channel capacity.

AREA 20

Area 20 is within the Barney Brook and is located between Daisy Lane and Field Point Drive. The approximate FEMA station is between 67+60 to 72+00. The computer model identification is Reach R-41 and R-42.

Remove sediment and vegetation. Repair damaged channel walls. Sections of the channel appear to be undersize (67+60 to 68+25). The existing channel appears to be too narrow to convey the design flow. Increasing the width of the channel may want to be considered. Further investigation is required to make a conclusive recommendation.

AREA 21

Area 21 is within the Barney Brook and is located between Park Road and Harriman Road. The approximate FEMA station is between 55+70 to 59+10. The computer model identification is Reaches R-27 to R-29.

Remove sediment and regrade to provide positive pitch.

Please note these culverts appear to have less capacity than the calculated upstream flow. They have not been identified as problematic flood areas and we do not propose any remediation at this time. However, the dimensions were revised in the computer model to keep the channels from overtopping. The 42 inch diameter culvert under Sycamore Road was changed to a 48 inch culvert. The 4'W x 2'H box culvert under Harriman Road was changed to a 4'W x 3.5'H box culvert.

AREA 22

Area 22 is within the Barney Brook Tributary and is located on Birch Lane. The approximate FEMA station is between 31+70 and 31+95. The computer model identification is Reach R-13T.

The existing culvert is back pitch and undersized. Consider replacing existing culvert.

AREA 23

Area 23 is within the Barney Brook and is located between Old Croton Aqueduct and Broadway. The approximate FEMA station is between 24+65 and 28+00. The computer model identification is Reaches R-11 to R-13.

Please note channel sections used along these sections of stream vary. The channel side slopes appear low near the neighboring properties. Installing a wall or raising the grade should be considered.

X. CONCLUSION

Frequent flooding occurs throughout the Village of Irvington. As the residential areas were developed, little improvements were made to the nearby stream to prevent flooding. The following items should be considered.

1. As discussed throughout this report, we recommend that the areas identified be surveyed and channel dimensions be verified prior to performing further analysis, design and construction.

2. We recommend the Village confirm the secondary and private areas identified in this report as impacted by flooding.

3. The Town of Greenburg and Village of Tarrytown make up approximately two-thirds of the tributary area of Sunnyside Brook, thereby contributing to flooding in Irvington. We recommend discussing potential solutions with these communities to assist in reducing peak flows within the Sunnyside Brook corridor (i.e. adding storage around existing bodies of water for detention).

4. Residents should be responsible to maintain sections of the stream that flow through their property. Therefore, we recommend assisting the residents with protocol to maintain the stream at the owner's expense.