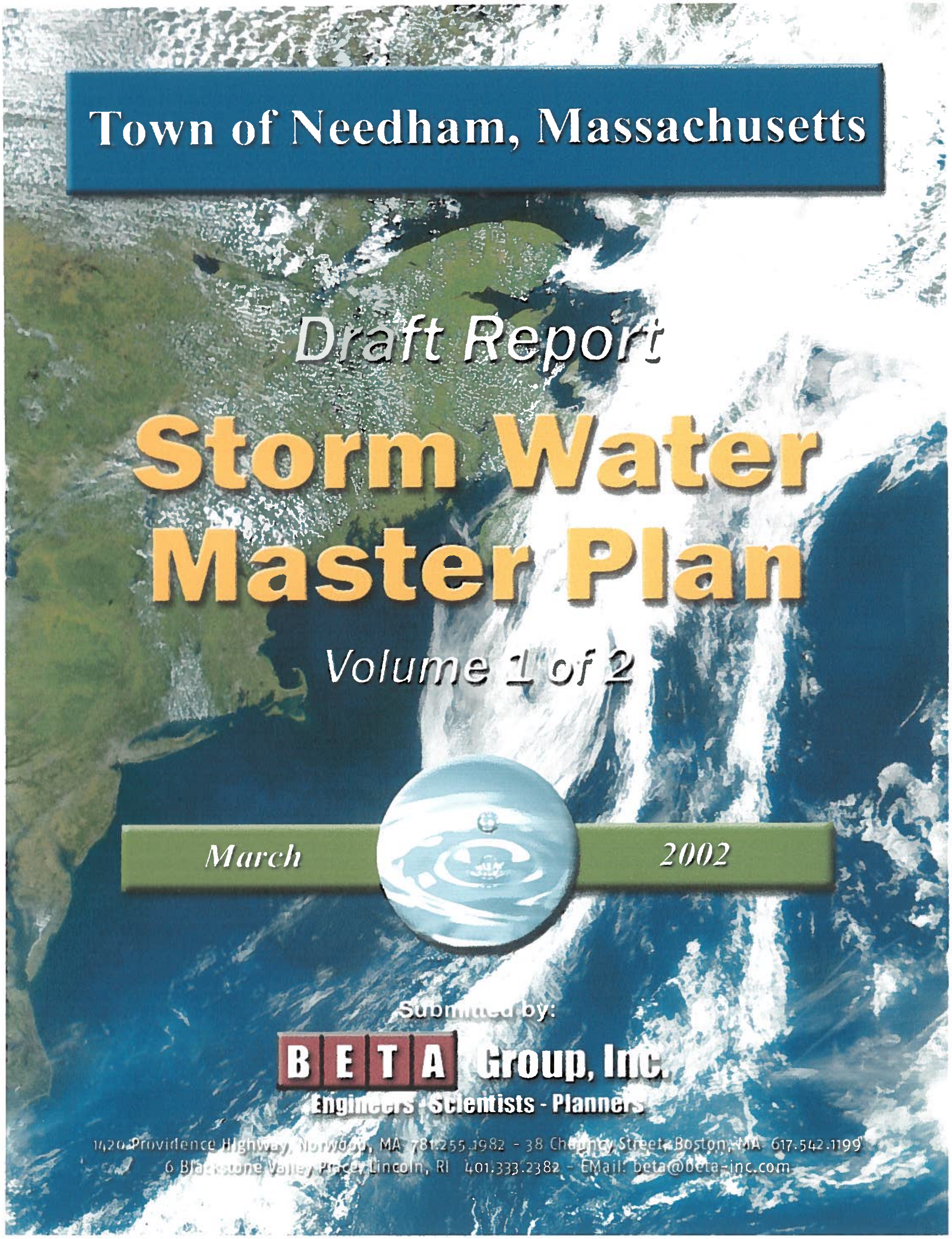

Town of Needham, Massachusetts

Draft Report

Storm Water Master Plan

Volume 1 of 2

March *2002*

Submitted by:

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SECTION 1
INTRODUCTION

1.1 Background

In an effort to comply with the United States Environmental Protection Agency's (EPA) goal of a "fishable and swimable" Charles River by Earth Day 2005, the EPA and the Town of Needham entered into a Consent Order Docket No. 96-08 and a Memorandum of Understanding (MOU) dated April 11, 1996 and May 28, 1996 respectively.

Under the MOU the Town developed a Storm Water Management Program for review by the EPA. The Storm Water Management Program has been revised and updated based on comments provided by the Center for Watershed Protection (CWP), the EPA's consultant. The revised Storm Water Management Program, submitted in June of 1998, has been under review since its submission and there are ongoing discussions between the Town and the EPA with respect to reaching a signed MOU between the Town and the EPA.

The Consent Order and MOU are described below.

Consent Order

The Consent Order required the Town to submit the following information to the EPA by November 30, 1996:

- Mapping each of the municipal storm water discharge pipes and drainage areas flowing into the Charles River.
- Visual examination and sampling of each discharge during dry-weather conditions. The samples must be analyzed for fecal coliform bacteria.
- Investigation and inventory of potential illicit connection to the storm water drainage system.
- Cost estimate to remove the illicit connections.

This information was submitted to the EPA on November 29, 1996 in a report titled "Stormwater Pollution Study of the Charles River."

Memorandum of Understanding

The MOU required the Town to submit the following information to the EPA by December 31, 1996:

- Development of a storm water management program in accordance with the Memorandum.

- Evaluation of management practices and programs to improve storm water quality, including source controls.
- Provide proof of adequate local funding mechanisms.
- Preparation of an annual report summarizing the results of the program in December of each year.

This information was submitted to the EPA on December 29, 1996 in a report titled "Storm Water Pollution and Management Program."

In an effort to continue to improve water quality in Needham, the Town applied for a loan in the amount of $500,000 from the DEP through the State Revolving Fund (SRF) to continue the storm water planning efforts. This funding, along with supplemental funding from the Town was used to develop the base and drainage mapping, complete the outfall inspections town wide, perform hydrologic/hydraulic analysis and prepare this Storm Water Master Plan.

1.2 Scope of Work

Storm Water Master Plan

The scope of this project is to develop a Storm Water Master Plan for Needham's drainage system on a town wide basis. Preliminary investigations included obtaining base mapping and converting available storm drain record plans to a Geographic Information System (GIS) format to assist in evaluating the drainage system on a watershed basis. Problem areas where chronic flooding occurs, were identified by the Town and coded as "Category A" in the drainage system database for analysis purposes. The hydraulic capacities of the Category A pipes were then evaluated using modeling software, providing the framework for isolating deficiencies on a subwatershed basis. A series of alternatives were then analyzed that focused on providing corrective measures to the flooding problems. Potential solutions and prioritized recommendations were then developed and documented in this report.

In an effort to identify and remove illicit discharges a Non-Point Source Pollution Study was completed. A storm water discharge inspection, inventory, and environmental sampling and testing program was conducted as part of the study. As indicated in the "Stormwater Pollution and Management Plan" prepared by BETA Group, Inc., previous efforts focused on ten drainage areas discharging directly to the Charles River. The efforts described in this report include all of the storm water discharges within the remaining drainage areas in Needham that were not previously inspected or sampled.

Geographic Information System (GIS) Data Development

A GIS is described as an organized collection of computer hardware, software, geographic data and personnel designed to efficiently capture, store, update, manipulate, analyze and display all forms of geographically referenced information. The Town of Needham uses GIS technology to create, manipulate and view land data as well as parcels and other infrastructure features. One of the major components of the SWMP was developing a storm drain network in GIS format compatible with the Environmental Research Systems Institute (ESRI) product line (ArcGIS 8.1) which is the Town's standard.

All topographic map data developed for the project was compiled at 1"=40' scale from a spring 1999 aerial photography. The base mapping was provided in ArcInfo format consisting of numerous planimetric features, including, but not limited to, infrastructure points (manholes and catch basins), edges of pavement, building footprints, water bodies, wetlands and 2-foot contours. Approximately 75% of the municipal drainage manholes and catch basins were located via photogrammetric methods, while the remaining 25% were located utilizing Global Positioning System (GPS) or field survey.

The infrastructure points provided the framework for establishing the geographic location for drainage pipes using record plans provided by the Town. These plans contained plan and profile information that is critical to developing an accurate drainage system map and database. As part of the automation process, pipe and structure attribute information was added to the GIS database. Pipe and structure features developed as part of this project included such elements as rim elevation, invert elevation, pipe size, pipe material and slope. This information played a key role in the drainage system evaluation and modeling completed for the Storm Water Master Plan.

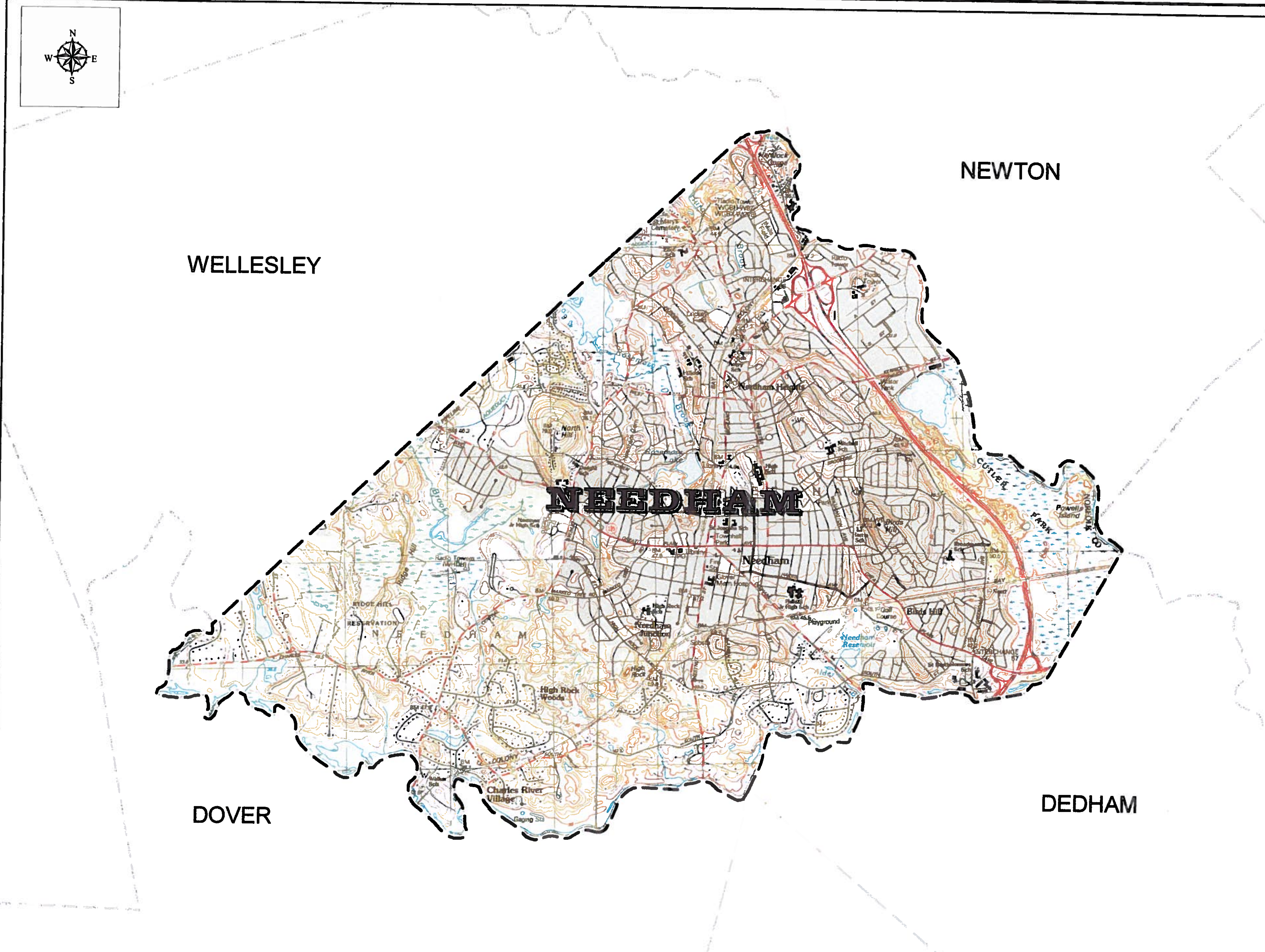
1.3 Project Location/Demographic Profile

Needham is located in eastern Massachusetts, just west of Boston in the metro-west suburbs as shown in Figure 1-1 on the following page. Needham is 10 miles southwest of Boston and approximately 30 miles east of Worcester. It is bordered by Wellesley on the west and northwest, Newton on the north and northeast, the West Roxbury section of Boston on the east, Dedham on the southeast and south, and Westwood and Dover on the south.

The 1990 U.S. Census defines an "urban area" as an area with a population density of at least 1,000 people per square mile. The following provides a breakdown of the demographic characteristics of Needham.

- Total Area – 12.70 sq. miles
- 1990 Population – 27,557 (1990 Census)
- 2000 Population – 28,911 (2000 Census)
- Density – 2,276 per sq. mile

The 2000 Census yielded a population of almost 29,000 or an increase of less than 1% from the 1990 Census value of 27,557. The bar graph (shown on the following page) indicates



Legend

Needham Outline

Surrounding Town Outline

2500000 0 2500000 5000000 Fee:

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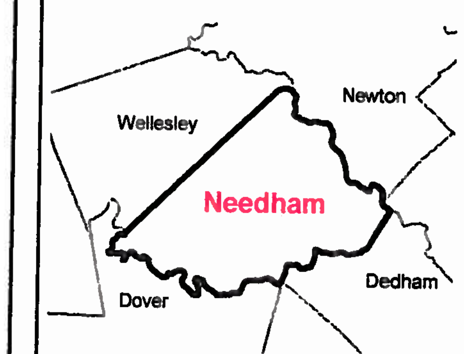
Locus



Storm Water Master Plan

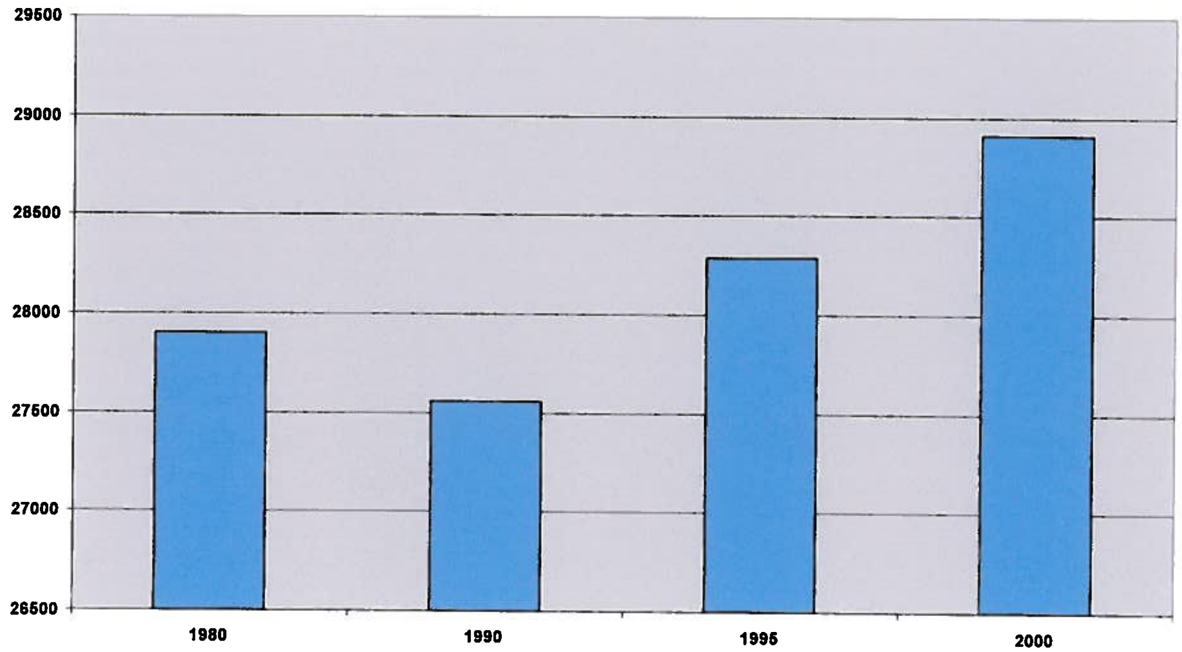
Needham, Massachusetts

Figure 1-1
Needham and
Surrounding Communities

Needham's population has not significantly increased over the past 20 years, with a slight decline from 1980 to 1990.

Because Needham is located within an urban boundary, the Town is obligated to meet the Phase II Storm Water requirements by March 2003. In addition to preparing this document, the Town is in the process of developing a Phase II Compliance Plan.

Needham Population Trends



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SECTION 2
DRAINAGE SYSTEM DESCRIPTION

2.1 General

The Town of Needham's overall storm water collection system is made up of pipes, culverts, streams, swales or ditches, wetland areas, detention basins, lakes, ponds, and rivers. All of Needham is located within the Charles River Drainage Basin, indicating that a high volume of surface water eventually flows to the Charles River. The focus of this report is the closed drainage system that consists of approximately 102 miles of pipe and 6,326 nodes (manholes, catch basins, outlets, headwalls and junctions). There is a total of catch basins total 4,225 catch basin and 1,392 drainage manholes within the system.

The Town of Needham consists of four major drainage areas as follows:

Table 2-1
Watershed Comparisons

Watershed	Area (acres)	Area (sq. miles)	Miles of Pipe	Total Catch Basins	Total Manholes	Total Outlets
Route 128	2,216.16	3.46	29.10	1147	39	14
Southern	3,177.96	4.97	36.80	1468	477	55
Interior A	1,513.39	2.36	29.60	1331	431	33
Interior B	1,252.56	1.96	6.30	279	86	27

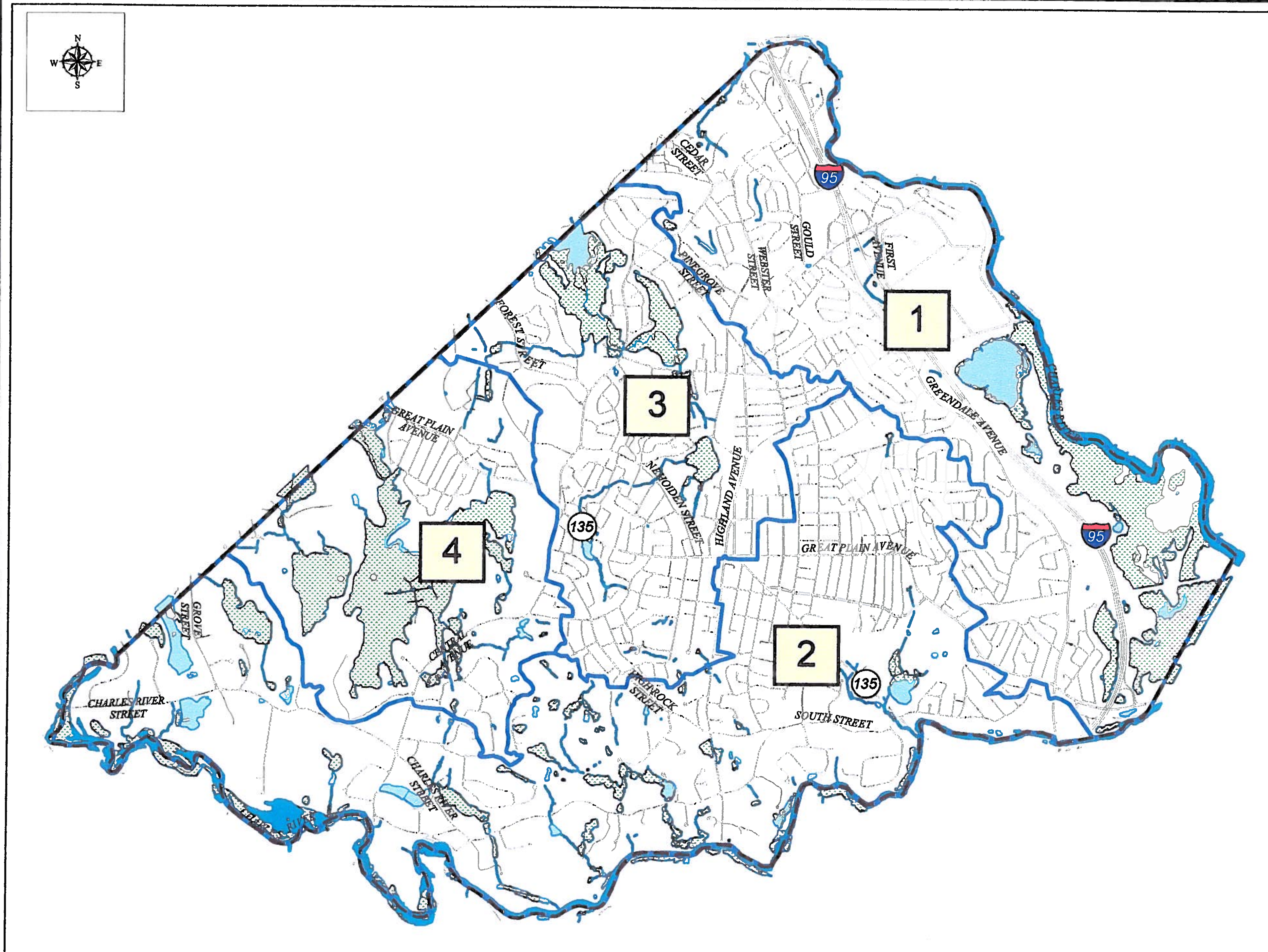
Two of the major drainage areas discharge directly to the Charles River, while the others discharge to the Charles through Wellesley via tributary waters such as Fuller Brook and Rosemary Brook. The four areas vary significantly in size and land use characteristics. An overall map of Needham's drainage system is provided in Figure 2-1.

2.2 Drainage Area Descriptions

The following section presents a description of the four major drainage areas in Needham. On the following pages is a graphic that provides the geographic location of each of the four watersheds with the Town of Needham.

Watershed 1 – Route 128

Watershed 1 is located along the Town's eastern boundary with the City of Newton (formed by the Charles River) and to the east of Watersheds 2 and 3. The area is also bisected by the Route 128 corridor with a major (full clover leaf) interchange at Highland Avenue and a smaller interchange (Great Plain Avenue) at the southern end of the area. The watershed is approximately 3.5 square miles and includes 29.1 linear miles of pipe, 1,147 municipal catch



Legend

- Major Watershed Areas
- Major Watershed No.
- Ponds
- Rivers and Streams
- Upland
- Wetland Areas
- Other Water Bodies

1250 0 1250 2500 Feet

BETA Group, Inc.

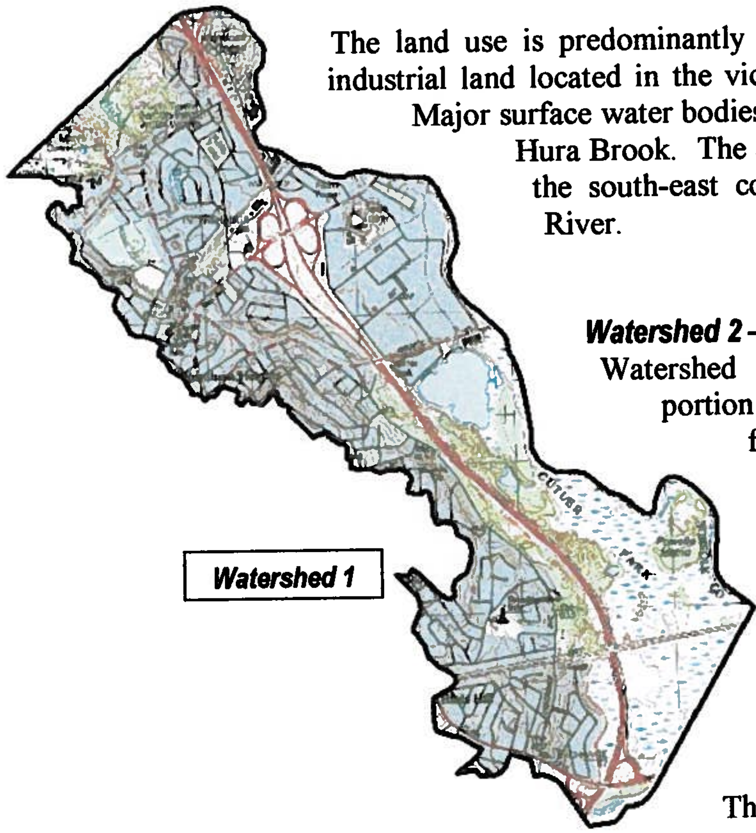
Locus

Storm Water Master Plan

Needham, Massachusetts

Figure 2-1
Major Watersheds

basins and approximately 14 discharge points or outlets. The drainage systems discharge to the State drainage system or directly to the Charles River.



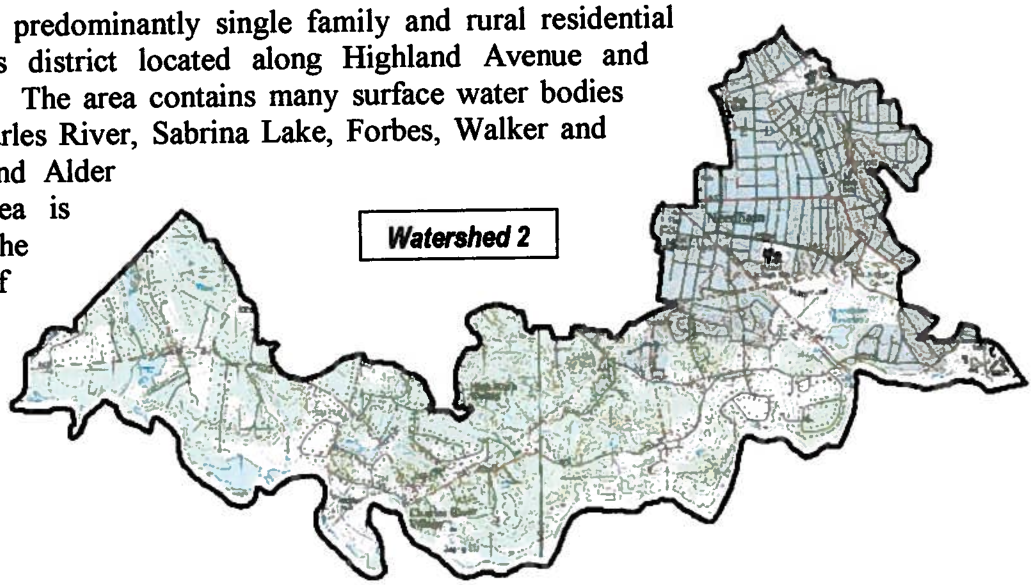
The land use is predominantly single family residential with a pocket of industrial land located in the vicinity of the Highland Avenue interchange. Major surface water bodies include the Charles River, Cutler Lake and Hura Brook. The area also contains a large wetland located in the south-east corner between Route 128 and the Charles River.

Watershed 2 – Southern

Watershed 2 is located in the southern and central portion of Needham. The southern limits are formed by the Charles River which is also the municipal boundary for the towns of Dover and Dedham and the northern limits of with Watersheds 3 and 4. Major transportation facilities and roadways include the Commuter Rail Line, which extends from Dover into Watershed 1, Route 135, South Street and Chestnut Street.

The size of the watershed is approximately 5 square miles and includes 36.8 linear miles of pipe, 1,468 municipal catch basins and approximately 55 discharge points or outlets. All discharges flow directly to the Charles River or through wetland/stream systems to the river.

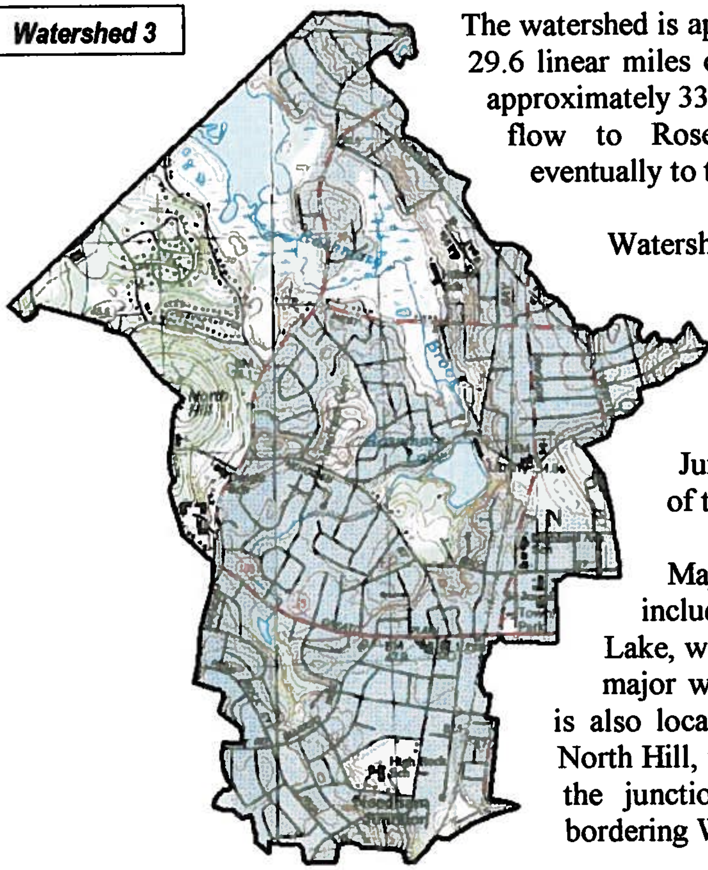
The land use is predominantly single family and rural residential with a business district located along Highland Avenue and Chestnut Street. The area contains many surface water bodies such as the Charles River, Sabrina Lake, Forbes, Walker and Farley Ponds and Alder Brook. The area is also home to the Needham Golf Club, DeFazio Park and a portion of the Ridge Hill Reservation.



Watershed 3 – Interior A

This watershed, located in the northwest portion of the Town, is bounded by the Town of Wellesley to the north. Honeywell Street is located along the eastern boundary and Watersheds 2 and 4 provide the southern and western boundaries respectively.

Watershed 3

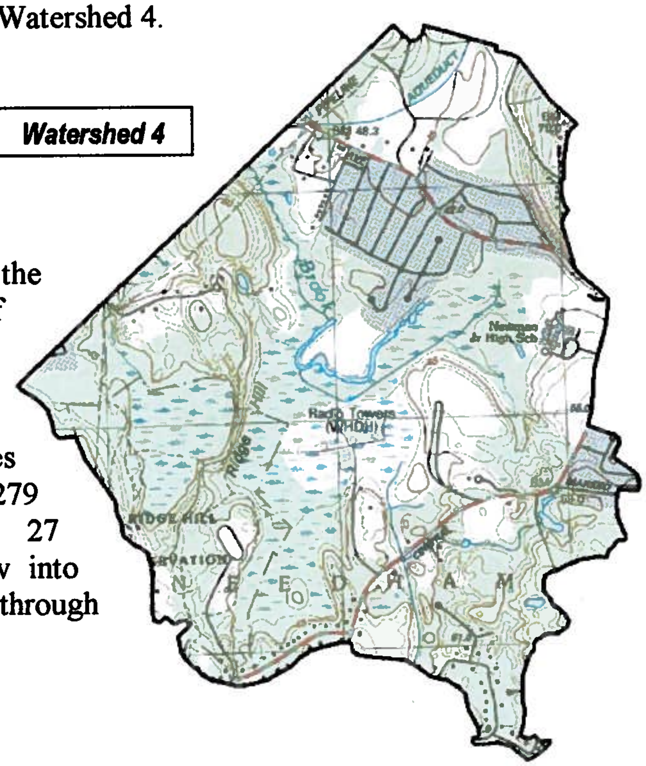


The watershed is approximately 2.4 square miles and includes 29.6 linear miles of pipe, 1,331 municipal catch basins and approximately 33 discharge points or outlets. All discharges flow to Rosemary Brook, through Wellesley and eventually to the Charles River.

Watershed 3 contains the most diverse land use characteristics of the four major watersheds. The area has a variety of commercial, residential and institutional uses, while also serving as the seat of local government. Needham Junction is located at the southern most point of the watershed.

Major surface water bodies in Watershed 3 include Wellesley Water Works and Rosemary Lake, which are connected by Rosemary Brook. A major wetland area, bisected by Rosemary Brook, is also located in the vicinity of these water bodies. North Hill, the highest elevation in Town, is located at the junction of Central Street and Forest Street, bordering Watershed 4.

Watershed 4



Watershed 4 - Interior B

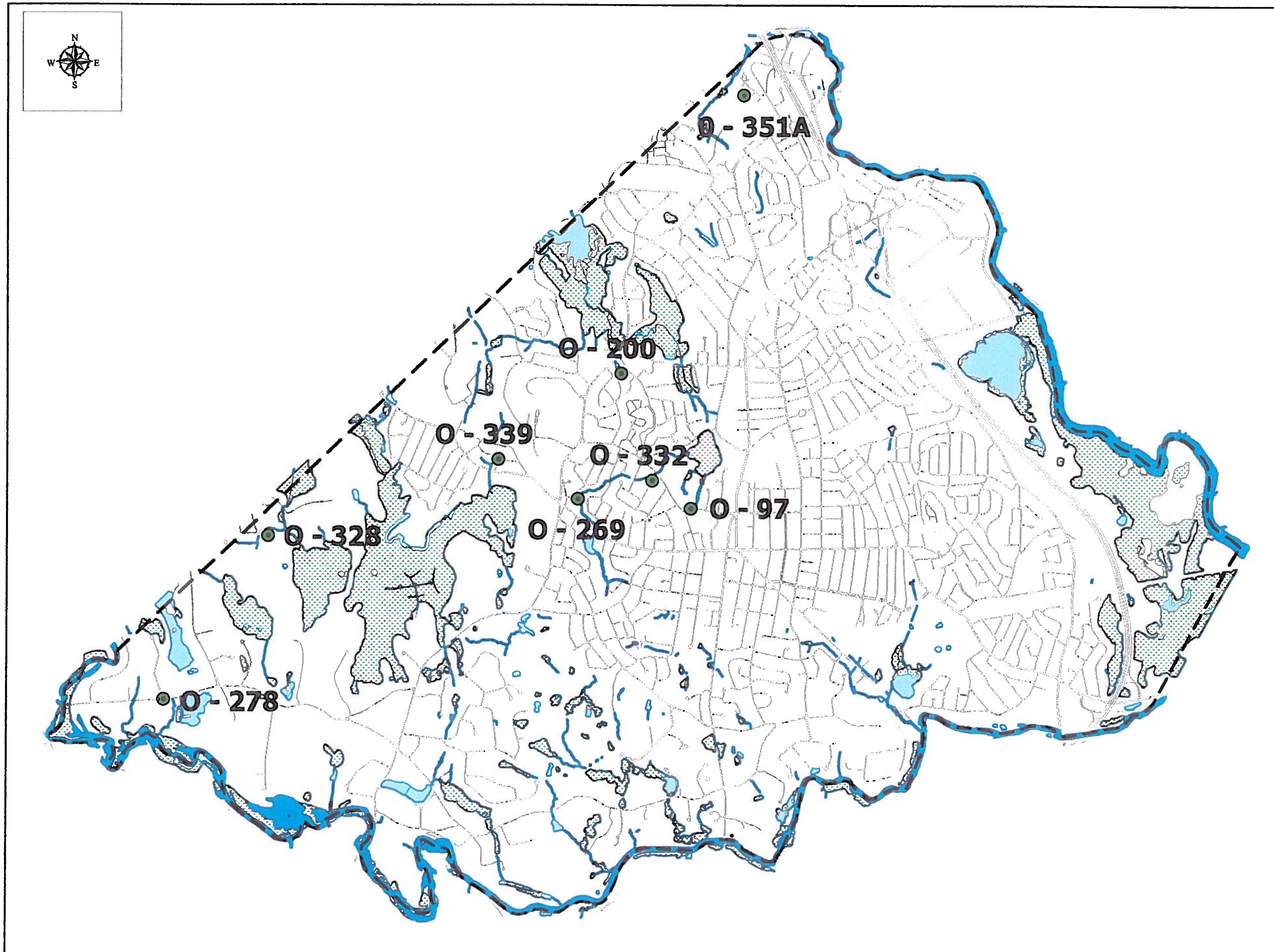
The "Interior B" Watershed is located along the Town's western boundary with the Town of Wellesley and is bounded to the south and east by Watersheds 2 and 3.

The watershed is approximately 2 square miles and includes 6.3 linear miles of pipe, 279 municipal catch basins and approximately 27 discharge points or outlets. Discharges flow into wetland areas associated with Fuller Brook, through Wellesley and eventually to the Charles River.

The area is characterized by wetlands and open space (Ridge Hill Reservation) with limited residential development.

One residential neighborhood can be found along Great Plain Avenue north of Fuller Brook, which constitutes the majority of the development in this watershed. The Newman School is also located in this area along Central Avenue.

3



Storm Water Master Plan
Needham, Massachusetts

Figure 3-1
Follow Up
Sampling Locations

4

SECTION 4
DRAINAGE SYSTEM ASSESSMENT

4.1 Categorization Criteria

Upon completion of the drainage system database, the next phase of the project involved establishing criteria for classifying the drainage system pipes into specific categories. Pipe categorization involves a ranking process to enable prioritization and program planning to be accomplished on a system-wide basis. The following criteria are typically used to categorize pipes:

- Category A (Critical) – Chronic areas of flooding identified by the Town, effect of failure on surrounding environment would be great, cost of repair or replacement after failure would be high.
- Category B (Less Critical) – Effects and cost of failure are less than those for Category A, but preventative action would still be cost effective. Pipe diameters 18-are inches or larger and not included as a Category A pipe.
- Category C (Non-Critical) – Little or no environmental effects. Preventative action is not cost effective unless numerous failures occurred within a confined area. Pipes less then 18-inches in diameter, all unknown pipe diameters and pipes not identified as Category A or B.

All the required data elements to categorize pipes were incorporated into one database and linked to the Drain Coverage. This relationship allows pipes to be analyzed based on the set criteria and then categorized. Although the categorization criterion was established, only Category A designations were included in the hydrologic/hydraulic modeling efforts of this project.

Based on the above criteria the following pipe lengths were determined:

- Category A – 44,812 linear feet (main line only)
- Category B – 78,007 linear feet (main line only)
- Category C – 417,326 linear feet

An overall pipe categorization figure is included in the Appendix.

4.2 Hydrology and Hydraulics Methodology

Model Selection and Data Sources

A hydrologic/hydraulic modeling program was used to determine peak flow rates and estimate the capacity of the Category A drains to allow identification of capacity deficiencies within the system. After several models were reviewed by BETA Group, Inc. and the Town, it was determined that the Storm Water Management Model (SWMM) Version 4.4GU would best fit the needs of the Town. The program is accepted by many federal and state agencies. SWMM was developed by the University of Florida in cooperation with the United States Environmental Protection Agency. For this project, a variation of the SWMM program known as PCSWMM was used. PCSWMM developed by Computational Hydraulics International (CHI) and includes a Windows® and Geographic Information System (GIS) interface which was used for the modeling. The program utilizes the EPA SWMM program as the computational engine; however, it simplifies data input and provides enhanced data output that works with the Town's GIS data elements. A detailed discussion of the SWMM program is given in the user's manual included with the program.

All drainage pipes have been classified as Category A, B or C. Category A pipes, considered critical in nature, were defined by the Town based on historical flooding experiences and were evaluated to determine anticipated flow rates and hydraulic capacity. Pipe geometry and material, and watershed size, soil types and land use were obtained from GIS databases developed as part of this project. When the input data describing the existing system was entered into SWMM, the program was able to rapidly calculate the hydraulic characteristics at the indicated time steps. When necessary input data was not available, values were estimated or assumed based on available record drawing information. It should be noted that the record drawing information provided by the Town varies from the early 1900's to present day. There is a direct correlation between the accuracy of the model and the accuracy of the input data (typical of computer models). The output, which includes the magnitude of pipe surcharging or flooding and the period of time that surcharging or flooding occur, was to evaluated to determine locations within the system that lack sufficient pipe capacity.

SWMM Modules

PCSWMM consists of six modules: Rain, Temperature, Runoff, Transport, Extran and Storage Treatment. Each module has a specific purpose as described below. (A detailed description of each module can be found in the SWMM Manual.)

- Rain – Generates a precipitation interface file that may be input into Runoff by reading a series of precipitation records and performing a storm event analysis.
- Temperature – Generates an interface file for Runoff including temperature, evaporation and wind speed data.

- Runoff – Generates surface and subsurface runoff based on arbitrary rainfall and/or snowmelt hyetographs, antecedent conditions, land use, and topography. Also routes flows and pollutants through the drainage system.
- Transport – Simulates routing of flows and pollutants through the drainage system, estimates dry weather flow and infiltration, and allows for internal storage of flows.
- Extran – Simulates routing of flows (not pollutants) through the drainage system. Extran is more sophisticated than the Transport module because it accounts for conditions such as backwater, looped connections, surcharging, and pressure flow.
- Storage Treatment – Simulates routing of flows and pollutants through a dry-weather or wet-weather storage/treatment plant.

Each drainage system that was modeled has specific characteristics and requirements. Therefore, a certain combination of modules must be used to meet the specific needs of each system. Each module uses an interface file that contains supplemental information and allows the modules to interact with each other. After careful review and based on previous experiences, it was determined that the Runoff and Extran modules would provide the required data and most reliable results. A brief description of these modules is given below.

Runoff

Runoff utilizes precipitation data to simulate the surface flow from a rain event through the inlets (catch basins) and conduits (pipes). Quality and quantity flow routing can be simulated in this module. In this block of SWMM, a user-defined hyetograph can be input to represent the precipitation. For this project, a ten year, twenty-four hour design storm for the Boston area was used to generate a composite hyetograph designated as number one. This hyetograph was input as part of the Runoff module.

There are many different variables that are manipulated in Runoff depending on the study area and the system characteristics. Some of the values of these variables can be determined at the onset and held constant throughout the modeling. Table 4-1 shows these variables and their values.

Channel/pipe characteristics are also entered into PCSWMM. This data was unique to each system that was modeled. The input data depicts the pipe configuration and characteristics of the pipes including inverts, length, material, and the presence of weirs. The necessity of some of the information is dependent on the type of channel or pipe. This input data can be viewed as part of the output from Runoff.

Table 4-1
Runoff Variables – Constant Throughout Simulation

Variable	Value
Simulation Time Period	
Starting	0 hrs 0 mins
Starting date of Storm	1/1/99 (arbitrary)
Wet time step (sec) – Precipitation occurring on any subcatchment	60
Transition time step (sec) – no precipitation, but water remaining in surface storage	300
Dry time step (sec) – no precipitation, or surface storage	900
Snowmelt Simulation	Not Simulated
Evaporation	Default Evaporation Rate
Unit	U.S. Units
Infiltration equation for all subcatchments	Green-Ampt

Any watershed (subcatchment) that contributes overland flow to an inlet must be represented in Runoff. Runoff is the only module that allows subcatchment characteristics to be input. Some of the variables describe the subcatchment and are unique to each system while some are constant throughout the simulation. There are also several variables that depend on soil classification, which was derived from the Soil Conservation Service. Variables that are constant throughout the simulation and soil dependent variables are depicted in Table 4-2.

When Runoff is executed, hydrographs for each inlet and summary tables for the subcatchments and channel/pipes are produced. The subcatchment summary table includes a small portion of the input characteristics and the runoff depth and peak flow rate. Flow and velocity results, as well as surcharging information, are given in the channel/pipe table.

Runoff can also be executed to incorporate water quality as well as quantity. That portion of the Runoff module was not utilized for this project. Runoff does not account for backwater or surcharging and is only a rough estimate of what is actually happening in the system. For this particular project, Runoff was utilized to simulate overland flow from the subcatchments. Very few conduits were actually modeled in Runoff. If a subcatchment was represented in Runoff and the conduit where it discharges was not, Runoff stored a hydrograph to represent the subcatchment. This Runoff file was used as the interface file for Extran. For many of the systems, the storm water from the subcatchments is represented in Runoff, but the pipe is represented in Extran to allow for backwater and surcharging effects.

Table 4-2
Subcatchment Characteristics

Variable	Description		Value
Hyeto#	Number of hyetograph representing precipitation		1
Imp'n'	Impervious area Manning's roughness coefficient		0.014
Per'n'	Pervious area Manning's roughness coefficient		0.27
Istore	Impervious area depression storage		0.05
Pstore	Pervious area depression storage		0.2
Coeffl	Average capillary suction		
		Soil type A	8
		Soil type B	10
		Soil type C	10
		Soil type D	7
Coeff2 –	Saturated hydraulic conductivity of soil		
		Soil type A	6
		Soil type B	4
		Soil type C	1
		Soil type D	0.6
Coeff3 -	Initial moisture deficit for soil		
		Soil type A	0.23
		Soil type B	0.21
		Soil type C	0.15
		Soil type D	0.11

Extran

Extran simulates flow routing through a network. Extran can simulate looped networks, represent the effects of backwater and surcharging, depict alternative hydraulic elements (orifices, pumps, or weirs), determine dry weather flow and infiltration, and incorporate storage routing. As in Runoff, there are variables in Extran where values can be chosen to remain constant throughout the simulation. These values are shown in Table 4-3.

Table 4-3
Extran Variables – Constant Throughout Simulation

Variable	Value
Computational Control	
Starting Time of Simulation (hr)	0
Time Step (sec)	1
Number of Time Steps	8,640
Number of Iterations	30
Allowable Error for Convergence	0.05
Simulation and Print Control	
First Time Step to Begin Print Cycle	1
Print Interval During Simulation	360
Print Interval at End of Simulation	360
Modify Short Pipe Lengths	Yes

The input data for channels or conduits depicts pipe configuration and describes the pipe type, slope, inverts and length. The junction data includes structure inverts and rims as well as outfall characteristics. A constant flow can also be input as part of the junction data.

To be executed properly, Extran requires an interface file containing hydrograph information. When Extran is executed, it produces plots denoting the head in the junctions and the flow in the conduits along with summary tables for each of the structures. The junction summary table includes storm water flow elevation and surcharging and flooding duration. The conduit summary table includes storm water flow and velocity results.

Since Extran accounts for backwater and surcharging, it more accurately represents conditions occurring in the system, although it should be noted that this is still only a model of the actual system and a number of assumptions had to be made to execute SWMM.

4.3 Hydraulic Analysis

The major problem areas, Category A, were modeled using the Runoff and Extran modules of SWMM. Runoff was utilized to calculate the watershed runoff that contributes directly to the system and to branches of the system, which feed into the main line. The majority of the Category A pipes were modeled in Extran, so the dynamics of the system including surcharging and flooding could be fully analyzed.

Hydraulic models are used as a planning tool to analyze and identify deficiencies within the existing drainage system. The recommendations provided here were developed on the basis that the only variable between the existing conditions and the proposed recommendations would be the pipe size. Therefore, rim and invert elevations were held to the existing elevations. However, because many of the existing systems are shallow and have insufficient cover over the pipes, rim elevations were adjusted to allow the models to execute.

Issues related to required cover over pipes and utility conflicts will need to be addressed during the detailed design process when more accurate information, based on field survey data, would be available.

A total of eleven Category A storm water systems were modeled for the Town of Needham, as shown in Figure 4-1. The results of the hydraulic analysis are included in the Appendix. The following paragraphs contain brief descriptions and recommendations for each of the problem areas.

Area 1 – Bradford Street

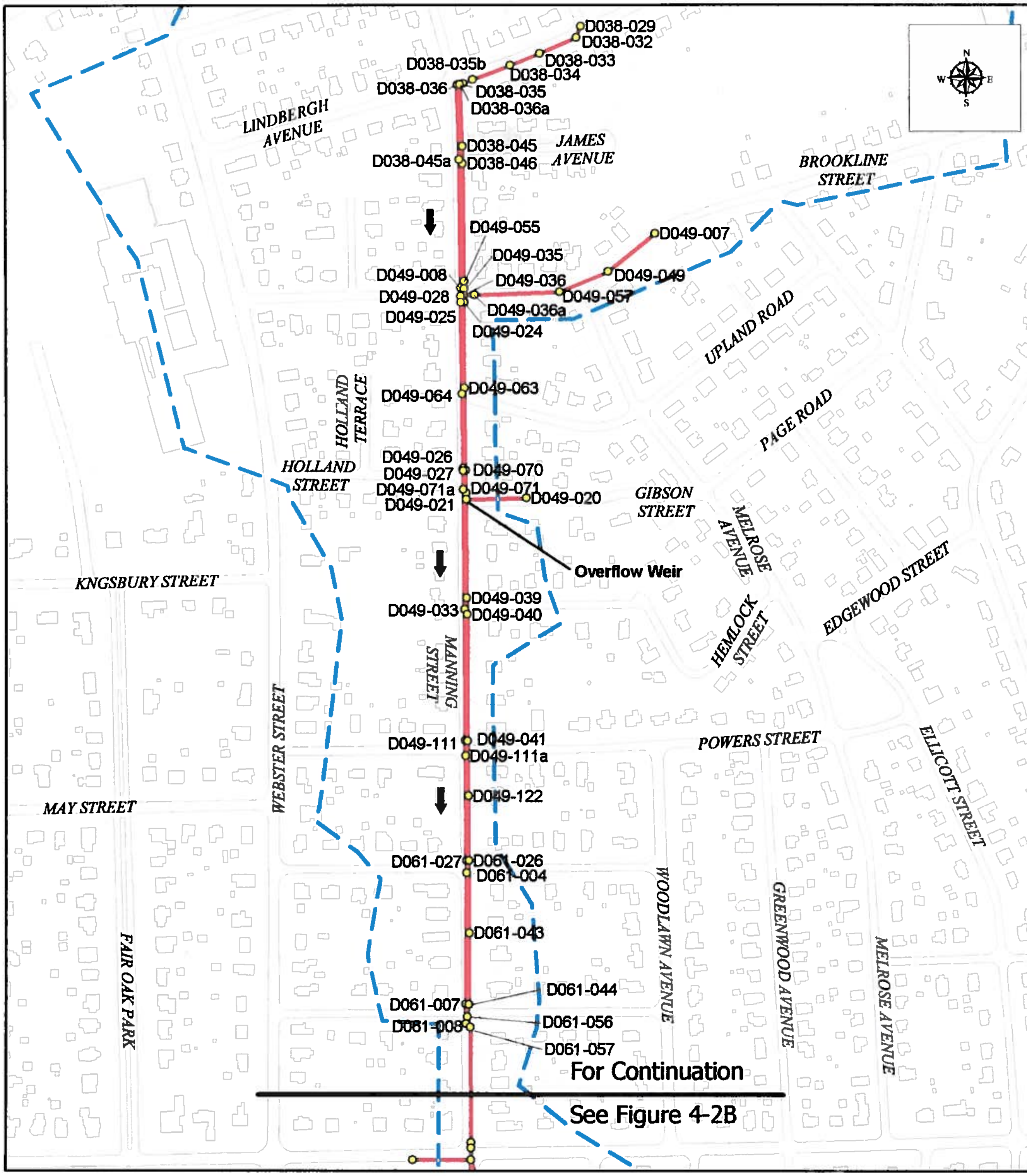
Description

Area 1 is located in the northern portion of Needham. A graphical representation of the watershed and Category A pipe system is shown in Figures 4-2A and 4-2B. The watershed is approximately 150 acres and contains two separate 42-inch discharge points, which direct

Storm Water Master Plan

Needham, Massachusetts

Figure 4-1
Overall Drainage System



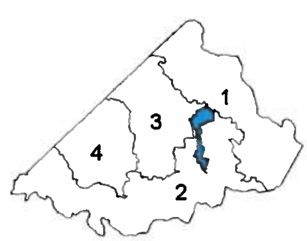
Legend

Modeled Pipes
Watershed Boundaries
Modeled Nodes
Flooding Nodes

125 0 125 250 Feet

BETA Group, Inc.

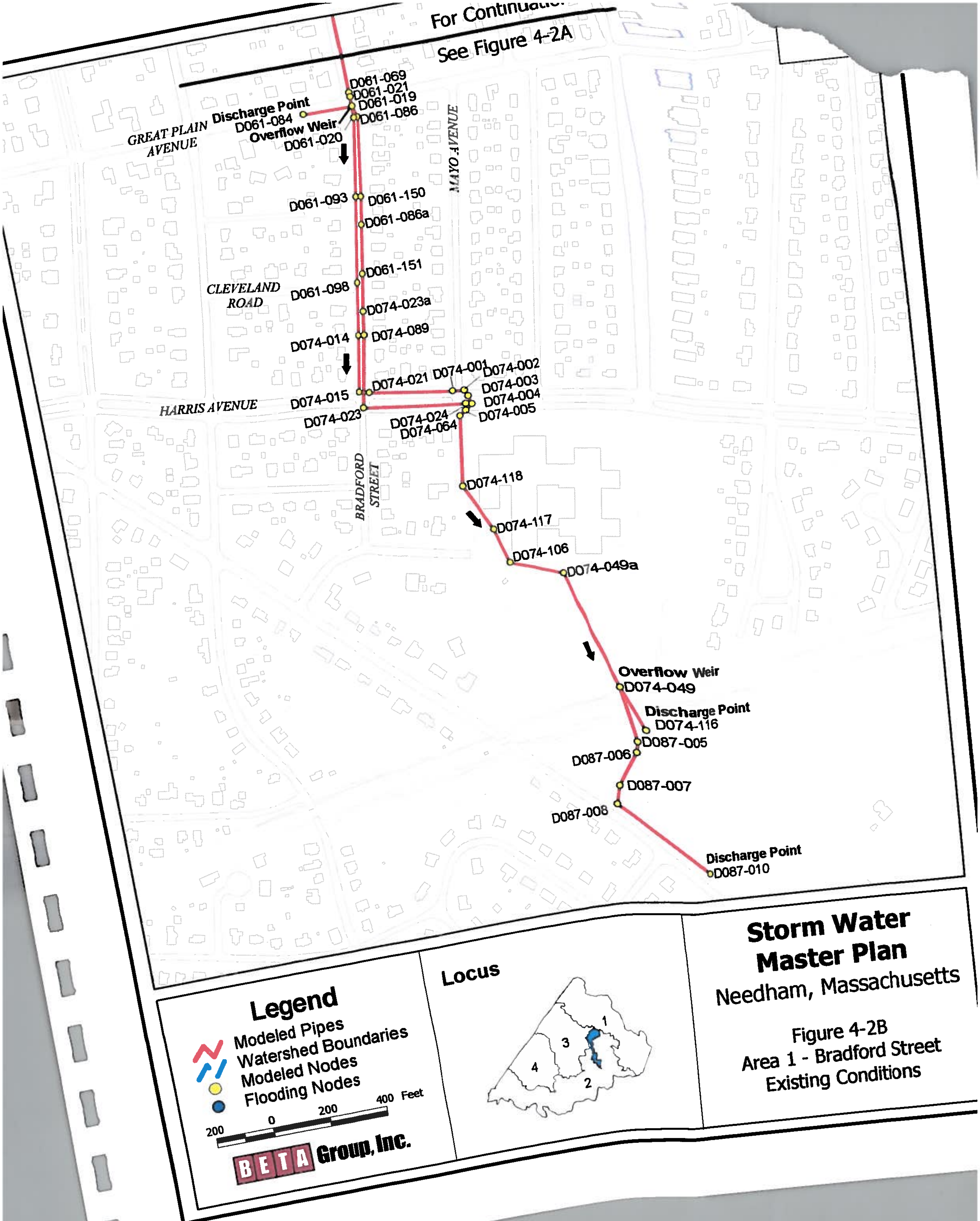
Locus



Storm Water Master Plan

Needham, Massachusetts

Figure 4-2A
Area 1 - Bradford Street
Existing Conditions



Storm Water Master Plan

Needham, Massachusetts

Figure 4-2B
Area 1 - Bradford Street
Existing Conditions

storm water flow to an unnamed brook. The hydraulic model includes 9,950 of the 25,700 linear feet of pipe within the watershed.

The first discharge is located in the Pollard Middle School area (D074-116) and the second is in the Defazio Complex adjacent to Dedham Avenue (D087-010). Outfall D074-116 was considered to be a free outfall with no constant water elevation and D087-010 was given an initial depth of 0.5 feet. The peak discharge for a 10-year design storm is 56.6 cfs for D074-116 and 29.3 cfs for junction D087-010 and. The following overflow structures have been represented by a sharp-crested, side flow weir: D038-036a, D049-036, D049-021, D061-019, and D074-049.

This system is comprised of two parallel pipes, which flow from Lindbergh Avenue south to Harris Avenue. The record drawings that depict these mainline pipes are inconsistent and it is difficult to determine what the actual connections between the two pipes are. The size and complexity of this system coupled with inconsistent record information made it difficult to run the model without making numerous assumptions.

Problem

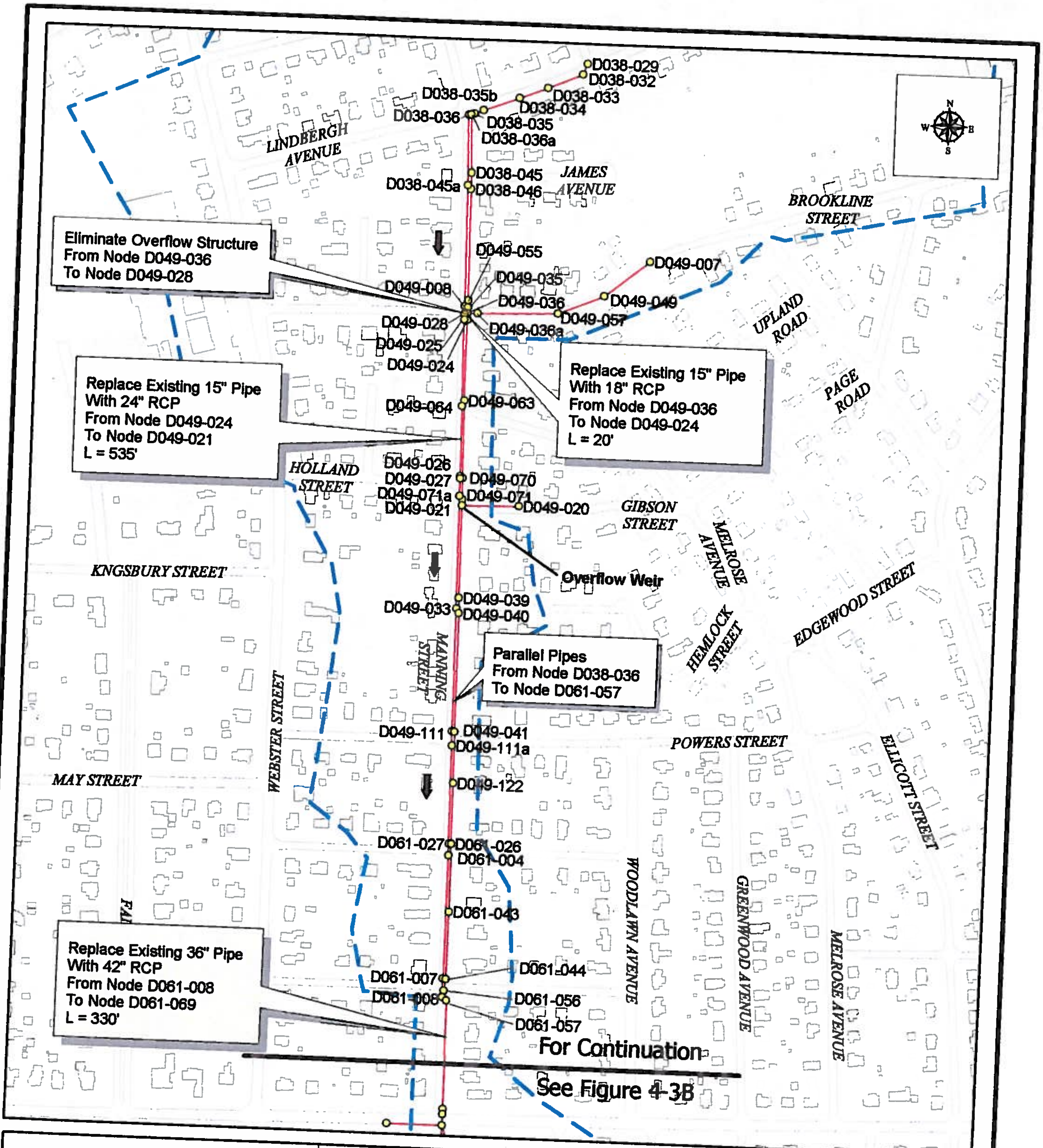
The results of the hydraulic model show that many of the pipes surcharge and some of the nodes flood. There appears to be flooding problems at the intersection of Brookline Street and Manning Street. Several pipes enter the 15-inch mainline at this point and there is an overflow structure which flows to the 30-inch parallel pipe at node D049-036. The pipe connecting D049-036 to D049-024 seems to be a restriction in this area. The model also indicates flooding at the beginning of the system at node D038-029. A large area discharges to this structure. The flooding at this junction may be due to the large amount of runoff entering the model at this individual point. There also seems to be a flooding problem at the intersection of Otis Street and Manning Street. The two parallel trunk lines converge at this point and the 36-inch pipe has a slope of only 0.0047 ft/ft along this portion of the system. The capacity of the pipes in this area is not sufficient to convey the flow for the ten year design storm.

Recommendations

Recommended improvements are shown in Figures 4-3A and 4-3B and consist of the following:

- Replace 20 feet of 15" pipe with 18" pipe from node D049-036 to D049-024.
- Replace 535 feet of 15" pipe with 24" pipe from node D049-024 to D049-021.
- Eliminate overflow structure at node D049-036.
- Replace 330 feet of 36" pipe with 42" pipe from node D061-008 to D061-069.

Based on recommended improvements, the model indicates that surcharging would be reduced. Flooding would also be reduced to less than one minute throughout most of the



Legend

- Modeled Pipes
- Watershed Boundaries
- Modeled Nodes
- Flooding Nodes

125 0 125 250 Feet

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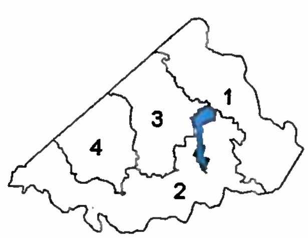
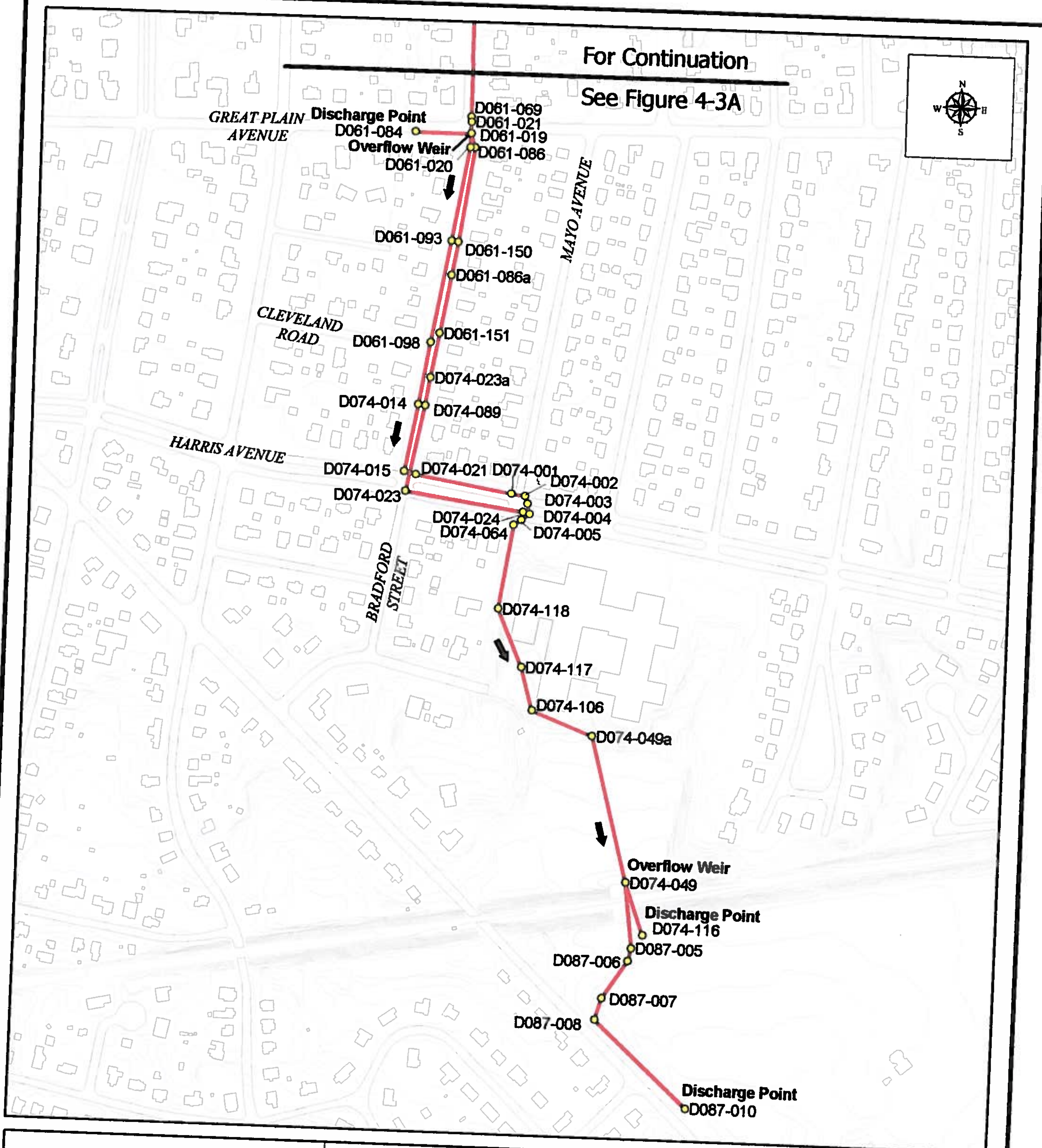
Locus



Storm Water Master Plan

Needham, Massachusetts

Figure 4-3A
Area 1 - Bradford Street
Recommendations



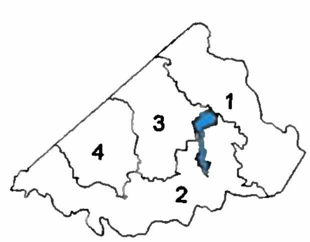
Legend

- Modeled Pipes
- Watershed Boundaries
- Modeled Nodes
- Flooding Nodes

200 0 200 400 Feet

BETA Group, Inc.

Locus



Storm Water Master Plan

Needham, Massachusetts

Figure 4-3B
Area 1 - Bradford Street Recommendations

system. The peak discharge would increase from 56.6 to 66.8 cfs at node D074-116 and from 29.3 to 33.9 cfs at node D087-010.

The increase in peak discharge would require mitigation improvements at the point of discharge during the final design process. Typical improvements include installation of riprap or construction of stone check dams to protect against erosion.

Area 2 – Carey Road

Description

Area 2 is located in the central portion of Needham. A graphical representation of the watershed and Category A pipe system is shown in Figure 4-4. The 68-acre watershed discharges east of Hillside Avenue through a 2-foot by 2-foot stone culvert to an unnamed tributary of the Charles River. The hydraulic model includes 3,910 of the 8,700 linear feet within the watershed.

The peak discharge is 8.7 cfs for a 10-year design storm event. A tailwater depth of 6 inches was assumed at the culvert for modeling purposes.

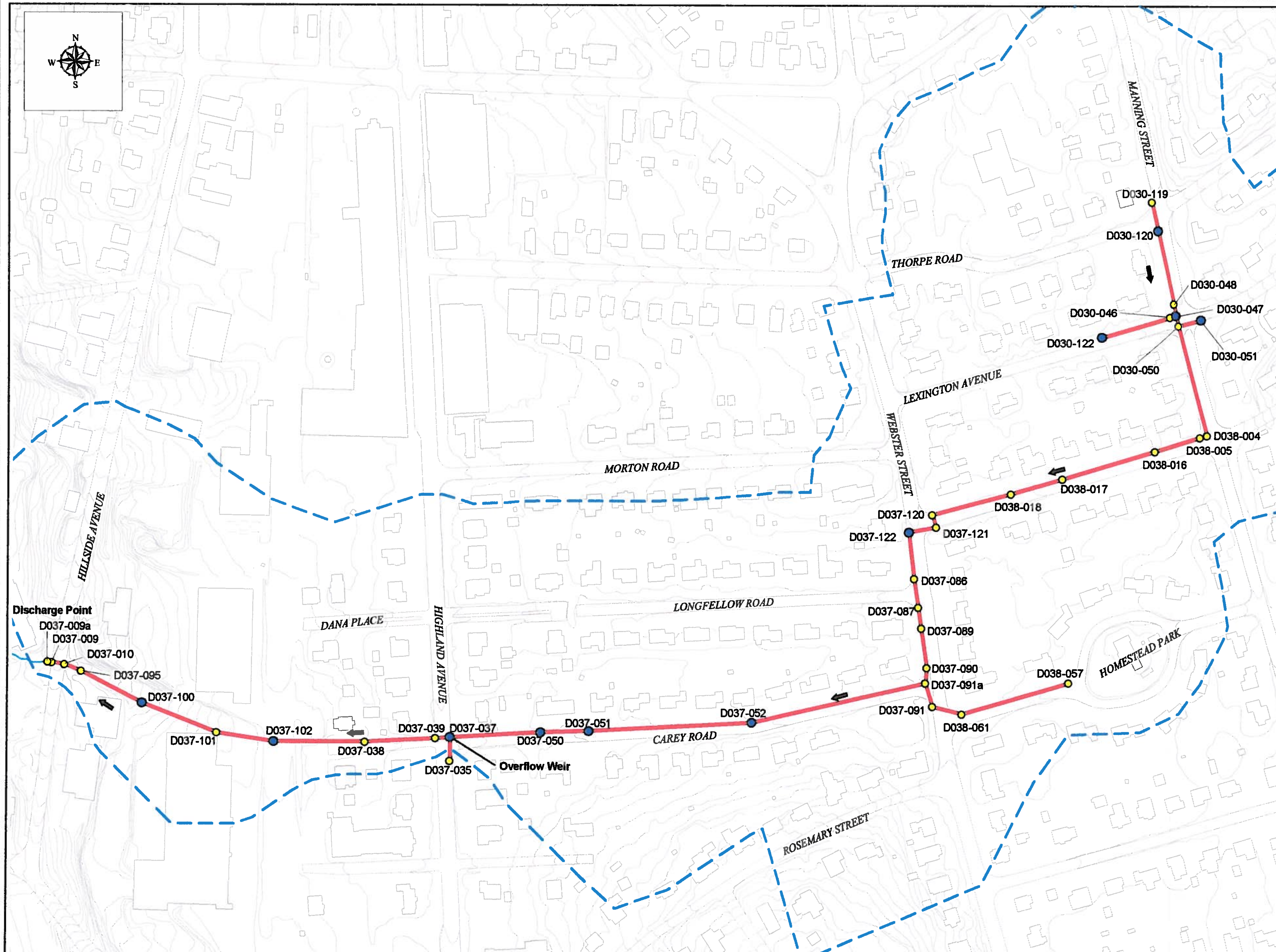
Information depicting the outfall located on the eastern side of Hillside Avenue was not available in the record drawings provided by the Town. Based on a field inspection, the outfall was estimated to be a 2-foot by 2-foot granite culvert. For modeling purposes, if necessary information was not available, the characteristics of the system were assumed using available pipe and manhole information.

Structure D037-037 acts as an overflow structure. The mainline from Carey Road is a 20-inch pipe that leads into a 12-inch pipe along Carey Place. The overflow pipe is a 24-inch pipe, which continues south on Highland Avenue. The overflow is represented by a sharp-crested, side flow weir that discharges to the 24-inch pipe. Only one length of pipe for the system along Highland Avenue was depicted in the model. Structure D037-035 was designated as a free outfall.

Problem

The results of the hydraulic model show that many of the pipes surcharge and flood during the design storm event. The only junctions that do not surcharge are D037-009, D037-010, D037-038, D037-035, and D037-101. Certain isolated areas along Carey Road, D037-050, D037-051 and D037-052 seem to show flooding for at least 25 minutes.

On Manning Street, between Thorpe Road and Lexington Avenue, D030-047 and D030-120 flood for 75 and 55 minutes, respectively. Lexington Avenue has two systems entering the mainline on Manning Street, one from the east and one from the west. Only one length of pipe was modeled to represent these systems. The structures depicting the start of these systems (D030-051 and D030-122) also flood for about 75 minutes. Record Drawing 76 depicts the system along Manning Street. The 10-inch pipe connecting D030-048 and D030-047 (D037-048:D037-047) flows from elevation 289.13 to 289.25. SWMM will not accept a negative slope, so this pipe was represented with a minimal slope (0.0001 ft/ft).



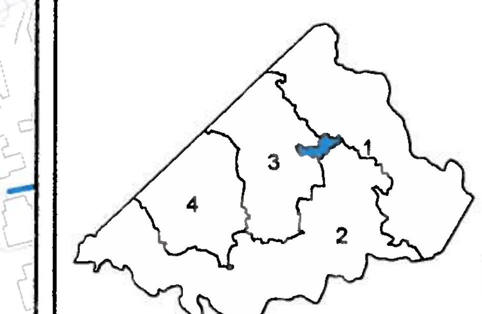
Legend

- Modeled Pipes
- Watershed Boundaries
- Modeled Nodes
- Flooding Nodes

100 0 100 200 Feet

BETA Group, Inc.

Locus



Storm Water Master Plan

Needham, Massachusetts

Figure 4-4
Area 2 - Carey Road
Existing Conditions

This pipe seems to be the restriction in this area. The size and slope of this pipe will not allow the structure to convey the computed flow.

Catch basin D037-122, at the intersection of Hoover Road and Webster Street, also floods for a short period of time. The pipes along Webster Street are all over capacity. This surcharging causes the flooding in that particular structure.

Structure D037-100 between Carey Place and Hillside Avenue floods for an hour. Pipe D037-101:D037-100 has a 14 percent slope and leads into pipe D037-100:D037-010, which has a 6.9 percent slope. Neither of these pipes, or the subsequent pipes, reaches their full capacity. Additionally, there is only 2 feet between the crown of the 12-inch pipe and the rim of the manhole. Based on the physical conditions of the system the flooding appears to be caused by a hydraulic jump in the system.

A hydraulic jump in the system is the result of a sudden change in the velocity of water within the pipe. When the velocity suddenly changes from fast to slow it causes the water level to quickly rise or surcharge within the pipe or manhole. Flooding occurs because the jump is not contained within the pipe system.

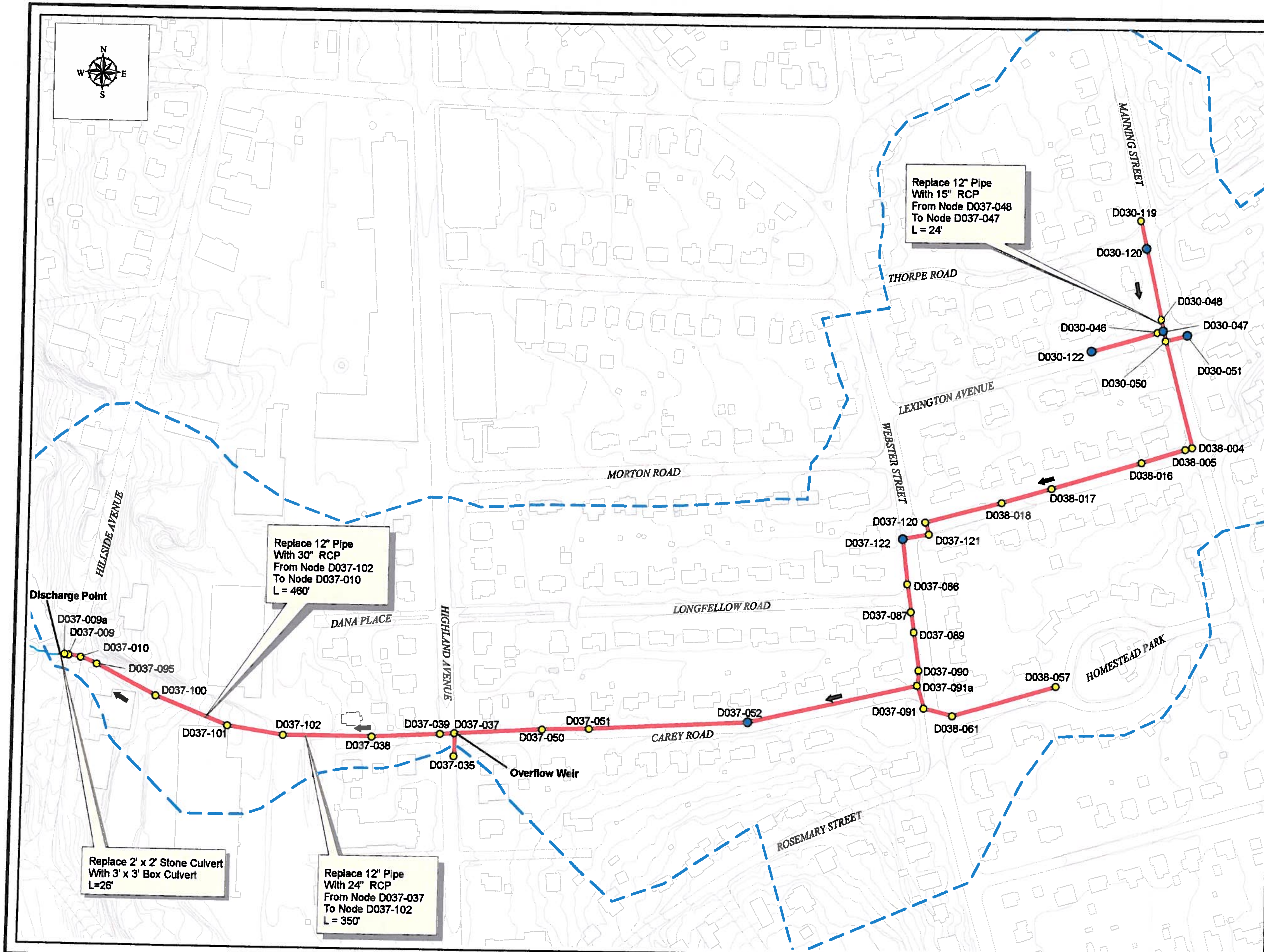
Recommendations

Recommended improvements are shown in Figure 4-5 and consist of the following:

- Replace 24 feet of 10" pipe with 15" pipe from node D030-048 to D030-047.
- Replace 350 feet of 12" pipe with 24" pipe from node D037-037 to D037-102.
- Replace 460 feet of 12" pipe with 30" pipe from node D037-102 to D037-010.
- Replace 26 feet of 2'x2'stone culvert with 3'x3' box culvert from node D037-010 to D037-009a.
- Construct drop-manholes within system from node D037-038 to D037-009a and lower the outfall elevation to accommodate new culvert.

Based on recommended improvements, the model indicates surcharging would be reduced and the flooding would be eliminated. The peak discharge within the system would increase from 8.7 to 74.2 cfs.

The increase in peak discharge would require mitigation improvements at the point of discharge during the final design process. Typical improvements include installation of riprap or construction of stone check dams to protect against erosion.



Legend

Modeled Pipes
Watershed Boundaries
Modeled Nodes
Flooding Nodes

100 0 100 200 Feet

BETA Group, Inc.

Locus

Storm Water Master Plan
Needham, Massachusetts

Figure 4-5
Area 2 - Carey Road
Recommendations

Area 3 – Fuller Brook Avenue

Description
Area 3 is located in eastern Needham. A graphical representation of the watershed and Category A pipe system is shown in Figure 4-6. This 53-acre watershed discharges to Fuller Brook through a 30-inch pipe south of Fuller Brook Avenue. The hydraulic model includes 1,215 of the 2,466 linear feet within the watershed.

Problem
The results of the hydraulic model show that there is minor surcharging at junction D034-004 and no flooding within the system. The pipes in this area seem to have enough capacity to convey the runoff from a 10-year design storm.

Town personnel identified problematic flooding in this area due to debris clogging the inlets to the system.

Recommendations
Recommended improvements within this area consist of developing an Operation and Maintenance Program to address problematic flooding areas with periodic inspection of critical inlets in the drainage system.

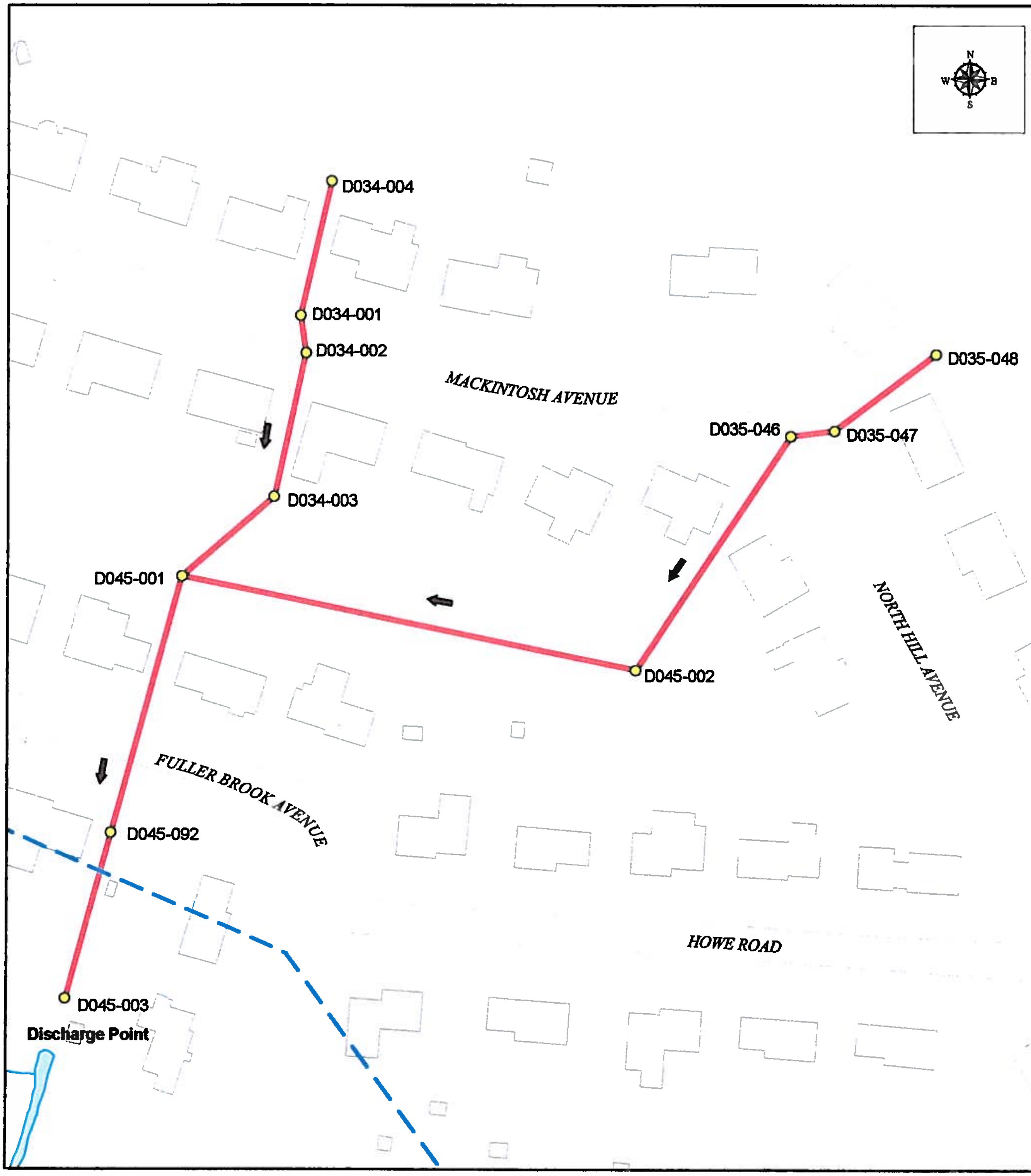
Area 4 – Greendale Avenue

Description
Area 4 is located in the northeastern section of Needham. A graphical representation of the watershed and Category-A pipe system is shown in Figure 4-7. This 119-acre watershed discharges onto state land east of Hunting Road through an assumed 24-inch pipe. The last two sections of pipe from structure D022-042a to D022-058a were assumed, because record information was not available for this area. The hydraulic model includes 3,400 of the 17,900 linear feet of drainage pipe within the watershed.

The peak discharge for this system is 35.24 cfs for a 10-year storm event. This system was assumed to have a free outfall condition. This area was not accessible for field verification because it is contained within the limits of the state highway.

Problem
The results of the hydraulic model show that many of the junctions surcharge and flood within the system during the design storm event. Flooding times range from 30 to 70 minutes for structures. The flooding nodes are shown in Figure 4-7.

The existing drainage system consists of an 18-inch line along Greendale Avenue that connects via a 12-inch line through an easement to an 18-inch line along Hazel Lane, and then changes to a 24-inch line through an easement and across Hunting Road and into the state drainage system.



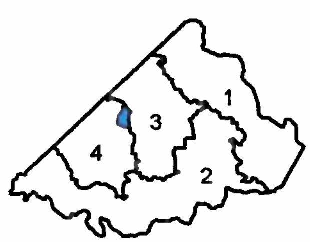
Legend

- Modeled Pipes
- Watershed Boundaries
- Modeled Nodes
- Flooding Nodes

50 0 50 100 Feet

BETA Group, Inc.

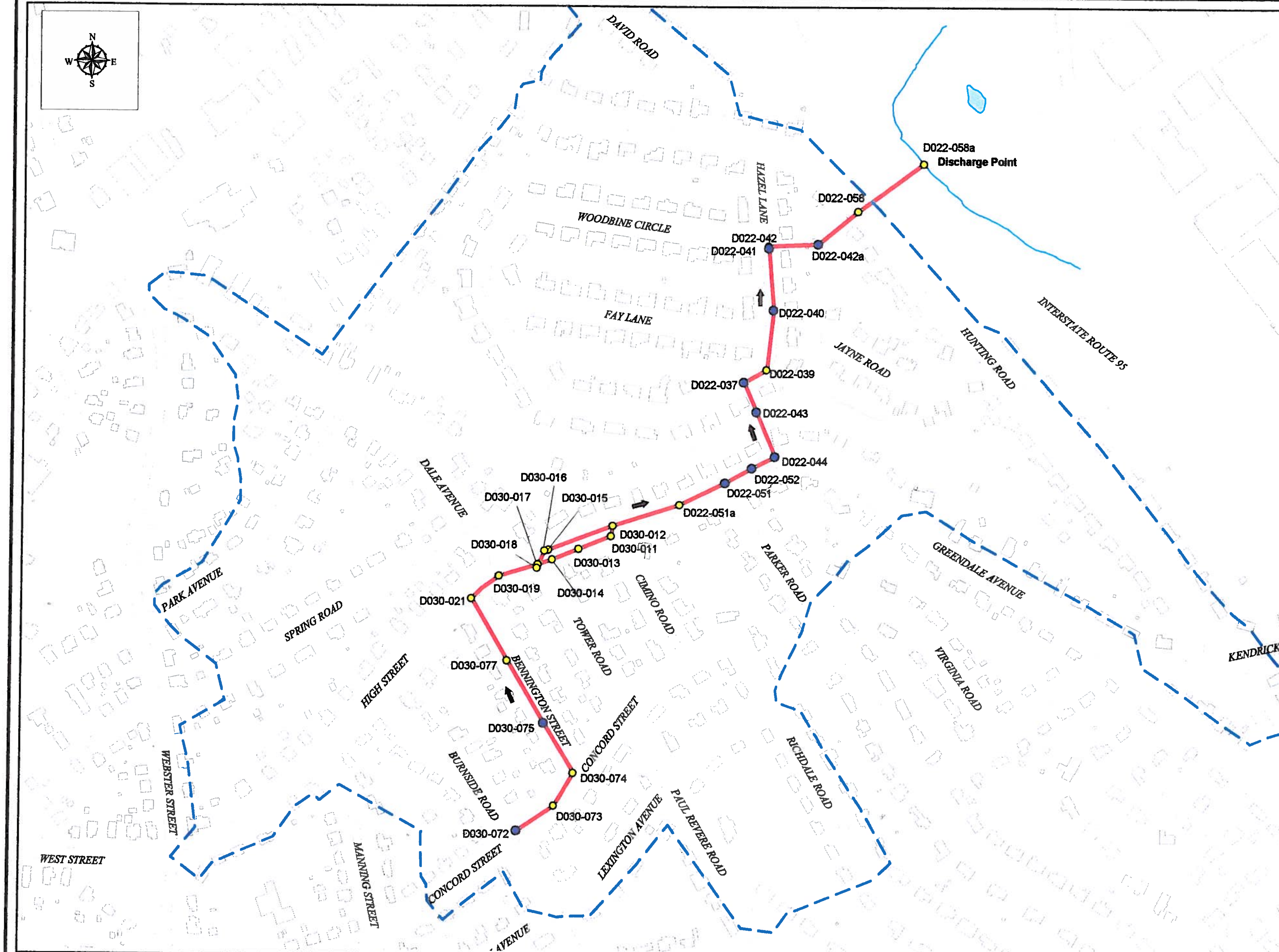
Locus



Storm Water Master Plan

Needham, Massachusetts

Figure 4-6
Area 3 - Fuller Brook Avenue
Existing Conditions



Legend

- Modeled Pipes
- Watershed Boundaries
- Modeled Nodes
- Flooding Nodes

150 0 150 300 Feet

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Locus

Storm Water Master Plan
Needham, Massachusetts

Figure 4-7
Area 4 - Greendale Avenue
Existing Conditions

Along Greendale Avenue, structure D030-017 acts as an overflow structure. The overflow pipe is a 15-inch pipe, which also continues along Greendale Avenue and connects back into the system a node D030-012. For modeling purposes, the overflow is represented by a sharp-crested, side flow weir that discharges to the 15-inch pipe.

Structures D022-037, D022-043, D022-044 and D022-051 all show flooding for 40 to 75 minutes. The 12-inch pipe from D022-044 to D022-043 has a slope of approximately 0.31 ft/ft and flows to a 12-inch pipe with a slope of 0.007 ft/ft. The geometry of the system could result in a hydraulic jump in the system at this point, based on the flatter 12-inch pipe being a restriction in the system.

There are also two low points, one located on Bennington Street (D030-075) and the other at the intersection of Burnside Road and Concord Street (D030-072), which also surcharge and flood during the design storm event.

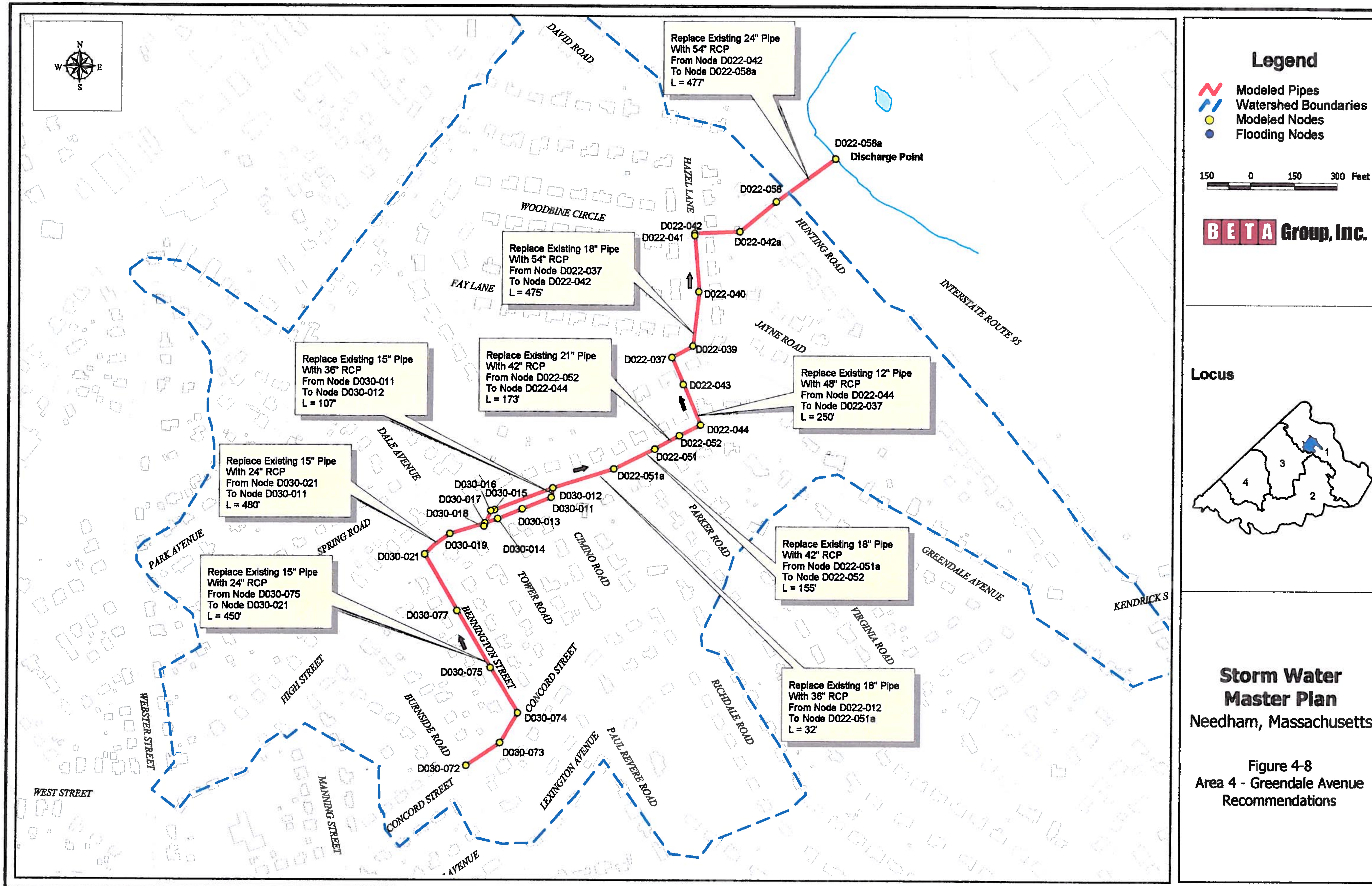
Recommendations

Recommended improvements are shown in Figure 4-8 and consist of the following:

- Replace 450 feet of 15" pipe with 24" pipe from node D030-075 to D030-021.
- Replace 480 feet of 15" pipe with 24" pipe from node D030-021 to D030-011.
- Replace 107 feet of 15" pipe with 36" pipe from node D030-011 to D030-012.
- Replace 32 feet of 18" pipe with 36" pipe from node D030-012 to D022-051a.
- Replace 155 feet of 18" pipe with 42" pipe from node D022-051a to D022-052.
- Replace 173 feet of 21" pipe with 42" pipe from node D022-052 to D022-044.
- Replace 250 feet of 12" pipe with 48" pipe from node D022-044 to D022-037.
- Replace 475 feet of 18" pipe with 54" pipe from node D022-043 to D022-042.
- Replace 477 feet of 24" pipe with 54" pipe from node D022-042 to D022-058a.

Based on recommended improvements, the model indicates surcharging would be reduced and flooding would be eliminated. The peak discharge within the system would increase from 35.24 to 92.59 cfs.

The increase in peak discharge would require mitigation improvements at the point of discharge during the final design process. Typical improvements include installation of riprap or construction of stone check dams to protect against erosion.



Storm Water Master Plan

Needham, Massachusetts

Figure 4-8

Area 4 - Greendale Avenue Recommendations

Area 5 – Great Plain Avenue

Description
Area 5 is located in the eastern portion of Needham. A graphical representation of the watershed and Category A pipe system is shown in Figure 4-9. The 74-acre watershed discharges east through a 12-inch pipe to an unnamed tributary of the Charles River.

The hydraulic model has not been completed due to unavailable information for the pipe system. Rim and invert elevations were missing from the plans provided, Record Drawing 255. In additional, there was not sufficient information to make reasonable assumptions for the missing system data.

The model will be completed upon receipt of additional information from the Town.

Area 6 – High Rock Street

Description
Area 6 is located in the eastern portion of Needham. A graphical representation of the watershed and CategoryA pipe system is shown in Figure 4-10. The 92-acre watershed discharges east of Woodland Drive through a 30-inch pipe to an unnamed tributary of the Charles River.

The overall watershed was divided into two sub-areas, Area 6A and Area 6B as shown in Figure 4-10.

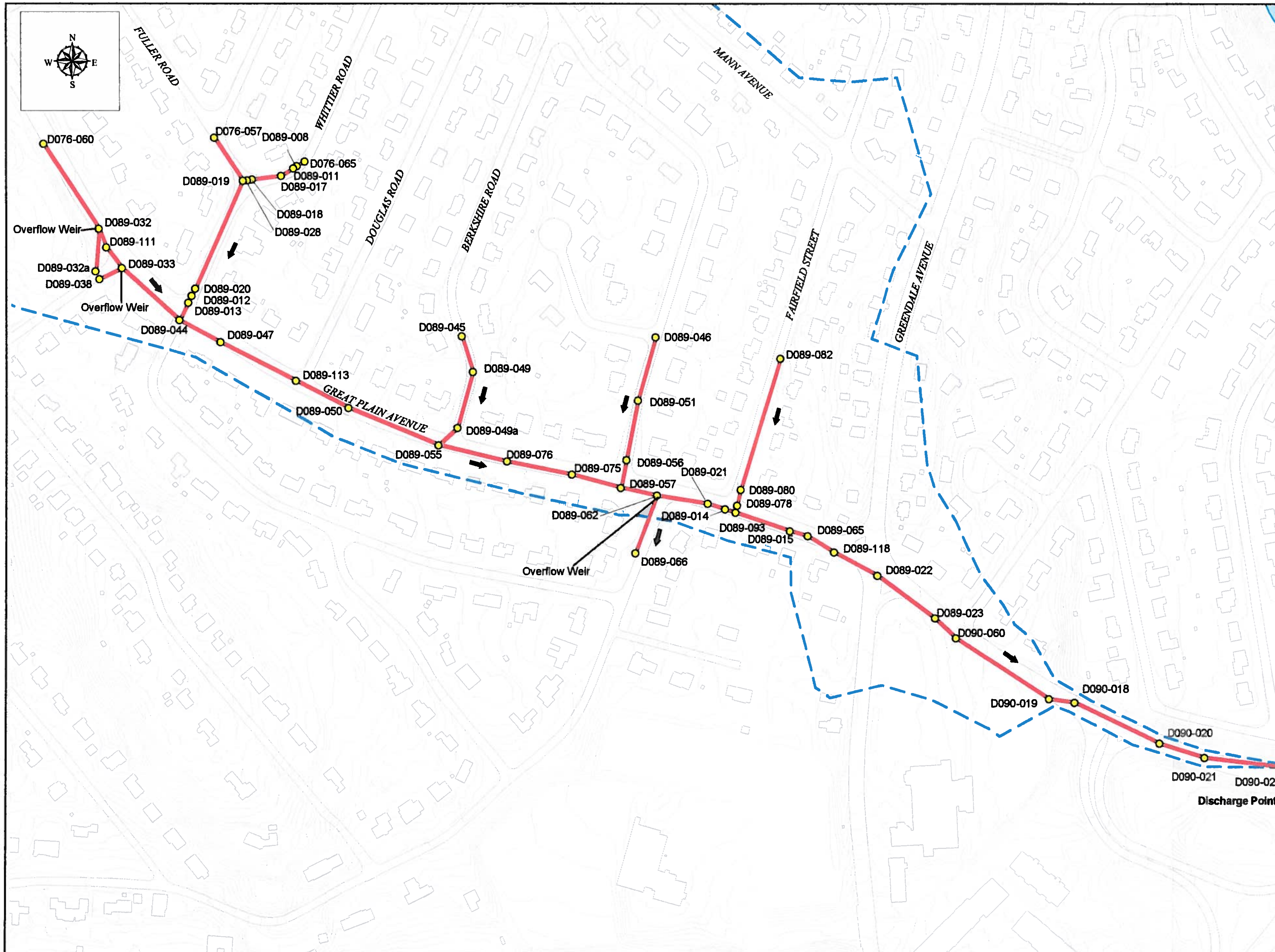
Drainage record information was not available for the pipe system in Area 6A, between Lantern Lane and Fletcher Road, and Area 6B was missing information between High Rock Street and South Street. In addition, the datum elevations differ between record drawings and there are no common structures identified to allow conversion to a common elevation.

Due to the extent of missing data the hydraulic model has not been completed at this time. The model will be completed upon receipt of additional information from the Town.

Area 7 – Mackintosh Avenue

Description
Area 7 is located in the eastern portion of Needham. A graphical representation of the watershed and Category A pipe system is shown in Figure 4-11. The 63-acre watershed discharges east of Mason Road through an 18-inch pipe to Fuller Brook. The hydraulic model includes 1,100 of the 1,700 linear feet of pipe within this watershed.

The peak discharge is 9.21 cfs for the 18-inch pipe for a 10-year storm event. For modeling purposes, a tailwater depth of 6 inches was assumed at the discharge during the storm event.



Legend

- Modeled Pipes
- Watershed Boundaries
- Modeled Nodes
- Flooding Nodes

125 0 125 250 Feet

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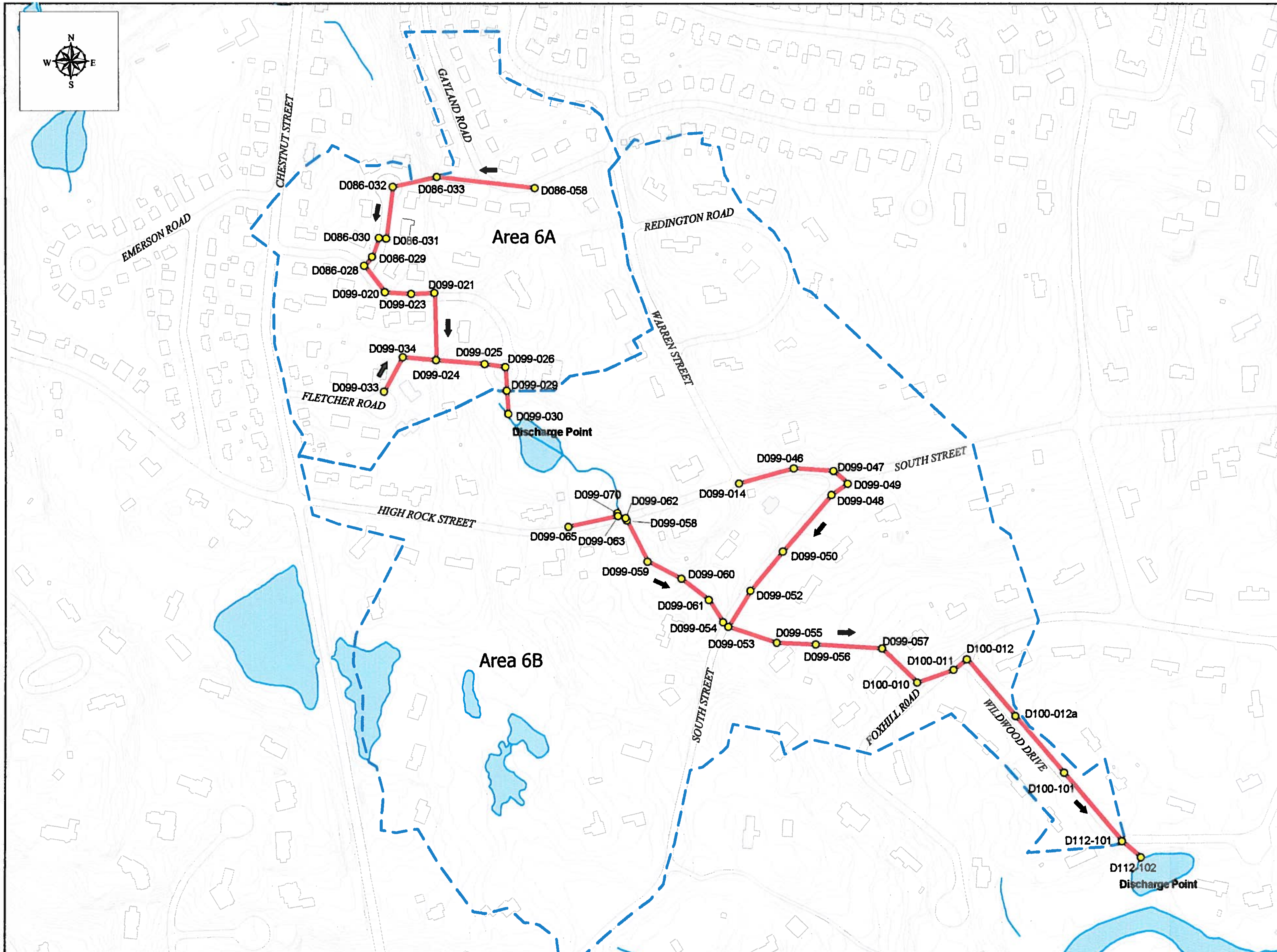
Locus

Storm Water Master Plan

Needham, Massachusetts

Figure 4-9
Area 5 - Great Plain Avenue
Existing Conditions



Legend

- Modeled Pipes
- Watershed Boundaries
- Modeled Nodes
- Flooding Nodes

150 0 150 300 Feet

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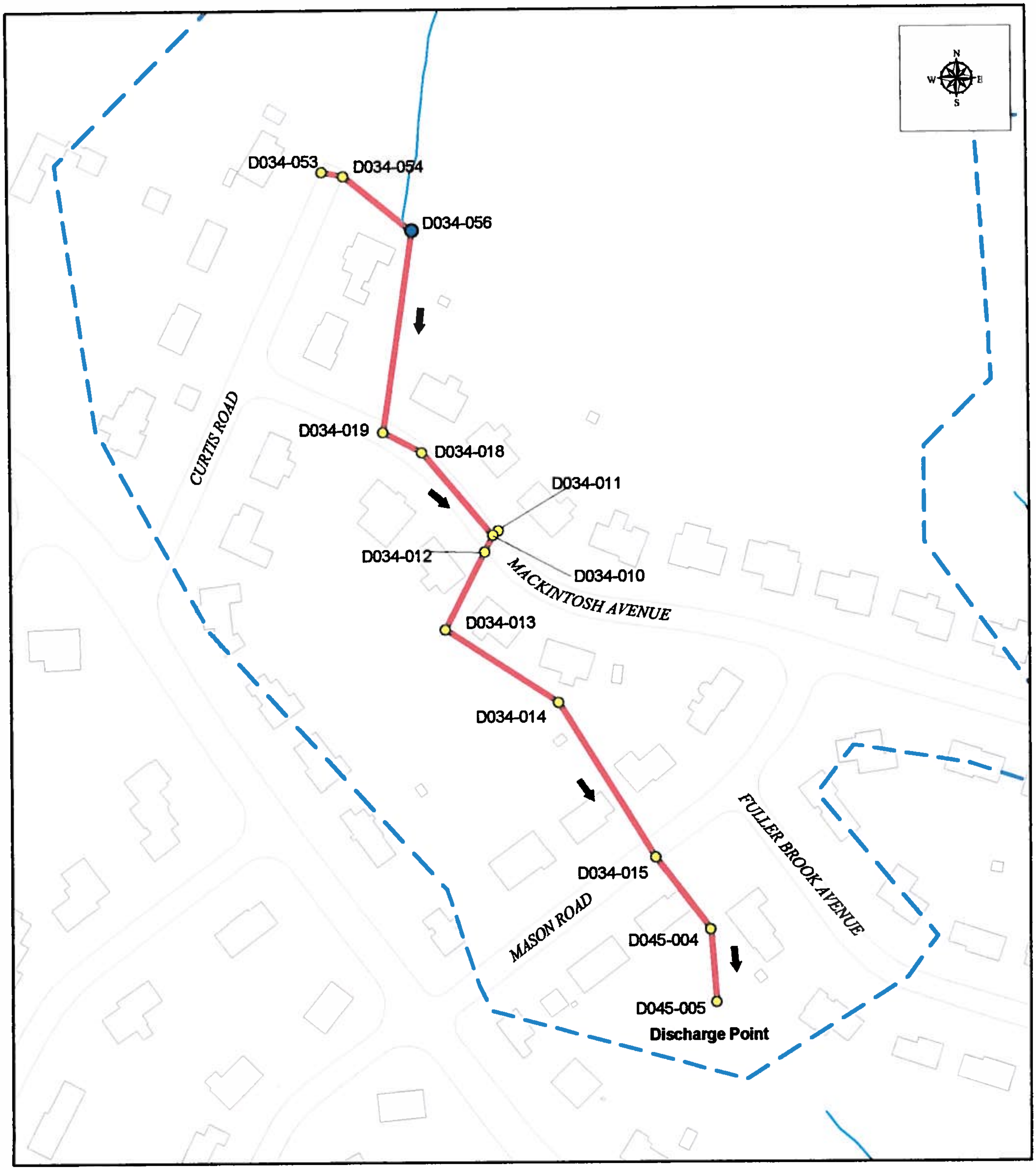
Locus

Storm Water Master Plan
Needham, Massachusetts

Figure 4-10
Area 6 - High Rock Street
Existing Conditions



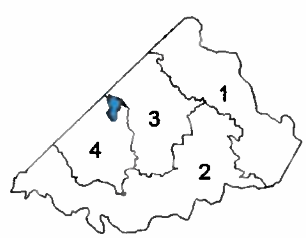
Legend

- Modeled Pipes
- Watershed Boundaries
- Modeled Nodes
- Flooding Nodes

75 0 75 150 Feet

BETA Group, Inc.

Locus



Storm Water Master Plan

Needham, Massachusetts

Figure 4-11
Area 7 - Mackintosh Avenue
Existing Conditions

Problem
The results of the hydraulic model show shows that all of the junctions surcharge for at least 25 minutes during the peak of the storm and junction D034-056 floods for approximately 19 minutes. This junction is located at a low point behind some of the homes on Curtis Road and Mackintosh Avenue. Based on record information, the capacity of the system is limited due to relatively flat slopes ranging from 0.001 to 0.004 ft/ft. across the entire system.

Recommendations
Recommended improvements are shown in Figure 4-12 and consist of the following:

- Replace 325 feet of 15" pipe with 18" pipe from node D034-013 to D034-015.
- Replace 168 feet of 18" pipe with 24" pipe from node D034-015 to D045-005.

Based on recommended improvements, the model indicates surcharging would be reduced and flooding would be eliminated. The peak discharge within the system would increase from 9.21 to 9.8 cfs.

The increase in peak discharge would require mitigation improvements at the point of discharge during the final design process. Typical improvements include installation of riprap or construction of stone check dams to protect against erosion.

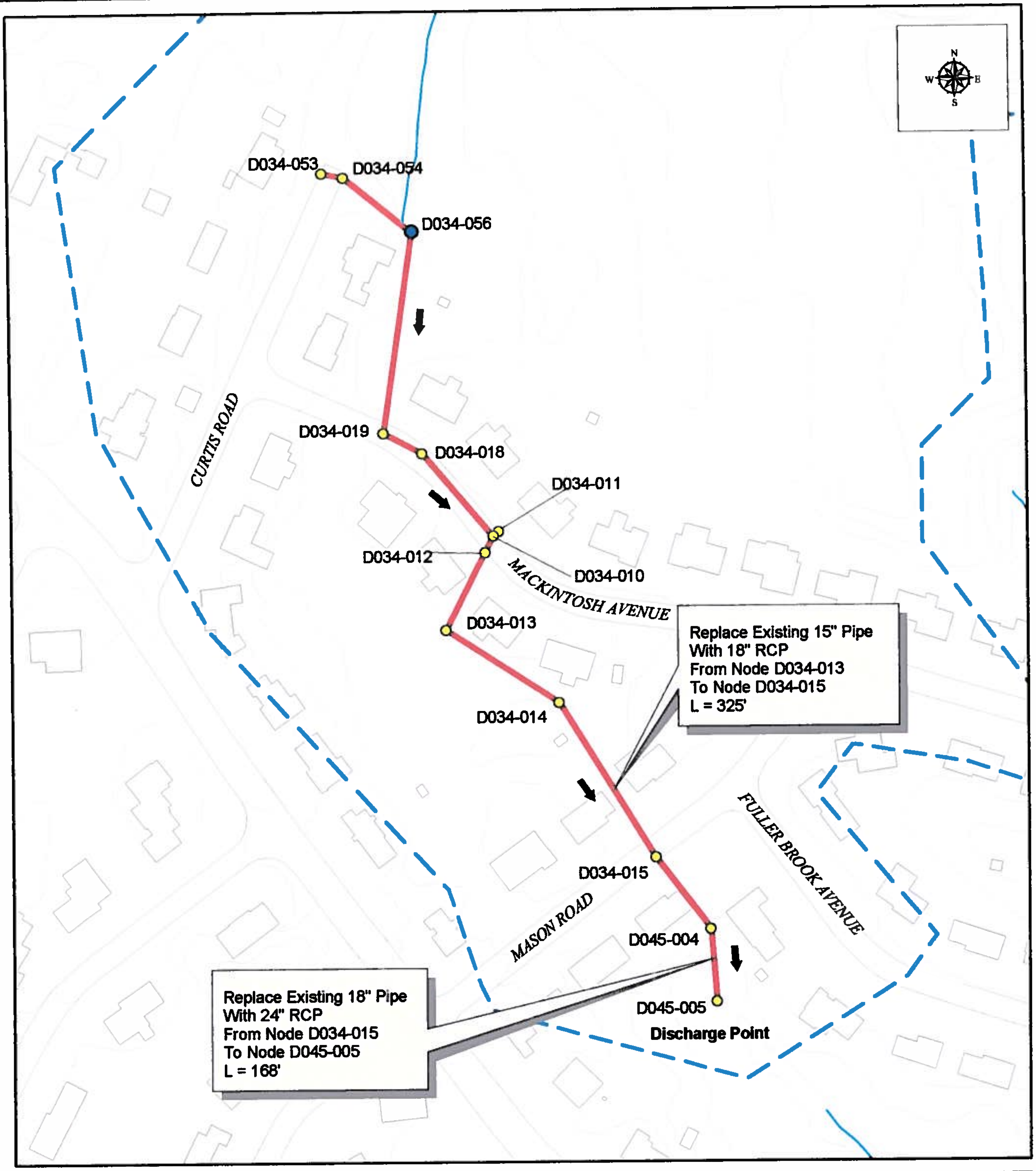
Area 8 – Oak Street

Description
Area 8 is located in the southern portion of Needham. A graphical representation of the watershed and Category A pipe system is shown in Figure 4-13. The 214-acre watershed discharges north of Perry Drive through a 42-inch culvert to an unnamed tributary. The overall watershed was divided into three sub-areas, Area 8A, Area 8B and Area 8C. The hydraulic model includes 4,600 of the 24,800 linear feet within the watershed.

Area 8A is approximately 64 acres in size and discharges to an unnamed brook through a 24-inch pipe east of Fairview Road. The brook continues through a 24-inch pipe, which crosses Memorial Circle and eventually flows to a 30-inch culvert, which crosses Linden Street. From Linden Street, the brook continues to flow through another 30-inch culvert, which crosses the driveway of a building complex before it discharges into Area 8C. The hydraulic model for Area 8A consists of 1,865 of the 8,795 linear feet within the sub-area as shown in Figure 4-13.

In addition to the runoff from Area 8A, the runoff from Area 8B also discharges to this brook through a 30-inch pipe west of Maple Street. Area 8B is approximately 19 acres and the hydraulic model for Area 8B consists of 420 of the 1,445 linear feet within the sub-area as shown in Figure 4-13.

The brook eventually flows to a 36-inch inlet headwall in Area 8C east of Linden Street. Area 8C is approximately 131 acres and the hydraulic model for Area 8C consists of 2,300 of the 14,580 linear feet within the sub-area as shown in Figure 4-13. The runoff from this



Legend

- Modeled Pipes
- Watershed Boundaries
- Modeled Nodes
- Flooding Nodes

75 0 75 150 Feet

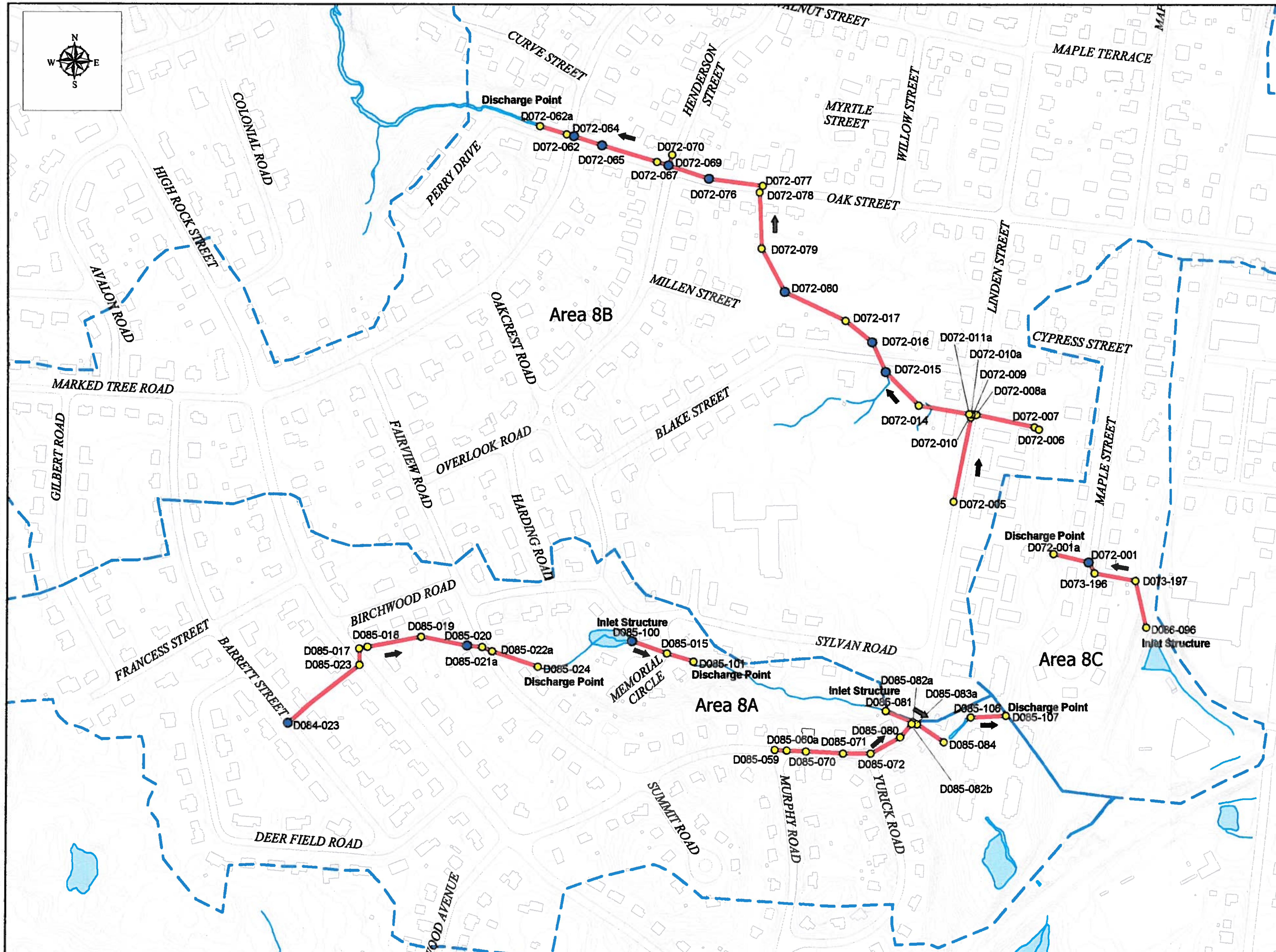
BETA Group, Inc.

Locus

Storm Water Master Plan

Needham, Massachusetts

Figure 4-12
Area 7 - Mackintosh Avenue
Recommendations



Storm Water Master Plan

Needham, Massachusetts

Figure 4-13
Area 8 - Oak Street
Existing Conditions

area is combined with runoff from Area 8A and Area 8B and is discharged through a 42-inch culvert north of Perry Drive.

For modeling purposes the sub-areas were connected via trapezoidal channels to approximate the existing conditions. By connecting the sub-areas together the model is able to analyze backwater effects through the system. In addition, a free outfall was assumed at the discharge during the storm event. The combined peak discharge for the overall watershed is 127 cfs for the 42-inch pipe for a 10-year storm event.

Problem

The results of the hydraulic model show that many of the junctions within Area 8A and Area 8B either surcharging for extended periods of time or are flooding. Area 8C shows minor flooding at junction D072-001, which also appears to be caused by a tailwater condition at the discharge to Area 8B.

Area 8A flooding could be attributed to the limited pipe capacity of a few of the conduits and backwater effects within the system resulting from restrictions or hydraulic losses at culvert crossings.

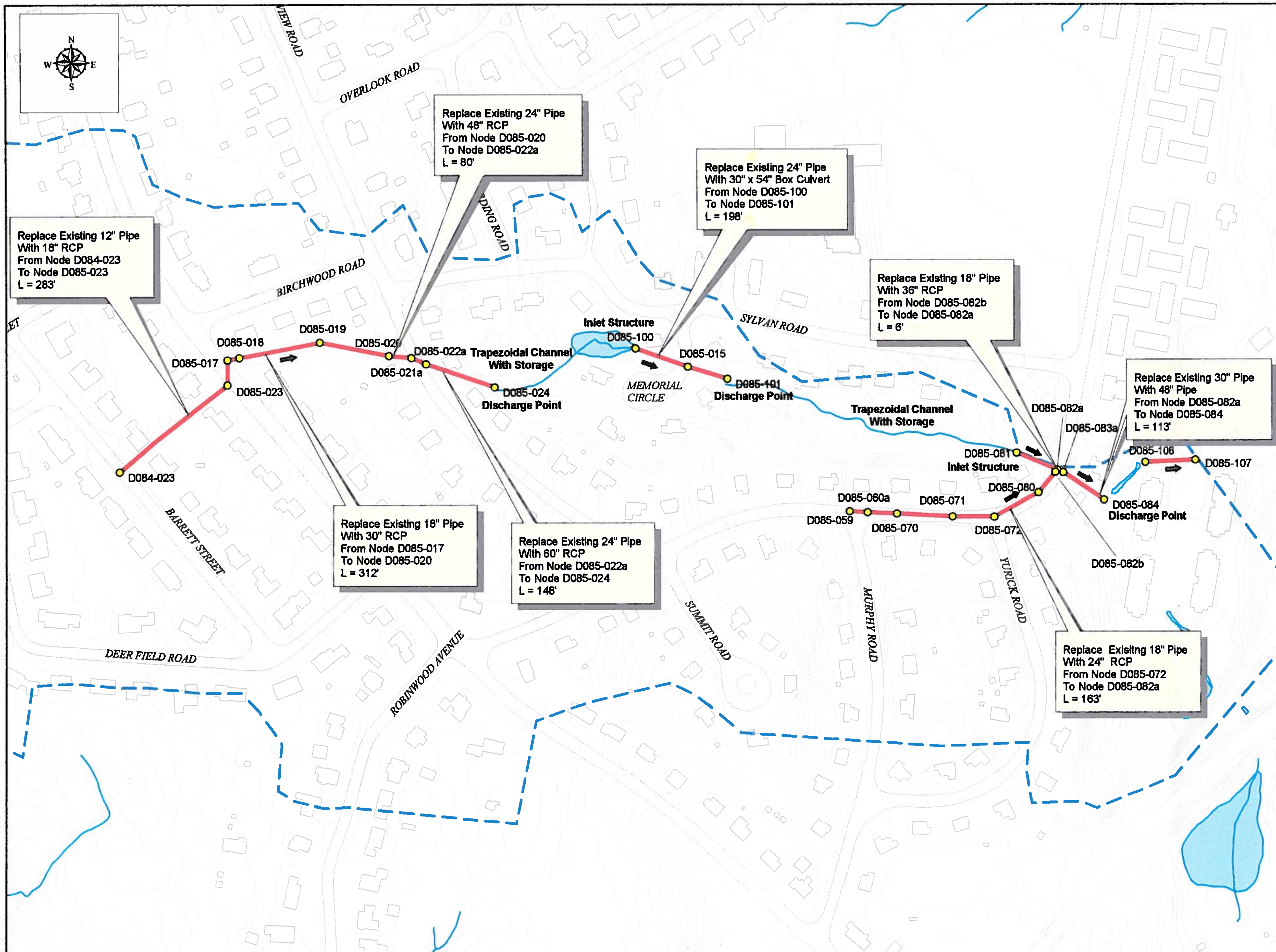
Area 8B shows minor flooding with many of the mainline junctions surcharging for over 60 minutes. The system appears to be at full capacity due to the relatively flat slope, less then half a percent to the point of discharge.

Recommendations

Recommended improvements are shown in Figures 4-14 and 4-15 and consist of the following:

Watershed 8A

- Replace 283 feet of 12" pipe with 18" pipe from node D084-023 to D085-023.
- Replace 25 feet of 18" pipe with 30" pipe from node D085-017 to D085-018.
- Replace 312 feet of 24" pipe with 36" pipe from node D085-018 to D085-020.
- Replace 80 feet of 24" pipe with 48" pipe from node D085-020 to D085-022a.
- Replace 148 feet of 24" pipe with 60" pipe from node D085-022a to D085-024.
- Replace 198 feet of 24" pipe with 30"x54" box culvert from node D085-100 to D085-101.
- Replace 163 feet of 18" pipe with 24" pipe from node D085-072 to D085-082a.
- Replace 6 feet of 18" pipe with 36" pipe from node D085-082b to D085-082a.



Legend

- Modeled Pipes
- Watershed Boundaries
- Modeled Nodes
- Flooding Nodes

100 0 100 200 Feet

BETA Group, Inc.

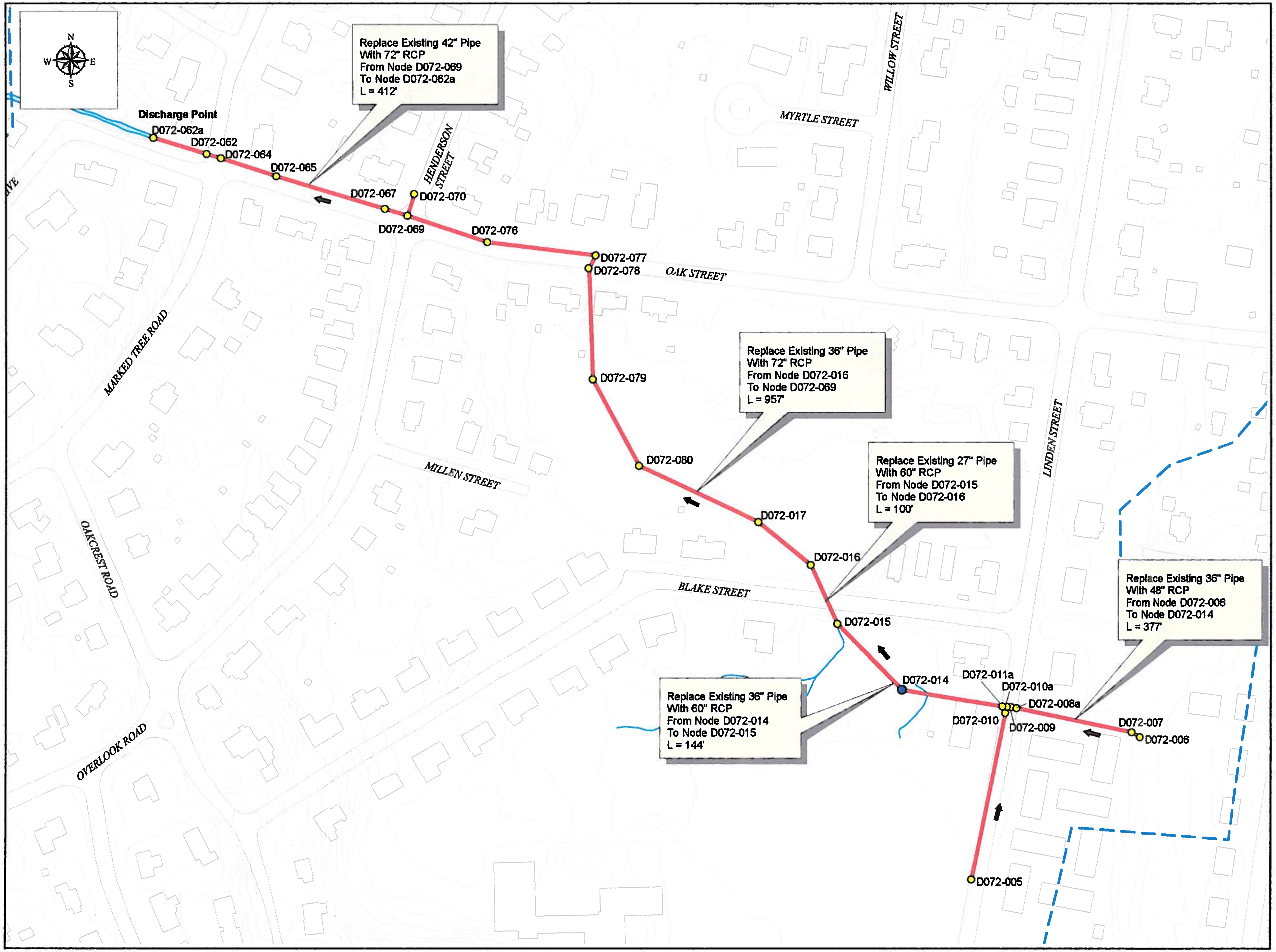
Locus

1 2 3 4

Storm Water Master Plan

Needham, Massachusetts

Figure 4-14
Area 8A - Oak Street
Recommendations



Legend

- Modeled Pipes
- Watershed Boundaries
- Modeled Nodes
- Flooding Nodes

75 0 75 150 Feet

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Locus

Storm Water Master Plan

Needham, Massachusetts

Figure 4-15
Area 8B - Oak Street
Recommendations

- Replace 113 feet of 30" pipe with 48" pipe from node D085-082a to D085-084.

Watershed 8B

- Replace 377 feet of 36" pipe with 48" pipe from node D072-006 to D072-014.
- Replace 144 feet of 36" pipe with 60" pipe from node D072-014 to D072-015.
- Replace 100 feet of 27" pipe with 60" pipe from node D072-015 to D072-016.
- Replace 957 feet of 36" pipe with 72" pipe from node D072-016 to D072-069.
- Replace 412 feet of 42" pipe with 72" pipe from node D072-069 to D072-062a.

Watershed 8C

- No improvements required.

The extensive improvements required within Area 8B were needed to eliminate flooding caused by the removal of upstream restrictions within Area 8A.

Based on recommended improvements, the model indicates that surcharging would be reduced and flooding would be eliminated. The peak discharge within the system would increase from 127 to 144.3cfs.

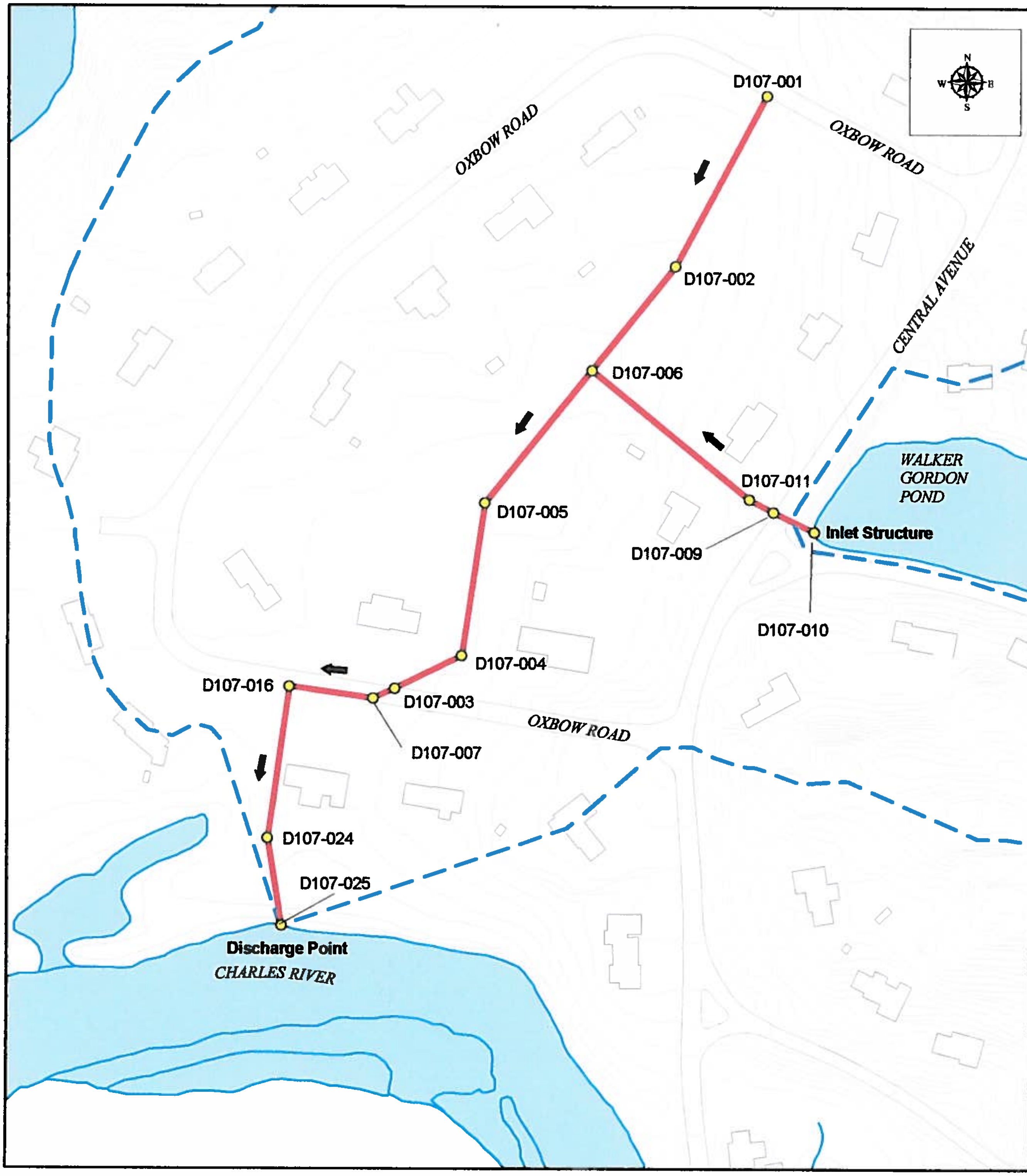
The increase in peak discharge will require mitigation improvements at the point of discharge during the final design process. Typical improvements include installation of riprap or construction of stone check dams to protect against erosion.

Area 9 – Oxbow Road

Description
Area 9 is located in the southeast portion of Needham. A graphical representation of the watershed and Category A pipe system is shown in Figure 4-16. The watershed for Area 9 is approximately 45 acres and runoff from this area discharges to the Charles River through a 30-inch pipe west of Oxbow Road. The hydraulic model includes 1,835 of the 2,750 linear feet within the watershed.

There is an additional 475-acre watershed adjacent to Area 9 that connects to the drainage system via a 42-inch pipe from Walker Gordon Pond.

Problem
The results of the hydraulic model show that if considered separately the drainage system within the Oxbow Road area is adequate for the design storm event and the problem is related to discharge from Walker Gordon Pond.



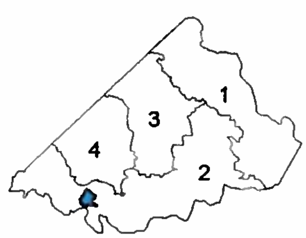
Legend

- Modeled Pipes
- Watershed Boundaries
- Modeled Nodes
- Flooding Nodes

100 0 100 200 Feet

BETA Group, Inc.

Locus



Storm Water Master Plan

Needham, Massachusetts

Figure 4-16
Area 9 - Oxbow Road
Existing Conditions

This area experiences flooding during severe storm events due to discharge from Walker Gordon Pond, which is connected to the Oxbow Road drainage system. Walker Gordon Pond serves as a detention area for approximately 475 acres of an upland watershed. The outlet structure for the pond consists of flashboards, a 4'-6" sharp crested weir, and a metal grate on top of the structure, which serves as the emergency overflow. The outlet structure is connected to Oxbow Road by a 42-inch concrete pipe. Typically, during severe storm events, the outlet structure becomes clogged with debris, which allows the pond to fill beyond the design elevation causing flooding to adjacent properties and roadways. As the water elevation increases, the discharge out of the basin increases, which results in down gradient flooding within the Oxbow Road neighborhood due to inadequate pipe capacity.

Recommendations
Based on a previous study of the area and the results of this study the recommended improvements are shown in Figure 4-17 and consist of the following:

- Construct a new outlet structure and installation of 806 feet of 48-inch RCP from Walker Gordon Pond to the Charles River.

The new discharge will eliminate surcharging and flooding within the Oxbow Road area.

Construction of a new outfall will require full compliance with current stormwater regulations. Mitigation improvements at the point of discharge will be addressed during the final design process. Typical improvements include installation of riprap or construction of stone check dams to protect against erosion.

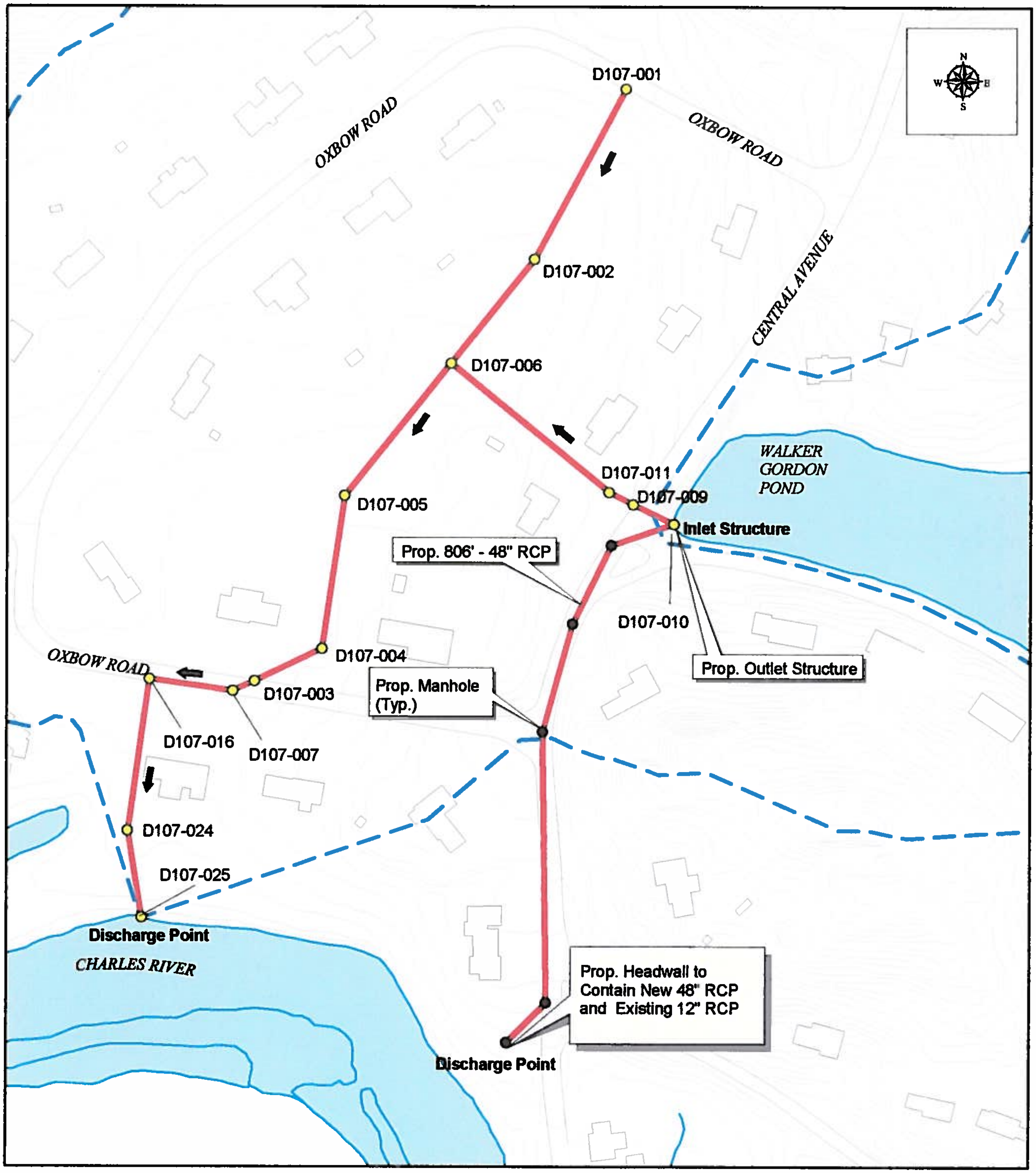
Area 10 – South Street

Description
Area 10 is located in the southern portion of Needham. A graphical representation of the watershed and Category A pipe system is shown in Figure 4-18. The 58-acre watershed discharges to the Charles River through a 30-inch pipe south of Wildwood Drive. The hydraulic model includes 3,025 of the 5,060 linear feet within the watershed.

The peak discharge for this system is 26.97 cfs for the 10-year storm event. This system was assumed to have a free outfall condition.

Problem
The results of the hydraulic model show flooding occurs at nodes D100-030 and D100-056 and surcharging occurs at approximately half of the nodes.

Approximately half of the structures surcharge for less than 55 minutes, but only two junctions actually flood. Structure D100-030 floods for about 10 minutes. The pipes from D100-030 to D100-001 all have a ratio of maximum computed flow to design flow values greater than one. The surcharging of these pipes could cause the brief flooding. Structure D100-056 floods for 16 minutes. The pipes from structure D100-056 to D100-001 surcharge and may cause the flooding issue. Downstream from these areas, the pipe from



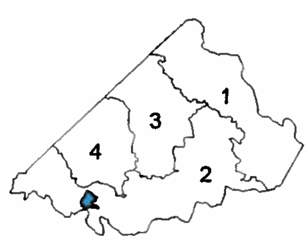
Legend

- Modeled Pipes
- Watershed Boundaries
- Modeled Nodes
- Flooding Nodes

100 0 100 200 Feet

BETA Group, Inc.

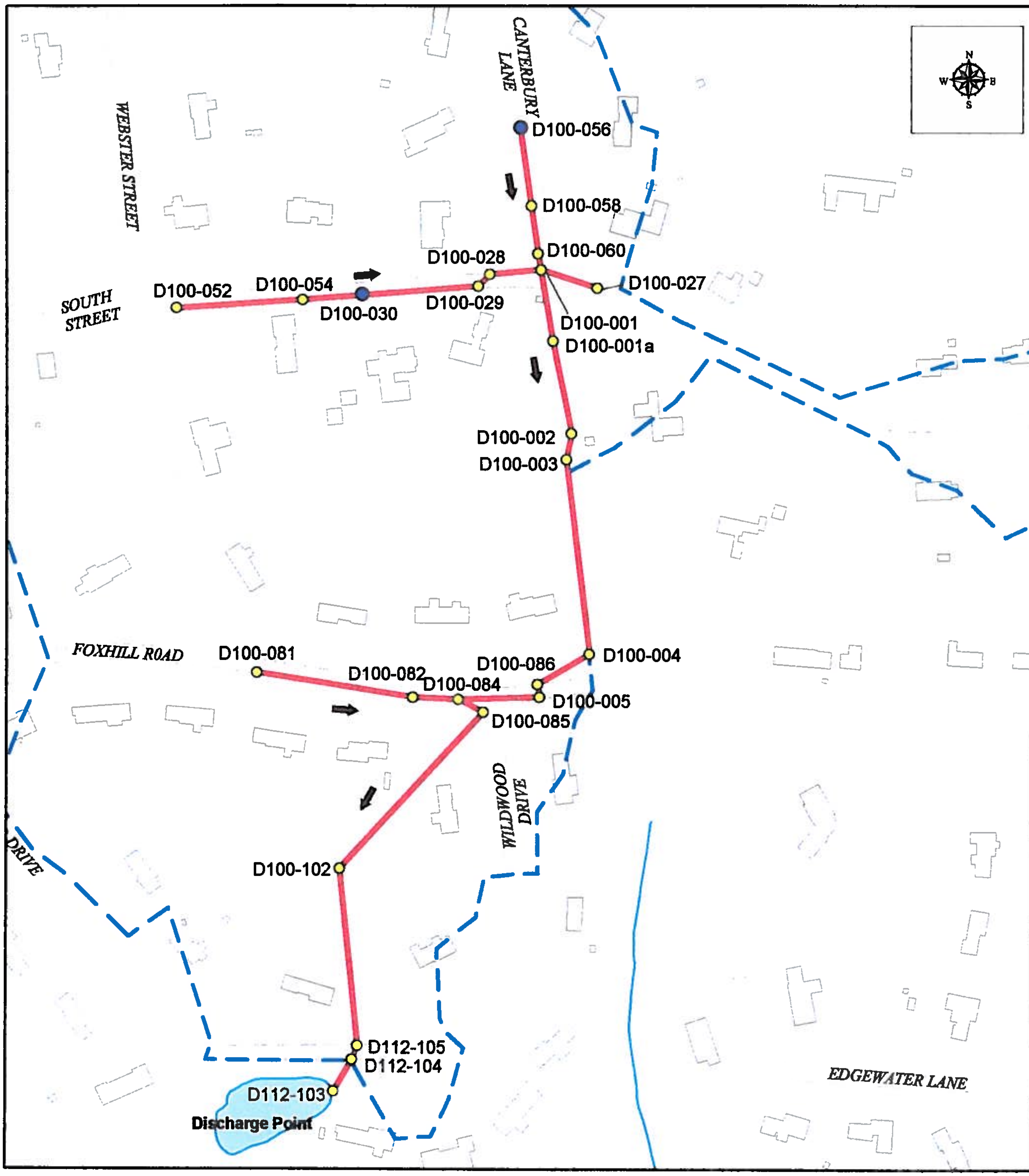
Locus



Storm Water Master Plan

Needham, Massachusetts

Figure 4-17
Area 9 - Oxbow Road Recommendations



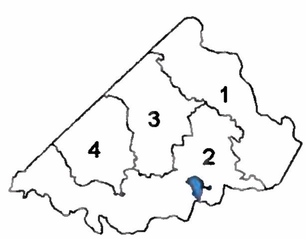
Legend

- Modeled Pipes
- Watershed Boundaries
- Modeled Nodes
- Flooding Nodes

125 0 125 250 Feet

BETA Group, Inc.

Locus



Storm Water Master Plan

Needham, Massachusetts

Figure 4-18
Area 10 - South Street
Existing Conditions

structure D100-001a to D100-002 has a zero percent slope with the upstream and downstream inverts set at elevation 95.5 feet. This pipe is a restriction within the system.

The record drawings used to depict this area have different datum elevations. The rims and inverts are in the 200-foot range for the upper part of the system and in the 100-foot range for the lower part of the system. The slopes, inverts and rims for the upper part of the system were converted to approximately match the lower part of the system. The base elevations start to differ at structure D100-001. A 12-inch pipe enters the manhole from the north on Canterbury Lane at elevation 206.5 feet. A 12-inch pipe enters from the east on South Street at 209.0 feet and from the west at 210.2 feet. The 24-inch discharge pipe from this manhole exits at an elevation of 99.0 feet. The lowest pipe entering the manhole (206.5 feet) was assumed to match crowns with the 24-inch discharge pipe. This would set that invert at elevation 100.0. All of the other pipes and structures in the upper system were converted based on this initial assumption.

Recommendations
Recommended improvements are shown in Figure 4-19 and consist of the following:

- Replace 312 feet of 12" pipe with 18" pipe from node D100-030 to D100-001.
- Replace 242 feet of 12" pipe with 18" pipe from node D100-056 to D100-001.
- Replace 660 feet of 24" pipe with 30" pipe from node D100-001 to D100-004.

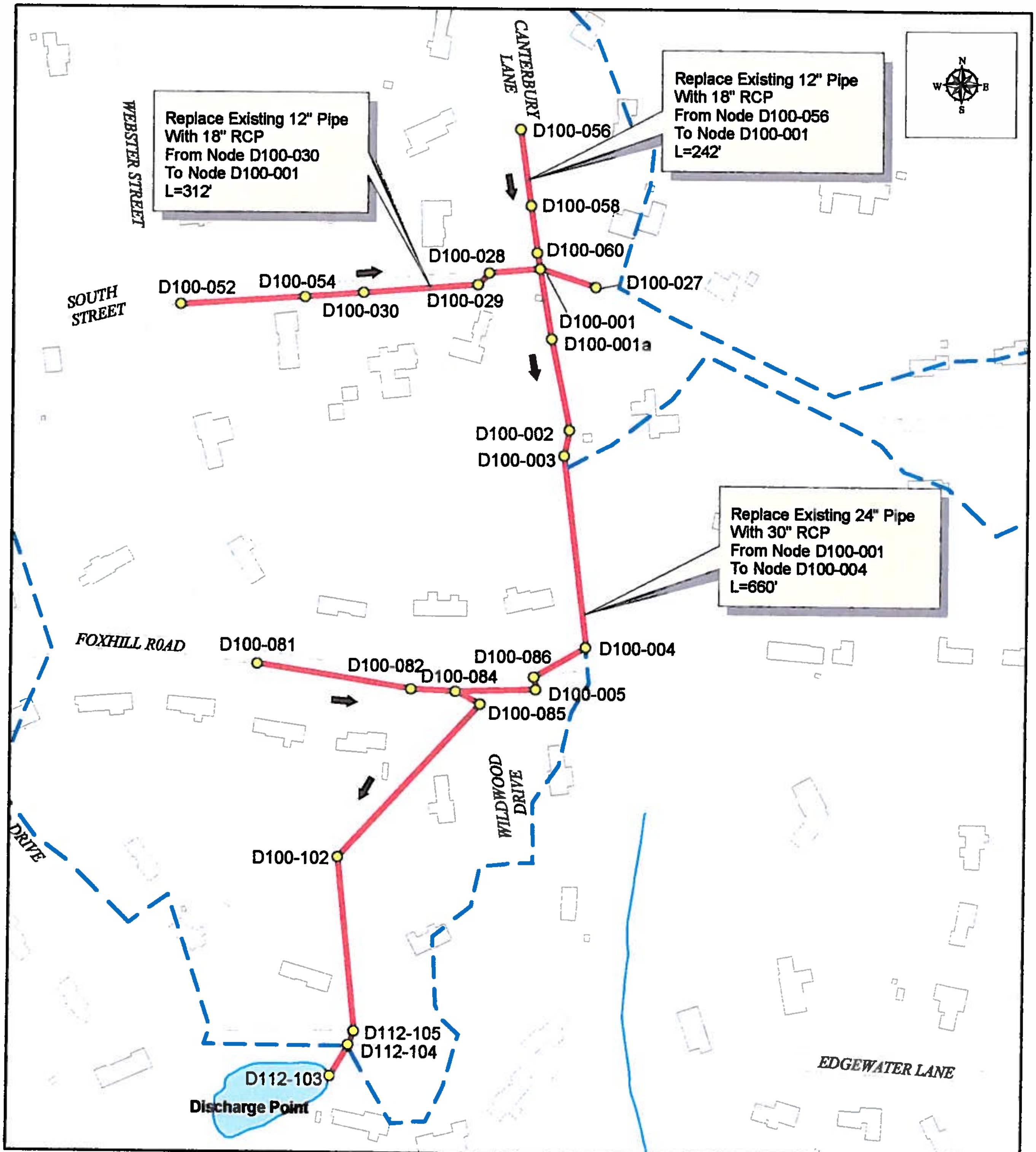
Based on recommended improvements, the model indicates surcharging would be reduced and flooding would be eliminated. The peak discharge within the system increased from 26.97 cfs to 28.46 cfs.

The increase in peak discharge will require mitigation improvements at the point of discharge during the final design process. Typical improvements include installation of riprap or construction of stone check dams to protect against erosion.

Area 11 – West Street

Description
Area 11 is located in the central portion of Needham. A graphical representation of the watershed and Category A pipe system is shown in Figure 4-20. The 50-acre watershed discharges north of West Street to the Rosemary Brook through a 4'x4' box culvert. The hydraulic model includes 3,200 of the 11,960 linear feet of pipe within this watershed. West Street contains of a 15-inch trunk line on the north side of West Street and an 18-inch trunk line on the south side.

The peak discharge entering the box culvert is 12.37 cfs for the 15-inch pipe and 17.22 cfs for the 18-inch pipe for a 10-year storm event. A tailwater depth of 1 foot was assumed at the culvert for modeling purposes during the storm event.



Legend

- Modeled Pipes
- Watershed Boundaries
- Modeled Nodes
- Flooding Nodes

125 0 125 250 Feet

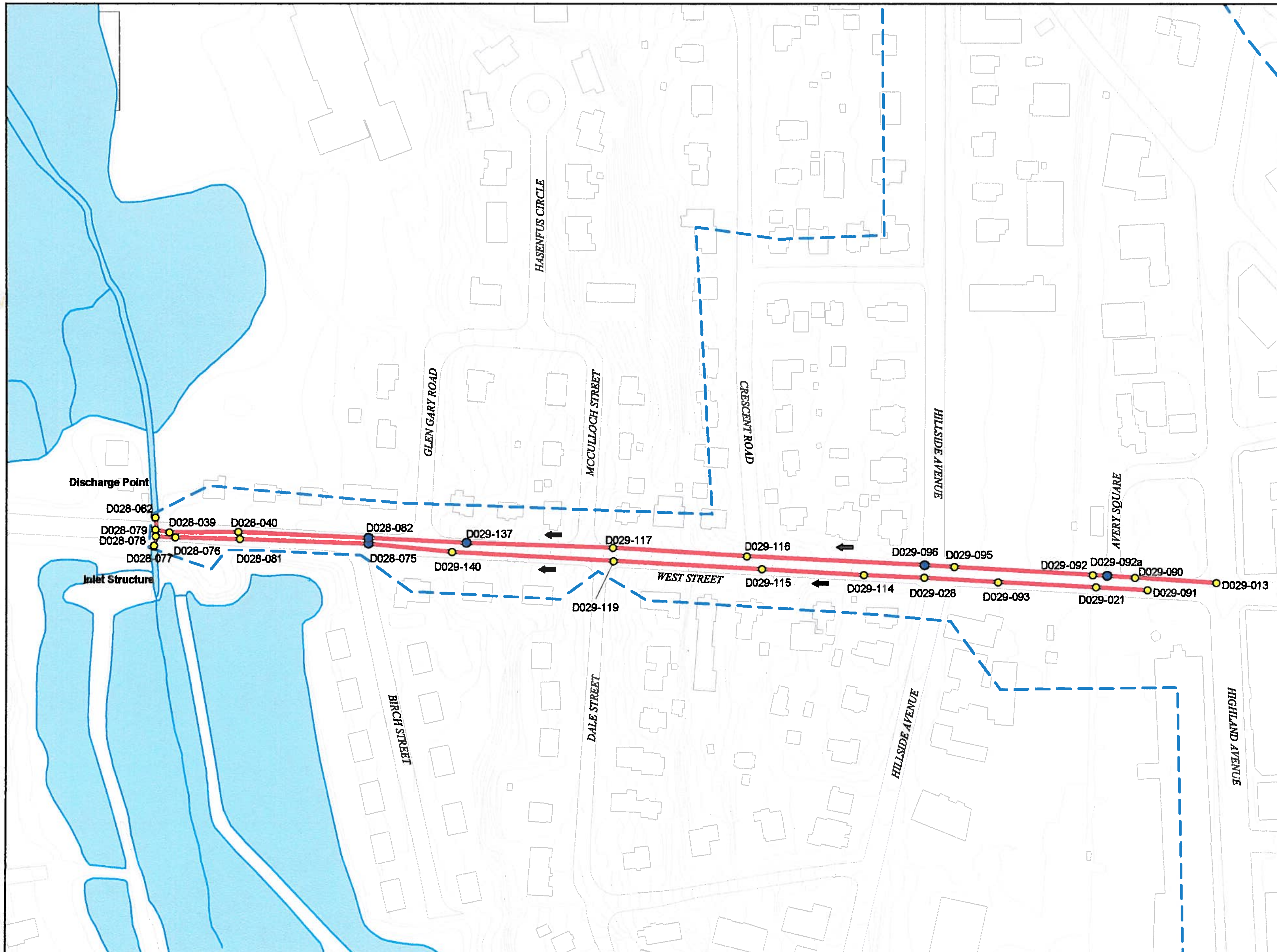
BETA Group, Inc.

Locus

Storm Water Master Plan

Needham, Massachusetts

Figure 4-19
Area 10 - South Street
Recommendations



Legend

- Modeled Pipes
- Watershed Boundaries
- Modeled Nodes
- Flooding Nodes

72 0 72 144 Feet

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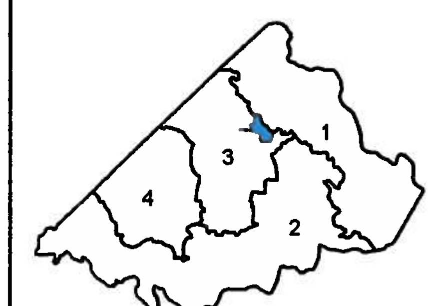
Locus



Storm Water Master Plan

Needham, Massachusetts

Figure 4-20
Area 11 - West Street
Existing Conditions

Problem

The results of the hydraulic model show that many junctions surcharge, but only five of the junctions flood during the design storm event. Flooding times range from 15 to 60 minutes for structures D029-096, D029-092, and D028-075. These three structures flood because the connecting pipes in the area are all over capacity. The pipes from structure D029-096 to D029-082 have a very steep slope. The slope of the pipe connecting D028-082 and D028-040 is dramatically decreased and the model appears to be depicting a hydraulic jump in this area. This could be the cause of the flooding from structures D029-137 and D028-082.

In addition, the exiting pipe geometry, with right angle connections at the culvert connection, creates hydraulic losses at the entrance that reduce the capacity of each of the pipe systems by creating backwater conditions within the pipe.

Recommendations

Recommended improvements are shown in Figure 4-21 and consist of the following:

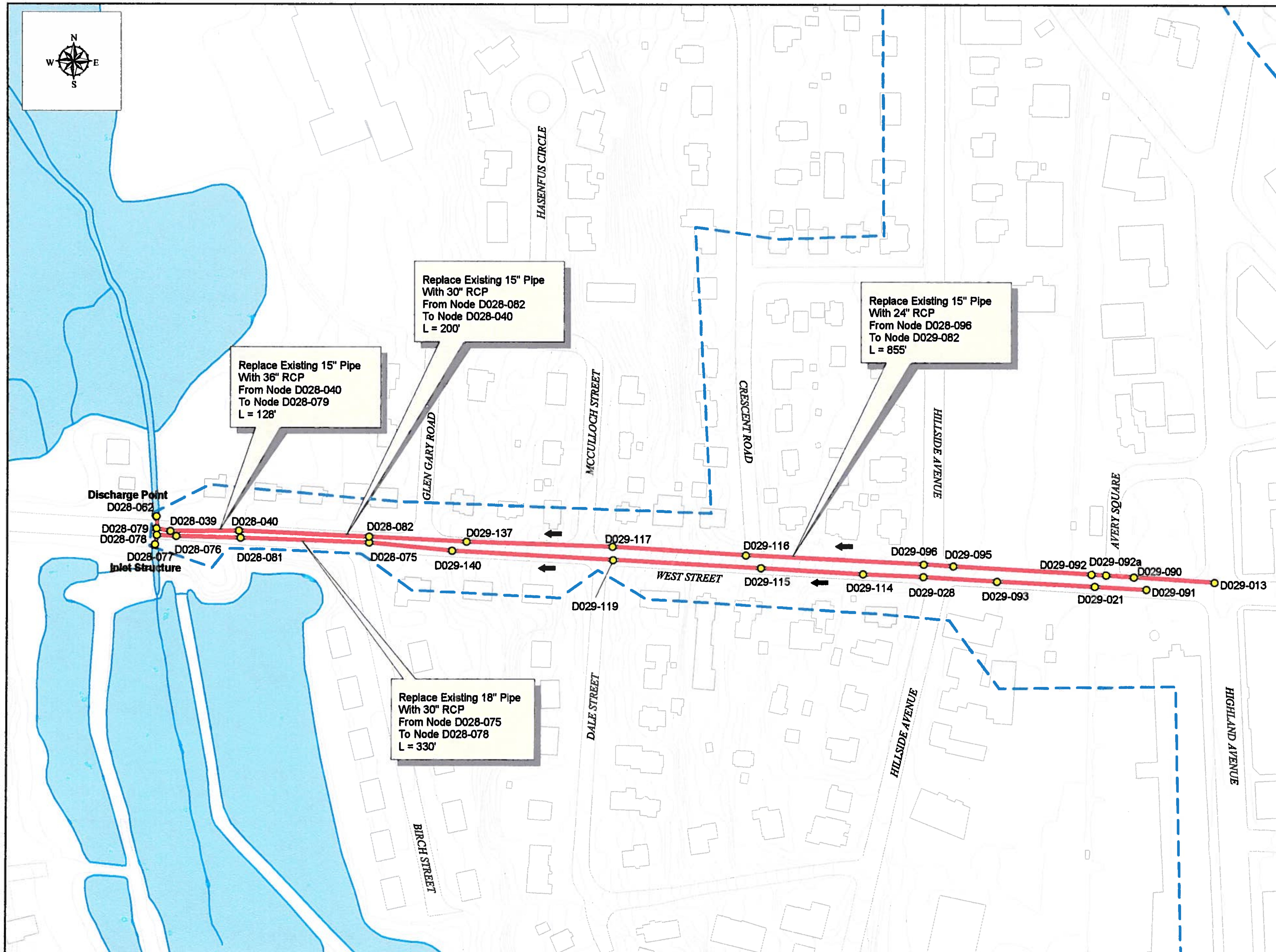
- Replace 128 feet of 15" pipe with 36" pipe from node D028-040 to D028-079.
- Replace 200 feet of 15" pipe with 30" pipe from node D028-082 to D028-040.
- Replace 855 feet of 15" pipe with 24" pipe from node D028-096 to D029-082.
- Replace 330 feet of 18" pipe with 30" pipe from node D028-075 to D028-078.

Optional Improvement

Construct a new outfall on north side of West Street to eliminate the right-angle connections with the box culvert. The new outfall could be designed to maintain the separate pipe systems. The new outfall will improve the hydraulic conditions within the drainage system, by reducing the entrance losses that occur where the existing pipes enter the box culvert. Additionally, a new outfall will reduce potential tailwater conditions that limit capacity at the discharge point.

Based on recommended improvements, the model indicates surcharging would be reduced and flooding would be eliminated. The peak discharge entering the box culvert is increased from 12.37 cfs to 38.57 for the 36-inch pipe and from 17.22 cfs to 18.69 cfs for the 30-inch pipe for a 10-year storm event.

The increase in peak discharge will require mitigation improvements at the point of discharge during the final design process. Typical improvements include installation of riprap or construction of stone check dams to protect against erosion.



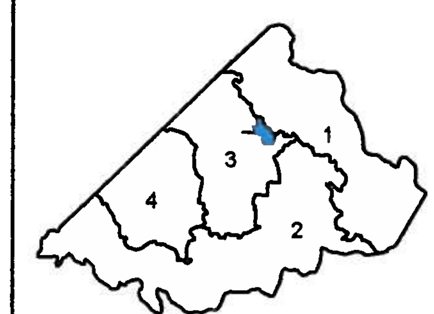
Legend

- Modeled Pipes
- Watershed Boundaries
- Modeled Nodes
- Flooding Nodes

72 0 72 144 Feet

BETA Group, Inc.

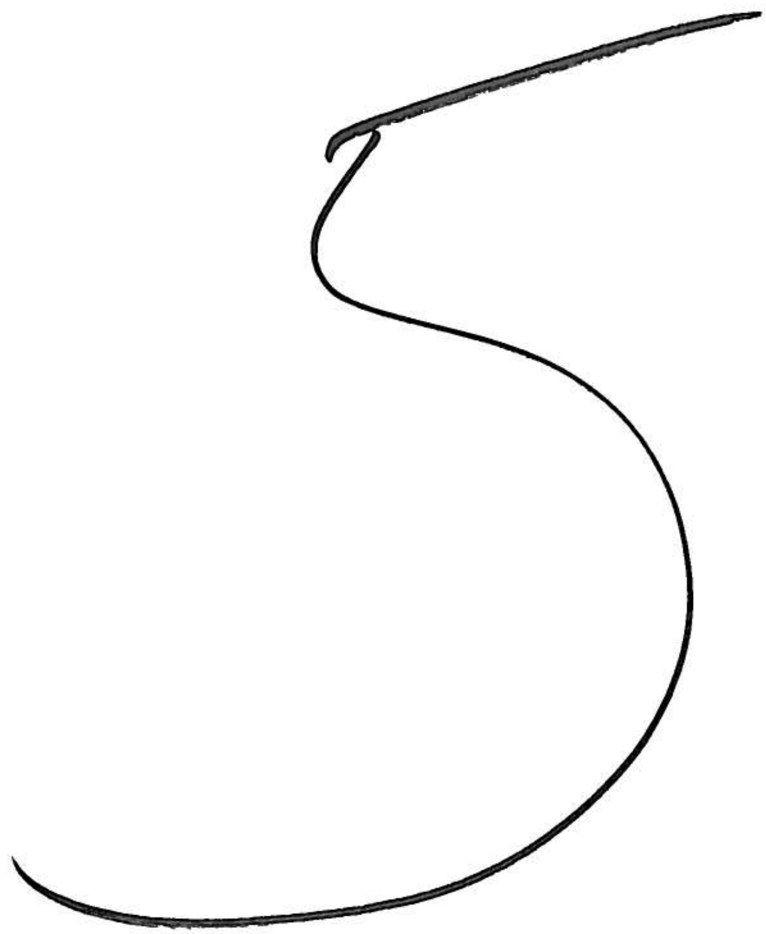
Locus



Storm Water Master Plan

Needham, Massachusetts

Figure 4-21
Area 11 - West Street
Recommendations



SECTION 5 RECOMMENDATIONS

5.1 Overview

This section summarizes the recommended improvements related to illicit discharge elimination (Section 3) and flooding problems (Section 4). These recommended improvements are based on a thorough sampling program and assessment of the existing municipal drainage system utilizing a variety of modeling and GIS analysis tools as described in Section 4.

5.2 Illicit Discharge Elimination

The following provides a summary of the recommended improvements to facilitate the elimination of illicit discharges. Costs associated with the following improvements will be estimated under the Phase II program that will be underway in Spring of 2002.

- Development of a standardized catch basin and storm drain inspection program, to include:
  - Continued inspection, cleaning and maintenance of storm water system components (ongoing).
  - A standardized inspection form, which includes information regarding the condition of the structure, construction material (brick, precast concrete, etc.) depth to invert, size, condition and type of pipes into and out of the structure, and condition of the frame and cover. The form shall be completed during each catch basin, manhole or storm drain cleaning operation. Evidence of illicit connections to the storm water system, petroleum residues or chemical odors shall also be noted on the forms (under development).
  - Inspection of sanitary sewer manholes, since evidence of surcharge, blockage and leakage may be evident in these structures. This is important, since the Town has documented areas where surcharging sanitary sewers impact storm water systems (under development).
- Continued television inspection of the sanitary sewers in Needham, under the existing Infiltration/Inflow (I/I) program. This program has revealed areas where sanitary sewers are in need of repair, and assists the Town in the prioritization of sewer and drainage improvement projects (ongoing).

- Additional follow up testing in the original ten areas identified previously and the additional eight areas identified in this study where high levels of pollutants were discovered. Testing goal will be to identify specific reaches of pipes where problems exist to allow repairs to be planned.

- Additional television inspections of drainage pipes within sub-area N10A-9 are warranted, due to continued levels of fecal coliform bacteria in dry weather storm water discharges.

5.3 Hydraulic Capacity Improvements

These recommended improvements are based on flooding problems identified by the Town and a system wide assessment of the municipal drainage system utilizing the GIS data described previously. The costs provided are planning level estimates and are subject to change based on design criteria and permitting requirements. They intended to assist the Town in prioritizing and implementing the various improvement projects.

Table 5-1
Summary of Project Recommendations

Problem Area	Description	Cost
Bradford Street	Replacement of 900 linear feet of pipe	$ 190,000
Carey Road	Replacement of 850 linear feet of pipe	$ 180,000
Fuller Brook Avenue	Operation and Maintenance	N/A
Greendale Avenue	Replacement of 2800 linear feet of pipe	$ 990,000
Great Plain Avenue	Incomplete Information – No Model	N/A
High Rock Street	Incomplete Information – No Model	N/A
Mackintosh Avenue	Replacement of 500 linear feet of pipe	$ 85,000
Oak Street	Replacement of 3100 linear feet of pipe	$ 1.7 Million
Oxbow Street	Replacement of 850 linear feet of pipe	$ 300,000
South Street	Replacement of 1300 linear feet of pipe	$ 220,000
West Street	Replacement of 900 linear feet of pipe	$ 275,000

The costs included in Table 5-1 are based on typical construction unit prices for the components of each recommendation. The cost also includes 25% for engineering and permitting. A 30% contingency factor was also applied to account for unforeseen construction issues.

The costs do not account for private property restoration, land acquisition or construction easements, police services, sewer relocation, or any other unforeseen utility adjustments resulting from the removal or addition of any drainage pipe.

5.4 Water Quality Considerations

Regulatory BMPs
In accordance with the EPA Phase II requirements, the Town of Needham must reduce the discharge of pollutants from a regulated system to the "maximum extent practicable" to protect water quality. This can be accomplished by implementing the following minimum control measures identified by the EPA:

- Public Education and Outreach
- Public Participation/Involvement
- Illicit Discharge Detection and Elimination
- Construction Site Runoff Mitigation
- Post Construction Runoff Control
- Pollution Prevention/Good Housekeeping

Existing Basin Retrofits
Needham, like many communities in Massachusetts, maintains existing storm water drainage/detention systems that were constructed to prevent flooding during storm events. These existing detention systems can be easily modified to enhance water quality, prior to discharge into the receiving waters.

Structural BMPs, such as pre-treatment sediment forbays, oil/water separators or other structural devices used to remove total suspended solids (TSS), can be incorporated into the existing drainage systems to enhance the overall water quality at the point of discharge.

New System Installations
All new drainage systems must be designed and constructed in accordance with federal, state and local requirements. This ensures that pre-developed peak runoff conditions are not exceeded and the removal of 80% average annual TSS for storm water is achieved.

In addition to new construction, the Town could implement a policy consistent with future Phase II requirements that targets water quality enhancement on redevelopment projects where drainage systems are replaced or upgraded. Currently, redevelopment projects are not required to comply with the water quality enhancement policies.