

Stormwater Management Report

Cherry Street Neighborhood

**Borough of Naugatuck
New Haven County
State of Connecticut**

January, 2010

CHA Project Number: 20466

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1.0 INTRODUCTION

1.1 PROJECT DESCRIPTION

The Cherry Street neighborhood lies on the west side of the Naugatuck River and south of Rubber Avenue in the south central part of the Borough of Naugatuck, CT (see Figure 1). Over the past 40 years many of the residents who live along the east side of Cherry Street between Spencer and Ann Streets have reported experiencing periodic flooding during heavy rainfall events. Symptoms reported range from elevated groundwater that rises during such events to water ponding more than knee deep in the street and flooding adjacent lots and homes. Others who live within the watershed report having runoff flow across their lands when storm water runoff overwhelms existing drainage systems in Pleasant Avenue, Charles Street and Spencer Street. An existing drainage channel that flows easterly about 150 feet south of, and parallel to, Spencer Street frequently overflows its banks and floods the adjacent yards.

Storm drains are typically designed to catch and convey storm water runoff during a prescribed design storm. These storms are referred to as a 1-Year, 2-Year, 10-Year, etc. storm referring to their statistical likelihood of occurring during any one year period. Thus a 1-year storm would have a near 100% statistical chance of occurring in any given year, a 2-Year storm would have a 50% chance of occurring during any given year, a 10-Year storm would have a 10% chance of occurring in any given year, and so forth. When actual storm events exceed the design storm for which a piped drainage system is designed, the excess storm water runoff runs overland following the path of least resistance. Often a street doubles as the overflow channel. When the street's ability to carry the runoff is exceeded, water will find and follow the path of least resistance to reach the watershed's natural low point, in this case runoff eventually reaches the Naugatuck River. Unfortunately, along the way there is a depression in the landscape that is centered at the intersection of Charles and Cherry Streets. Existing drainage pipes in this area are not of sufficient size to convey the existing runoff and water pools at that location causing the flooding described above.

1.2 EXISTING CONDITION CHARACTERISTICS

1.2.1 Existing topography and drainage systems: The Borough of Naugatuck provided Geographic Information System (GIS) mapping of the drainage area that included known pipe locations, sizes, inlets and outlets; 10' contour interval topography (approximated from USGS topographic mapping); aerial photos; watershed boundaries; and tax mapping. This mapping provided guidance when CHA conducted a detailed reconnaissance of the neighborhood to further refine the existing information. CHA measured pipe diameters,

pipe depths and elevations of the storm drainage structures along the collector pipe and determined the relative elevations of existing storm drains and catch basin grates. CHA also refined the watershed boundary based on field observations. Elevations of the existing drainage system were referenced to an assumed elevation of 500 at the top of the existing storm drain manhole located approximately 200 feet southeast of the intersection where the driveway to the Kuehne & Nagel parking lot enters on the east side of Cherry Street. This assumed datum was purposely not related to the GIS mapping due to the approximate nature of the latter.

The watershed contains a total of approximately 268 acres, and is approximately 16% impervious. Impervious surfaces increase runoff by preventing water from infiltrating the ground and include such barriers to infiltration as roof tops, asphalt roadways, driveways and sidewalks. Land use is predominately residential, with some institutional and a few small retail and office parcels. The terrain within the upper reaches of the watershed is relatively steep and mostly wooded, having an average slope of 10 to 15%. Slopes decrease toward the lower portion of the watershed where there is more development. A map of the Cherry Street neighborhood's existing drainage conditions showing watershed boundaries and existing known drainage pipes is provided in Figure 2.

Also noted on Figure 2 is the location of an ancient drainage channel as it appeared on a USGS topographic map dated 1893. Apparently this natural drainage channel was filled to accommodate construction of houses throughout the neighborhood. The drainage depression lying south of Spencer Street and west of Pleasant Avenue appears to be a remnant of that natural channel. As the neighborhood was developed there was an apparent attempt to replace the natural channel with a piped drainage system. This was common practice in days gone by, but we have since learned that the best policy is generally to leave natural drainage channels unaltered. Mr. Thornton, the resident at 356 Cherry Street, provided us with a copy of a plan he had showing what appears to be the original 18 inch diameter piped drainage system crossing Cherry Street at its intersection with Charles Street and continuing easterly under his home and through the rear yards of his neighbors to the south. A later plan indicates that the 18 inch pipe was to have been plugged and a new 30 inch pipe constructed down Cherry Street and into the former Uniroyal tire manufacturing facility. This 30 inch pipe is still in place and provides the primary means of conveying storm water from the intersection of Charles and Cherry Streets.

A second 24 inch pipe was found above the 30 inch pipe. This appears to have been constructed as a previous attempt to eliminate or reduce flooding in the neighborhood. Both the 30 inch and 24 inch pipes are in good

condition, but the occurrence of flooding is evidence that their combined capacity is insufficient to convey runoff from intense storm events.

1.2.2 Soil Characteristics: As part of their soil classification system, the USDA Natural Resource Conservation Service (NRCS) assigns each soil series to a hydrologic soil group (HSG). The HSG is a four letter index (A-D) that is intended to indicate the relative ability of a soil to absorb rain water and thus its potential to shed storm water runoff. NRCS describes HSG A soils as those "...having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission." NRCS describes HSG B as those "...having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained to well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission." NRCS describes HSG C soils as those "...having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission." HSG A, B and C soils make up most of the soils within the study watershed. Figure 3 is a copy of the NRCS map of soil types along with descriptions of each soil and its drainage classification.

1.2.3 Neighborhood Workshop: Residents of the neighborhood were invited to attend an informational meeting with Mayor Robert Mezzo, Borough Engineer James Stewart, PE, and CHA Engineer Martin Risley, PE on the evening of September 9, 2009. At the meeting, the scope of the study was reviewed and the residents were asked to provide input regarding the flooding they have witnessed and also any comments they might offer regarding the perceived cause of the flooding. A summary of the comments received is included on Figure 4 which also provides a key to the location of the house each resident occupies.

During the meeting, residents were enthusiastic in their reports of repeated flooding events in this neighborhood. The most severe flooding reported was along the east side of the low-lying portion of Cherry Street at its intersection with Charles Street. The resident at 356 Cherry Street reported several instances when floodwater rose to just inches below his ground floor elevation and totally filled his basement. He reported that his neighbor's home had been flooded to an elevation several inches above its ground floor on more than one occasion.

More common were reports of storm waters running across front and back yards, pooling especially in Cherry

Street, water in basements, development of sink holes in lawns, and foundation damage. The resident at 345 Cherry Street reported severe foundation damage had occurred as a result of water emerging from the storm drain manhole located just feet from his foundation. The existing drainage pipes run beneath at least two houses in the neighborhood.

Residents along the south side of Spencer Street between Sharon Avenue and Pleasant Avenue reported repeated instances of flooding in their back yards. Residents on the east side of Pleasant Avenue reported street flooding and overtopping of the drainage system that conveys water from Pleasant Avenue to Charles Court. There was an additional report of runoff overtopping the curb on the east side of Charles Court and running overland to Cherry Street.

1.2.4 Site Reconnaissance: CHA completed a thorough reconnaissance of the watershed during the week of September 7, 2009. We observed the storm water collection system and looked for indications of flooding. Generally, the existing system appears to have been constructed in a piecemeal manner. There are numerous instances where large pipes flow into smaller ones. Pipe materials and conditions vary. Some manholes are of poor construction or are badly deteriorated while others are in very good condition.

One resident correctly characterized the depression at the intersection of Charles and Cherry Streets as a “bathtub with a plugged drain”. During intense storm events, large volumes of water conveyed from the majority of the study watershed accumulate in this low-lying area because water flows to it at a much higher rate than the existing drainage pipes can carry it away. This particular area is totally dependent on the existing undersized drainage pipes and when they are not able to convey water away fast enough it has nowhere to go but up until it eventually overtops the low point in the adjacent landscape. Before it can reach that elevation, the street and several homes are flooded.

The resident at the corner of Spencer Street and Pleasant Avenue converted the drainage ditch to a stone channel in an attempt to control the flooding there. However, the constructed channel and a box culvert that was part of the alteration has created a bottleneck measuring just 24 inches wide by 18 inches high that actually obstructs the flow of water in the drainage ditch before it can enter the larger 30 inch diameter culvert under Pleasant Street.

When runoff overtops the drainage system at the intersection of Pleasant Avenue and Spencer Street, the excess water flows easterly on Spencer Street to a low point approximately half way between Pleasant Avenue

and Cherry Street. There it enters a catch basin having a 12 inch pipe outlet. When the 12 inch pipe becomes overloaded, the excess water flows southerly over the ground surface between two houses until it reaches Cherry Street.

Near the south end of Pleasant Avenue, water from a 30 inch diameter culvert enters a 24 inch culvert that becomes an 18 inch culvert before discharging to a small ditch about 200 feet to the northeast. This ditch conveys water to a 12 inch culvert that frequently overtops, spilling runoff overland to Charles Court. Additionally, water that overtops the 24 inch pipe overflows into Pleasant Avenue and is conveyed to the intersection of Pleasant Avenue and Spencer Street where it adds to the flows described above.

2.0 PROJECT OBJECTIVES

The objective of this project was to identify deficiencies that contribute to flooding in the Cherry Street neighborhood, and to suggest potential measures that could be constructed to eliminate or reduce the severity of the reported flooding. The study was originally limited to determining how stormwater was conveyed to the land previously occupied by the Uniroyal plant. However, the study goes beyond that point to give conceptual consideration as to how runoff would flow to the Naugatuck River.

3.0 HYDROLOGIC EVALUATION

3.1 METHODOLOGY

Existing and observed data were used to construct a computer model of the watershed and analyze how water passes through it during various storm events. 1", 2", 1-Year (2.7"), 2-Year (3.3"), 10-year (5.0") and 25-Year (5.6") storm events were modeled to analyze the relative capacity of existing pipes and to test proposed alternatives.

Runoff curve numbers and times of concentration were computed using standard NRCS TR-55 methodology. Additionally, peak stormwater flows and hydrographs for the existing conditions and proposed condition alternatives were computed using HydroCAD[®] (Version 9.00) Storm Water Modeling Software.

3.2 EXISTING CONDITION HYDROLOGY

In analyzing this watershed, the key points of interest are at the following locations:

- The intersection of Cherry and Charles Streets. This location is labeled C-4 in the existing condition model and PC-4 in the proposed conditions models.

- The intersection of Pleasant Avenue and Spencer Street. This location is labeled C-10 in the existing condition model and PC-10 in the proposed condition models.
- Near the southerly end of Pleasant Street where the existing 30 inch culvert enters an existing catch basin on the west side of the road. This location is labeled C-15 in the existing condition model and PC-15 in the proposed conditions models.

Figure 2 is an Existing Storm Water Plan that illustrates the watershed, and the major components of the existing drainage system. It labels each of the points of interest (or nodes) that were analyzed within the drainage system. Sub-catchment areas are also described on the plan. The results of the existing condition analysis are summarized in Table 3-1. Detailed computations are included in Appendix B.

Table 3-1

Summary of Performance of Existing Drainage System – Cherry Street Neighborhood

Node	Location	Overflow Peak Flow Rate / Volume in CFS and AF					
		1"	2"	1-Year	2-Year	10-Year	25-Year
C4	Cherry/Charles	0/0	0/0	5.8/0.18	6.1/0.60	325.5/14.84	412.6/20.80
C5	SW Cherry/Charles	0/0	0/0	4.2/0.08	12.4/0.95	12.7/1.59	12.6/1.82
C6	NW Charles/Cherry	0/0	0/0	14.1/0.68	19.1/1.65	25.4/3.76	25.7/4.45
C7	Costeira	0/0	0/0	9.5/0.39	15.0/0.75	36.3/2.74	41.4/3.40
C8	Wishing Well	0/0	0/0	21.9/0.90	22.4/1.46	41.2/3.95	43.6/4.80
C9	Pleasant N	0/0	0/0	0/0	0/0	20.8/0.63	39.8/1.19
C10	30" Culvert	0/0	0/0	10.4/0.07	60.3/1.85	199.3/9.44	252.3/12.95
C10.5	Sharon Culvert	0/0	0/0	14.8/0.36	47.4/1.74	157.4/8.05	199.0/10.82
C11	Charles	0/0	0/0	0/0	0/0	0/0	0/0
C11.5	12" Culvert Inlet	0/0	0/0	11.9/0.53	18.4/1.39	25.1/4.08	28.2/5.15
C15	Pleasant S	0/0	0/0	0/0	11.0/0.28	54.8/2.69	65.9/3.58
C15.5	30" Culvert Inlet	0/0	0/0	0/0	0/0	20.6/0.27	36.4/0.69

Node	Location	Pond Depth Above Cherry Street in Feet					
		1"	2"	1-Year	2-Year	10-Year	25-Year
C-4	Cherry/Charles	0.0	0.0	0.6	2.9	5.1	5.3

A review of Table 3-1 reveals that the existing system is capable of conveying a storm with a total rainfall of 2 inches and begins to experience minor flooding when a 1-year (2.7 inch) storm event occurs. During a 1-year storm event water would pond to a depth of 0.6 feet at the intersection of Cherry and Charles Street. A 2-year storm event would likely cause water to pond to a depth of 2.9 feet in Cherry Street. At this level, basements of the lowest homes on the east side of Cherry Street may begin to flood. More intense 10-year and 25-year

storms would likely flood the basements of several homes and reach the ground floor level of some as has occurred in the past.

3.3 PROPOSED SYSTEM HYDROLOGY

Due to the deteriorated condition of the existing undersized drainage systems that currently convey storm water runoff between Pleasant Avenue and Cherry Street, CHA concluded that new pipe construction would be required to resolve the flooding in this neighborhood. Analysis of the data led to development and consideration of three potential alternative solutions. They are:

- Construct a new collection system and a new large diameter outfall to the Naugatuck River
- Construct a new collection system and demolish existing homes to create a storm water detention basin capable of controlling the rate of flow to a level below the capacity of the existing drainage outfall
- Construct a new collection system, demolish existing homes to create a storm water detention basin capable of controlling the rate of flow to a level that would significantly reduce the size of a new outfall to the Naugatuck River

3.3.1 New Collection System and New Outfall: The conventional approach to reducing the frequency of flooding in this watershed is to increase the size of both the collection system and the outfall pipes so that runoff can be expeditiously conveyed to the Naugatuck River. This alternative is illustrated in Figure 5. It would require construction of the following major components:

- A new 60 inch pipe would be constructed from the east end of the open drainage channel that lies south of Spencer Street at Pleasant Avenue (node C10 on Figure 2 and PC10 on Figure 5) to the intersection of Cherry and Charles Streets (node C4 on Figure 2 and PC4 on Figure 5)
- A new 42 inch pipe would be constructed from the existing headwall lying approximately 200 feet west of Pleasant Avenue (node C15.5 on Figure 2 and PC15.5 on Figure 5) to the east end of Ann Street (node C12 on Figure 2 and PC12 on Figure 5)
- A new 72 inch outfall pipe would be constructed from the intersection of Cherry and Charles Streets to the Naugatuck River. This outfall would also intercept the proposed 42 inch pipe at the intersection of Cherry and Ann Streets.

Overflow rates in cubic feet per second (CFS) and volumes in acre-feet (AF) at representative points throughout the system are provided in Table 3-2 for this alternative. Table 3-2 also tabulates the expected depth of ponding at the intersection of Cherry and Charles Streets for the analyzed storm events. Hydrologic computations for this alternative can be found in Appendix C.

Table 3-2

**Summary of Performance with New Collection System and New Outfall
Cherry Street Neighborhood**

Node	Location	Overflow Peak Flow Rate / Volume in CFS and AF						
		1"	2"	1-Year	2-Year	10-Year	25-Year	100-Year
PC1	Outfall Drain	0/0	0/0	0/0	0/0	0/0	0/0	
PC4	Cherry/Charles	0/0	0/0	0/0	0/0	0/0	0/0	
PC7	Costeira	0/0	0/0	0/0	0/0	0/0	32.0/0.58	
PC10	60" Culvert Inlet	0/0	0/0	0/0	0/0	0/0	31.8/0.55	
C10.5	Sharon Culvert	0/0	0/0	14.8/0.36	47.4/1.73	157.3/8.05	198.9/10.82	
PC15	Pleasant South	0/0	0/0	0/0	0/0	0/0	8.3/0.10	
PC 15.5	42" Culvert Inlet	0/0	0/0	0/0	0/0	0/0	7.2/0.04	

Node	Location	Pond Depth Above Cherry Street in Feet						
		1"	2"	1-Year	2-Year	10-Year	25-Year	100-Year
C-4	Cherry/Charles	0.0	0.0	0.0	0.0	0.0	0.8	5.0

A review of Table 3-2 reveals that with the exception of the culvert at Sharon Avenue, this proposed system would eliminate overflows from the drainage pipes during a 10-Year storm event. Minor overflows would begin to occur between Pleasant Avenue and Charles Street, and at the south end of Pleasant Street during the peak of a 25-Year storm event, but they would be very short in duration and of minimal volume. Also water would begin to pool in Cherry Street (node PC4) and at the culvert inlet located about 200 feet west of Pleasant Avenue (node PC15.5) during the 25-Year event. Flooding would become more severe during a 100-Year event, most significantly the pool at the intersection of Cherry and Charles Streets would be 5 feet in depth and homes would become flooded as currently occurs during much less intense storms.

In addition to, but somewhat separate from, the segments of the collection system that are described above, the Sharon Avenue culvert becomes flooded during a 2-Year storm event. Because no flood damage was reported at the Sharon Avenue culvert, no improvements were analyzed. It is likely that overflows at this location simply overtop the road and re-enter the drainage channel or flow to Spencer Street where they are conveyed easterly toward its intersection with Pleasant Avenue. Due to the shallow depth of the existing culvert and the

relationship between the elevations of the road surface and the invert of the drainage channel, to increase capacity it would be necessary to add parallel culvert(s) to the crossing as opposed to replacing it with a larger culvert. Consideration of the Sharon Avenue culvert is consistent through all of the alternatives that were evaluated.

3.3.2 New Collection System and New Detention Basin: Another conceptual solution considered was to detain the storm water runoff within the watershed so that it could be released at a rate that does not overtax the existing drainage system. To accomplish this it would be necessary to create a relatively large detention basin(s) located at or near the low point(s) within the watershed. Such a solution for this watershed is illustrated in Figure 6. It would require construction of the following major components:

- A new 60 inch pipe would be constructed from the east end of the open drainage channel that lies south of Spencer Street at Pleasant Avenue (node C10 on Figure 2 and PC10 on Figure 6) to the intersection of Cherry and Charles Streets (node C4 on Figure 2 and PC4 on Figure 6)
- A new 42 inch pipe would be constructed from the existing headwall lying approximately 200 feet west of Pleasant Avenue (node C15.5 on Figure 2 and PC15.5 on Figure 6) to the east end of Ann Street (node C12 on Figure 2 and PC12 on Figure 6)
- Demolition of the southerly 6 homes currently located on the east side of Cherry Street and excavation of approximately 8,150 cubic yards of soil to create a detention basin.

Overflow rates in cubic feet per second (CFS) and volumes in acre-feet (AF) at representative points throughout the system are provided in Table 3-3 for this alternative. Table 3-3 also tabulates the expected depth of ponding at the intersection of Cherry and Charles Streets for the analyzed storm events. Hydrologic computations for this alternative can be found in Appendix D.

From a comparison of Tables 3-2 and 3-3 it can be seen that the level of flood control achieved in the collection system above Cherry Street is the same for this alternative as for the previous one. This is to be expected because both include the same proposed system improvements within that part of the watershed. However, with this alternative, the runoff would pool to a depth of nearly 5 feet during a 10-year storm at the intersection of Charles and Cherry Streets. Because the houses that currently flood would no longer exist, they could not be flooded. Cherry Street would flood less frequently than it currently does, but still more frequently than is reasonable.

Table 3-3

**Summary of Performance with New Collection System and New Detention Basin
Cherry Street Neighborhood**

Node	Location	Overflow Peak Flow Rate / Volume in CFS and AF					
		1"	2"	1-Year	2-Year	10-Year	25-Year
PC4	Cherry/Charles	0/0	0/0	0/0	0/0	150.6/4.63	265.0/10.64
PC7	Costeira	0/0	0/0	0/0	0/0	21.8/0.40	32.0/0.58
PC10	60" Culvert Inlet	0/0	0/0	0/0	0/0	0/0	31.8/0.55
C10.5	Sharon Culvert	0/0	0/0	14.8/0.36	47.4/1.73	157.3/8.05	198.9/10.82
PC15	Pleasant South	0/0	0/0	0/0	0/0	0/0	8.3/0.10
PC 15.5	42" Culvert Inlet	0/0	0/0	0/0	0/0	0/0	7.2/0.04

Node	Location	Pond Depth Above Cherry Street in Feet					
		1"	2"	1-Year	2-Year	10-Year	25-Year
C-4	Cherry/Charles	0.0	0.0	0.0	0.0	4.7	5.1

3.3.3 New Collection System, New Detention Basin and New Outfall: A third approach combines elements of the first two. The collection system above Cherry Street would be replaced and a new outfall would be constructed, but the detention basin in the previous alternative would be added for the purpose of reducing the size and construction cost of the outfall pipe. This alternative is illustrated in Figure 7. It would require construction of the following major components:

- A new 60 inch pipe would be constructed from the east end of the open drainage channel that lies south of Spencer Street at Pleasant Avenue (node C10 on Figure 2 and PC10 on Figure 7) to the intersection of Cherry and Charles Streets (node C4 on Figure 2 and C4 on Figure 7)
- A new 42 inch pipe would be constructed from the existing headwall lying approximately 200 feet west of Pleasant Avenue (node C15.5 on Figure 2 and PC15.5 on Figure 7) to the east end of Ann Street (node C12 on Figure 2 and PC12 on Figure 7)

- Demolition of the southerly 6 homes currently located on the east side of Cherry Street and excavation of approximately 8,150 cubic yards of soil to create a detention basin.
- A new 60 inch outfall pipe would be constructed from the intersection of Cherry and Charles Streets to the Naugatuck River. This outfall would also intercept the proposed 42 inch pipe at the intersection of Cherry and Ann Streets.

Overflow rates in cubic feet per second (CFS) and volumes in acre-feet (AF) at representative points throughout the system are provided in Table 3-4 for this alternative. Table 3-4 also tabulates the expected depth of ponding at the intersection of Cherry and Charles Streets for the analyzed storm events. Hydrologic computations for this alternative can be found in Appendix E.

Table 3-4

**Summary of Performance with New Collection System,
New Detention Basin and New Outfall
Cherry Street Neighborhood**

Node	Location	Overflow Peak Flow Rate / Volume in CFS and AF						
		1"	2"	1-Year	2-Year	10-Year	25-Year	100-Year
PC1	Outfall Drain	0/0	0/0	0/0	0/0	0/0	0/0	
C4	Cherry/Charles	0/0	0/0	0/0	0/0	0/0	0/0	
PC7	Costeira	0/0	0/0	0/0	0/0	0/0	24.9/0.43	
PC10	60" Culvert Inlet	0/0	0/0	0/0	0/0	0/0	31.8/0.55	
C10.5	Sharon Culvert	0/0	0/0	14.8/0.36	47.4/1.73	157.3/8.05	198.9/10.82	
PC15	Pleasant South	0/0	0/0	0/0	0/0	0/0	8.3/0.10	
PC 15.5	42" Culvert Inlet	0/0	0/0	0/0	0/0	0/0	7.2/0.04	

Node	Location	Pond Depth Above Cherry Street in Feet						
		1"	2"	1-Year	2-Year	10-Year	25-Year	100-Year
C-4	Cherry/Charles	0.0	0.0	0.0	0.0	0.0	0.0	4.4

A review of Table 3-4 reveals results similar to the New Outfall Alternative presented in paragraph 3.3.1 above. Performance is slightly better and the outfall size is reduced from a 72 inch pipe to a 60 inch pipe, but 6 homes must be purchased and removed and a detention basin must be constructed in their place.

4.0 STUDY-LEVEL OPINION OF PROBABLE CONSTRUCTION COSTS

For purposes of comparing the costs of the various alternatives, unit construction costs for the various sizes of pipe were approximated using current RSMeans Construction Cost Data. Comparative Opinions of Probable Construction Costs for the various options are presented in Table 4-1 on the following page.

Item	Unit Price (see note below)	New Collection and New Outfall (see Figure 5 and paragraph 3.3.1)	New Collection and New Detention Basin (see Figure 6 and paragraph 3.3.2)	New Collection, New Detention and New Outfall (see Figure 7 and paragraph 3.3.3)
		Quantity		
72" HDPE Pipe (LF)	840	2550	0	0
60" HDPE Pipe (LF)	625	600	600	3230
54" HDPE Pipe (LF) [2-54" pipes replace 1-72" pipe under RR]	730	160	0	0
42" HDPE Pipe (LF)	425	950	950	950
72" Steel RR Casing (LF)	2300	0	0	80
Double 72" Steel RR Casing (LF)	4600	80	0	0
Detention Basin (CY)	10	0	8150	8150
House Purchase and Demolition (EA)	200,000	0	6	6
Detention Basin Inlet/Outlet Structures (LS)	25,000	0	1	1
Comparative Opinion of Construction Cost by Option		\$3,405,550	\$2,085,250	\$3,913,000
Contingencies and Engineering @ 30%		\$1,021,665	\$ 625,575	\$1,173,900
Comparative Opinion of Project Cost by Option		\$4,427,215	\$2,710,825	\$5,086,900

Note: Unit prices are based on RSMeans Construction Cost Data and are adjusted for 2010 construction in Naugatuck, CT. They include allowances for demolition, excavation, pipe, installation, bedding, backfill, restoration of surface improvements, access structures, connections to existing pipes, general conditions, and contractor overhead and profit. They assume pipes will be constructed in existing roads and do not include any significant amounts of curb replacement, nor do they include full-width road reconstruction, water or sewer line relocations, relocations of other utilities, or easement acquisition costs.

5.0 RECOMMENDED SYSTEM IMPROVEMENTS

5.1 PERIODIC MAINTENANCE AND REPAIR

Residents reported instances where debris had clogged or obstructed flow at pipe inlets or within the storm drains. This often results during the course of a storm when debris is washed into the drainage system due to high water elevations. Continued periodic maintenance will help keep the existing system functioning at its capacity. However, as has been described, the existing capacity is inadequate to protect some properties in the watershed from flood damage.

5.2 RECOMMENDED ALTERNATIVE

The alternative presented in paragraph 3.3.2 (New Collection System and New Detention Basin) can be constructed for about \$2.7 million, the lowest cost of the solutions evaluated in this report. However, it also provides the lowest level of flood protection and includes the demolition of six existing homes.

The least expensive alternative that provides an acceptable level of flood protection is the alternative described in paragraph 3.3.1 (New Collection System and New Outfall). This alternative does not require the loss of any homes. It could be phased so that the outfall was constructed first at a cost of about \$3.4 million to eliminate the flooding at the intersection of Cherry and Charles Streets. However, flooding above that location in the watershed would continue as it is currently until the balance of the project was completed at an additional cost of about \$1.0 million.

The most expensive alternative is described in paragraph 3.3.3 (New Collection System, New Detention Basin and New Outfall). This alternative could be constructed in phases that might be more manageable. The first phase would include demolition of six existing homes, and construction of the collection system and the detention basin at a cost of about \$2.7 million. With this construction, property damage within the watershed would largely be eliminated and the frequency of flooding at the intersection of Cherry and Charles Streets would be reduced. The remainder of the project, the outfall to the Naugatuck River, could be constructed at a later date to complete the project at an additional cost of about \$2.4 million.

Assuming the Borough could raise the funds needed to do so, our recommendation would be to construct the alternative described in paragraph 3.3.1 (New Collection System and New Outfall) in one phase. If one phase is not feasible, it could be constructed in two phases as described above. If that cannot be accomplished, we would recommend that the Borough construct the system described in paragraph 3.3.3 in two phases.