



RANGER ENGINEERING GROUP, INC.

130 Main Street Suite 202

Salem, NH 03079

Tel: 978-208-1762

www.rangereng.com

October 1, 2024

Andover Conservation Commission
Andover Planning Board
Andover Town Offices
36 Bartlet Street
Andover, MA 01810

RE: 140 Haverhill Street, Amended Plan
DEP File # 090-1387 Response to Peer Review Comments

Dear Conservation Commission and Planning Board Members,

Please accept this letter and the attached plans as a response to the review comments provided by Horsley Whitten Group in a letter dated 16, 2024. Our responses to comments are located below. Comments that did not require any response are not included.

Standard 2 requires that post-development runoff does not exceed pre-development runoff off-site.

- a. The narrative in the Drainage Report is not consistent with the proposed amended design. HW recommends that the Applicant revise the narrative to avoid confusion.

The introductory portions of the narrative have been revised to reflect the new project.

September 16, 2024: The Applicant has revised the narrative under Section V. Proposed Conditions as suggested. The narrative under Section X. Stormwater Management Standards, specifically Standards 2 and 7 has not been updated.

October 1 response: The edits have been made

- b. It appears that the existing driveway on the north side of the parcel will be removed in accordance with the Demolition Plan. It is not obvious if this driveway will be repaved or replaced with loam and seed. HW recommends that the Applicant clarify the proposed plans for the northern driveway. If the driveway is removed credit for the reduction of impervious surfaces can be accounted for.

It has been noted that the area where the parking lot pavement is being removed is replaced with topsoil and seed on the landscape plan.

September 16, 2024: The Applicant has stated that the area where the parking lot pavement is being removed is replaced with topsoil. HW was questioning the access driveway on the north side of the site. The Demolition Plan calls out to remove the pavement and curb for this driveway as highlighted in red in the image below. No further direction was obvious in the plan set. HW recommends that the Applicant clarify the proposed plans for the northern driveway.

October 1 response: There was a leader pointing to the wrong location. This has been corrected and should eliminate the confusion

- c. HW recommends that the Applicant provide the closed drainage system sizing calculations to confirm the network is adequately sized.

Calculations for the drainage system pipes have been included as an attachment to this letter.

September 16, 2024: The Applicant has stated that the closed drainage pipe calculations were included as an attachment. The response letter HW received included a figure for the catch basin drainage areas, and a calculation of the sediment sump calculations as well as the water quality calculations. HW did not receive the closed drainage system calculations as requested. HW notes that the slope listed on the plans between CB 6 and DMH 5 does not appear accurate. HW recommends that the Applicant provide the closed drainage system sizing calculations to confirm the pipes are adequately sized and confirm the slope listed on the plans.

October 1 response: A HydroCAD model was used to route stormwater through each reach of pipe. A table showing the proposed flow in the 10 year storm through each pipe and its capacity is included as an attachment. It should be noted that some of the pipes are at capacity or slightly above capacity, however, when the system is modeled as ponds, the catch basin and manhole structures do not overtop. The entire 10-year flow is contained within the drainage system with one exception.

CB 4 is located in close proximity to an existing catch basin that is being replaced. This catch basin is located at the lowest elevation on the site and currently has an 8" discharge pipe. The parking area it serves is not being modified in elevation, but is being made smaller. There is not enough cover to provide a larger pipe so in the 10-year storm there will be some temporary ponding in the area of CB 4. Please keep in mind that this is an existing system that has been in service for many years without any major flooding problems. The system is being upgraded to the greatest extent possible without having to rebuild the entire site.

- d. The Applicant has revised the plans and eliminated one of the previously approved buildings and one of the previously approved subsurface detention systems. HW has the following comments regarding the amended plans.

v. HW recommends that the Applicant clarify the limit of clearing around the site. The leader on the north side is not pointing to another specific.

The limit of clearing line has been adjusted.

September 16, 2024: The Applicant has eliminated the erroneous leader. HW recommends that the limit of work as well as the property boundaries be clearly shown on all the plans of the set.

October 1, response: The property lines and LOW are now shown on the appropriate plan sheets.

Standard 3 requires that the annual recharge from post-development shall approximate annual recharge from pre-development conditions.

The Applicant has designed the underground chambers as a detention system, so no groundwater recharge is provided. The bottom of the chambers is set at elevation 85.0, the top is set at elevation 88.0 and groundwater in the area based on TP2 and TP3 is approximately 87.2. The Applicant has added an impermeable liner to prevent groundwater from entering the chamber system. HW recommends that the Applicant also confirm that buoyance will not be an issue for this system.

Buoyancy calculations are attached to this letter.

September 16, 2024: The Applicant has provided buoyance calculations. HW is concerned that buoyance may still be an issue. ADS has issued a Technical Note, TN 6.50 Thermoplastic Liners for Detention Systems. The document states that

“ADS recommends against installing lined chamber systems below groundwater. Although the total weight of a chamber system generally exceeds the buoyant force, a limiting stability condition may result when the buoyant pressure exceeds the resistance pressure directly under the chamber. This could result in a heave of the bedding under the chamber leading to instability.” HW recommends that the Applicant consider installing an underdrain system as recommended by ADS or propose a different type of subsurface system where buoyance is not an issue.

October 1 response: The chamber system has been replaced with a pipe in stone system. The buoyancy calculations have been revised to reflect this new system.

2. *Standard 8 requires a plan to control construction related impacts including erosion, sedimentation or other pollutant sources.*
 - a. The Applicant has provided a Soil Erosion & Sediment Control Plan. HW notes that the erosion controls measures shown are close to the wetland resource areas and it appears that they could be pulled back to the edge of the northern access drive in most areas. HW recommends that the Applicant review the location of the erosion control barrier and adjust to be as far from the resource areas as possible.

The erosion control locations have been adjusted.

September 16, 2024: The Applicant has adjusted the location of the erosion control barriers as suggested. It appears that one of the leaders is calling out a setback line and not the erosion control (EC) line type. If the pavement on the northern driveway is proposed to be removed the Applicant will need to extend the erosion control barriers along the edge of the driveway.

October 1 response: The EC Barriers have been adjusted

- b. HW recommends that the Applicant list a size of 12 to 18-inches on the compost sediment sock detail.

The detail has been revised

September 16, 2024: The Applicant has stated that the detail has been revised. However, it does not appear that the Silt Fence Barrier Detail on Sheet CS8501 has been updated with a callout for the size of the compost sock. HW recommends that the Applicant list a size of 12 to 18-inches on the compost sediment sock detail.

October 1 response: The detail has been revised

I will be in attendance at the planning board meeting and the October 29, 2024 conservation commission meeting to discuss this matter. If you have questions prior to the meeting, please do not hesitate to contact this office.

Sincerely,

A handwritten signature in blue ink that reads "Ben C Osgood Jr." in a cursive style.

Benjamin C Osgood Jr. PE
President

|

140 HAVERHILL STREET 10 YEAR PIPE CAPACITY CALCULATIONS
 10-1-2024 BENJAMIN C OSGOOD JR.

NORTH DRAINAGE SYSTEM

REACH NUMBER	UPSTREAM STRUCTURE	DOWNSTREAM STRUCTURE	PEAK FLOW CFS	PIPE SIZE	SLOPE '/'	PIPE CAPACITY CFS	STRUCTURE RIM ELEVATION	PEAK WATER ELEVATION
1R	CB2	DMH8	1.96	12"	0.0097	3.5		
2R	DMH8	DMH1	1.96	12"	0.0099	3.55		
3R	CB1	DMH1	1.2	12"	0.0094	3.46		
4R	DMH1	DMH2	3.04	12"	0.0147	4.32		
5R	DMH2	DMH3	3.2	15"	0.0032	3.67		
6R	CB3A	DMH3	1.5	12"	0.0104	3.63		
7R	CB3	DMH3	1.49	12"	0.0077	3.12		
8R	DMH3	DMH4	6.98	18"	0.005	7.43	87.75	85.35
9R	DMH4	DMH5	7.79	18"	0.0046	7.15	87.4	85.04
10R	CB4	DMH4	3.81	8"	0.0056	0.9	PARKING LOT PONDING WILL OCCUR	
11R	CB6	DMH5	1.53	12"	0.0806	10.11		
12R	CB5	DMH4	1.51	12"	0.0592	8.67		
13R	DMH5	JELLYFISH FILTER	8.97	18"	0.0045	7.08	87.35	85.47
SOUTH DRAINAGE SYSTEM								
14R	CB10	DMH9	1.1	8"	0.0048	0.83	102.84	101.79
15R	DMH9	JELLYFISH FILTER	1.82	12"	0.0046	2.41		
17R	CB9	DMH9	0.99	8"	0.0229	1.83		

140 HAVERHILL STREET PIPE DESIGN

Prepared by {enter your company name here}

HydroCAD® 10.10-7b s/n 02248 © 2022 HydroCAD Software Solutions LLC

Printed 10/1/2024

Page 1

Rainfall Events Listing (selected events)

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	10 YEAR	Type II 24-hr		Default	24.00	1	5.10	2

140 HAVERHILL STREET PIPE DESIGN

Type II 24-hr 10 YEAR Rainfall=5.10"

Prepared by {enter your company name here}

Printed 10/1/2024

HydroCAD® 10.10-7b s/n 02248 © 2022 HydroCAD Software Solutions LLC

Page 2

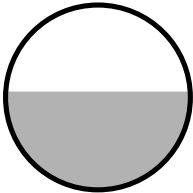
Summary for Reach 1R: CB2 TO DMH8

Inflow Area = 0.357 ac, 0.00% Impervious, Inflow Depth > 2.98" for 10 YEAR event
Inflow = 1.96 cfs @ 11.95 hrs, Volume= 0.089 af
Outflow = 1.91 cfs @ 11.95 hrs, Volume= 0.089 af, Atten= 2%, Lag= 0.3 min
Routed to Reach 2R : DMH8 TO DMH1

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.58 fps, Min. Travel Time= 0.2 min
Avg. Velocity = 1.40 fps, Avg. Travel Time= 0.7 min

Peak Storage= 26 cf @ 11.95 hrs
Average Depth at Peak Storage= 0.53' , Surface Width= 1.00'
Bank-Full Depth= 1.00' Flow Area= 0.8 sf, Capacity= 3.50 cfs

12.0" Round Pipe
n= 0.013 Corrugated PE, smooth interior
Length= 62.0' Slope= 0.0097 '/
Inlet Invert= 86.70', Outlet Invert= 86.10'



140 HAVERHILL STREET PIPE DESIGN

Type II 24-hr 10 YEAR Rainfall=5.10"

Prepared by {enter your company name here}

Printed 10/1/2024

HydroCAD® 10.10-7b s/n 02248 © 2022 HydroCAD Software Solutions LLC

Page 3

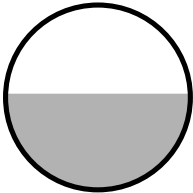
Summary for Reach 2R: DMH8 TO DMH1

Inflow Area = 0.357 ac, 0.00% Impervious, Inflow Depth > 2.98" for 10 YEAR event
Inflow = 1.91 cfs @ 11.95 hrs, Volume= 0.089 af
Outflow = 1.85 cfs @ 11.96 hrs, Volume= 0.089 af, Atten= 3%, Lag= 0.6 min
Routed to Reach 4R : DMH1 TO DMH2

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.58 fps, Min. Travel Time= 0.4 min
Avg. Velocity = 1.42 fps, Avg. Travel Time= 1.2 min

Peak Storage= 42 cf @ 11.96 hrs
Average Depth at Peak Storage= 0.52' , Surface Width= 1.00'
Bank-Full Depth= 1.00' Flow Area= 0.8 sf, Capacity= 3.55 cfs

12.0" Round Pipe
n= 0.013 Corrugated PE, smooth interior
Length= 101.0' Slope= 0.0099 '/'
Inlet Invert= 86.00', Outlet Invert= 85.00'



140 HAVERHILL STREET PIPE DESIGN

Type II 24-hr 10 YEAR Rainfall=5.10"

Prepared by {enter your company name here}

Printed 10/1/2024

HydroCAD® 10.10-7b s/n 02248 © 2022 HydroCAD Software Solutions LLC

Page 4

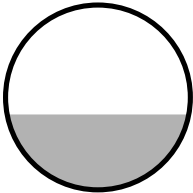
Summary for Reach 3R: CB1 TO DMH 1

Inflow Area = 0.171 ac, 100.00% Impervious, Inflow Depth > 4.86" for 10 YEAR event
Inflow = 1.20 cfs @ 11.96 hrs, Volume= 0.069 af
Outflow = 1.19 cfs @ 11.97 hrs, Volume= 0.069 af, Atten= 2%, Lag= 0.4 min
Routed to Reach 4R : DMH1 TO DMH2

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.99 fps, Min. Travel Time= 0.2 min
Avg. Velocity = 1.20 fps, Avg. Travel Time= 0.7 min

Peak Storage= 16 cf @ 11.97 hrs
Average Depth at Peak Storage= 0.41' , Surface Width= 0.98'
Bank-Full Depth= 1.00' Flow Area= 0.8 sf, Capacity= 3.46 cfs

12.0" Round Pipe
n= 0.013 Corrugated PE, smooth interior
Length= 53.0' Slope= 0.0094 '/
Inlet Invert= 85.50', Outlet Invert= 85.00'



140 HAVERHILL STREET PIPE DESIGN

Type II 24-hr 10 YEAR Rainfall=5.10"

Prepared by {enter your company name here}

Printed 10/1/2024

HydroCAD® 10.10-7b s/n 02248 © 2022 HydroCAD Software Solutions LLC

Page 5

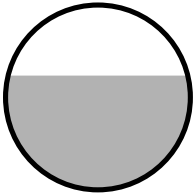
Summary for Reach 4R: DMH1 TO DMH2

Inflow Area = 0.528 ac, 32.34% Impervious, Inflow Depth > 3.58" for 10 YEAR event
Inflow = 3.04 cfs @ 11.96 hrs, Volume= 0.158 af
Outflow = 3.02 cfs @ 11.97 hrs, Volume= 0.158 af, Atten= 1%, Lag= 0.2 min
Routed to Reach 5R : DMH2 TO DMH3

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.94 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 1.72 fps, Avg. Travel Time= 0.3 min

Peak Storage= 17 cf @ 11.97 hrs
Average Depth at Peak Storage= 0.62' , Surface Width= 0.97'
Bank-Full Depth= 1.00' Flow Area= 0.8 sf, Capacity= 4.32 cfs

12.0" Round Pipe
n= 0.013 Corrugated PE, smooth interior
Length= 34.0' Slope= 0.0147 '/
Inlet Invert= 85.00', Outlet Invert= 84.50'



140 HAVERHILL STREET PIPE DESIGN

Type II 24-hr 10 YEAR Rainfall=5.10"

Prepared by {enter your company name here}

Printed 10/1/2024

HydroCAD® 10.10-7b s/n 02248 © 2022 HydroCAD Software Solutions LLC

Page 6

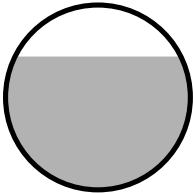
Summary for Reach 5R: DMH2 TO DMH3

Inflow Area = 0.748 ac, 52.28% Impervious, Inflow Depth > 3.92" for 10 YEAR event
Inflow = 3.20 cfs @ 11.97 hrs, Volume= 0.244 af
Outflow = 3.17 cfs @ 11.97 hrs, Volume= 0.244 af, Atten= 1%, Lag= 0.3 min
Routed to Reach 8R : DMH3 TO DMH4

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.36 fps, Min. Travel Time= 0.2 min
Avg. Velocity = 1.16 fps, Avg. Travel Time= 0.4 min

Peak Storage= 29 cf @ 11.97 hrs
Average Depth at Peak Storage= 0.90' , Surface Width= 1.12'
Bank-Full Depth= 1.25' Flow Area= 1.2 sf, Capacity= 3.67 cfs

15.0" Round Pipe
n= 0.013 Corrugated PE, smooth interior
Length= 31.0' Slope= 0.0032 '/
Inlet Invert= 84.25', Outlet Invert= 84.15'



140 HAVERHILL STREET PIPE DESIGN

Type II 24-hr 10 YEAR Rainfall=5.10"

Prepared by {enter your company name here}

Printed 10/1/2024

HydroCAD® 10.10-7b s/n 02248 © 2022 HydroCAD Software Solutions LLC

Page 7

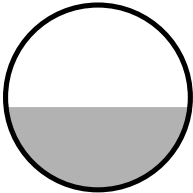
Summary for Reach 6R: CB3A TO DMH3

Inflow Area = 0.187 ac, 100.00% Impervious, Inflow Depth > 4.86" for 10 YEAR event
Inflow = 1.50 cfs @ 11.90 hrs, Volume= 0.076 af
Outflow = 1.48 cfs @ 11.90 hrs, Volume= 0.076 af, Atten= 1%, Lag= 0.1 min
Routed to Reach 8R : DMH3 TO DMH4

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.40 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 1.27 fps, Avg. Travel Time= 0.3 min

Peak Storage= 8 cf @ 11.90 hrs
Average Depth at Peak Storage= 0.45' , Surface Width= 0.99'
Bank-Full Depth= 1.00' Flow Area= 0.8 sf, Capacity= 3.63 cfs

12.0" Round Pipe
n= 0.013 Corrugated PE, smooth interior
Length= 25.0' Slope= 0.0104 '/
Inlet Invert= 84.61', Outlet Invert= 84.35'



140 HAVERHILL STREET PIPE DESIGN

Type II 24-hr 10 YEAR Rainfall=5.10"

Prepared by {enter your company name here}

Printed 10/1/2024

HydroCAD® 10.10-7b s/n 02248 © 2022 HydroCAD Software Solutions LLC

Page 8

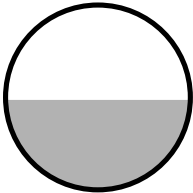
Summary for Reach 7R: CB3 TO DMH3

Inflow Area = 0.187 ac, 100.00% Impervious, Inflow Depth > 4.86" for 10 YEAR event
Inflow = 1.49 cfs @ 11.90 hrs, Volume= 0.076 af
Outflow = 1.48 cfs @ 11.90 hrs, Volume= 0.076 af, Atten= 1%, Lag= 0.1 min
Routed to Reach 8R : DMH3 TO DMH4

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.93 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 1.15 fps, Avg. Travel Time= 0.2 min

Peak Storage= 5 cf @ 11.90 hrs
Average Depth at Peak Storage= 0.49' , Surface Width= 1.00'
Bank-Full Depth= 1.00' Flow Area= 0.8 sf, Capacity= 3.12 cfs

12.0" Round Pipe
n= 0.013 Corrugated PE, smooth interior
Length= 13.0' Slope= 0.0077 '/
Inlet Invert= 84.45', Outlet Invert= 84.35'



140 HAVERHILL STREET PIPE DESIGN

Type II 24-hr 10 YEAR Rainfall=5.10"

Prepared by {enter your company name here}

Printed 10/1/2024

HydroCAD® 10.10-7b s/n 02248 © 2022 HydroCAD Software Solutions LLC

Page 9

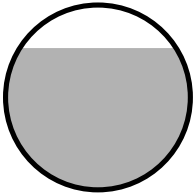
Summary for Reach 8R: DMH3 TO DMH4

Inflow Area = 1.308 ac, 72.72% Impervious, Inflow Depth > 4.32" for 10 YEAR event
Inflow = 6.98 cfs @ 11.92 hrs, Volume= 0.471 af
Outflow = 6.89 cfs @ 11.93 hrs, Volume= 0.471 af, Atten= 1%, Lag= 0.8 min
Routed to Reach 9R : DMH4 TO DMH5

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.76 fps, Min. Travel Time= 0.4 min
Avg. Velocity = 1.62 fps, Avg. Travel Time= 1.0 min

Peak Storage= 149 cf @ 11.93 hrs
Average Depth at Peak Storage= 1.15' , Surface Width= 1.27'
Bank-Full Depth= 1.50' Flow Area= 1.8 sf, Capacity= 7.43 cfs

18.0" Round Pipe
n= 0.013 Corrugated PE, smooth interior
Length= 102.0' Slope= 0.0050 '/'
Inlet Invert= 83.71', Outlet Invert= 83.20'



140 HAVERHILL STREET PIPE DESIGN

Type II 24-hr 10 YEAR Rainfall=5.10"

Prepared by {enter your company name here}

Printed 10/1/2024

HydroCAD® 10.10-7b s/n 02248 © 2022 HydroCAD Software Solutions LLC

Page 10

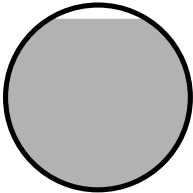
Summary for Reach 9R: DMH4 TO DMH5

Inflow Area = 1.796 ac, 80.12% Impervious, Inflow Depth > 4.47" for 10 YEAR event
Inflow = 7.79 cfs @ 11.93 hrs, Volume= 0.669 af
Outflow = 7.64 cfs @ 11.94 hrs, Volume= 0.668 af, Atten= 2%, Lag= 0.7 min
Routed to Reach 13R : DMH5 TO JELLYFISH

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.61 fps, Min. Travel Time= 0.4 min
Avg. Velocity = 1.76 fps, Avg. Travel Time= 1.0 min

Peak Storage= 185 cf @ 11.94 hrs
Average Depth at Peak Storage= 1.39' , Surface Width= 0.79'
Bank-Full Depth= 1.50' Flow Area= 1.8 sf, Capacity= 7.15 cfs

18.0" Round Pipe
n= 0.013 Corrugated PE, smooth interior
Length= 108.0' Slope= 0.0046 '/'
Inlet Invert= 83.10', Outlet Invert= 82.60'



140 HAVERHILL STREET PIPE DESIGN

Type II 24-hr 10 YEAR Rainfall=5.10"

Prepared by {enter your company name here}

Printed 10/1/2024

HydroCAD® 10.10-7b s/n 02248 © 2022 HydroCAD Software Solutions LLC

Page 11

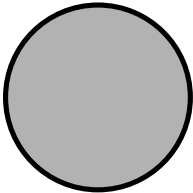
Summary for Reach 10R: CB4 TO DMH4

Inflow Area = 0.487 ac, 100.00% Impervious, Inflow Depth > 4.86" for 10 YEAR event
Inflow = 3.81 cfs @ 11.90 hrs, Volume= 0.197 af
Outflow = 0.90 cfs @ 11.70 hrs, Volume= 0.197 af, Atten= 76%, Lag= 0.0 min
Routed to Reach 9R : DMH4 TO DMH5

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.86 fps, Min. Travel Time= 0.3 min
Avg. Velocity = 1.42 fps, Avg. Travel Time= 0.5 min

Peak Storage= 16 cf @ 11.65 hrs
Average Depth at Peak Storage= 0.67'
Bank-Full Depth= 0.67' Flow Area= 0.3 sf, Capacity= 0.90 cfs

8.0" Round Pipe
n= 0.013 Corrugated PE, smooth interior
Length= 45.0' Slope= 0.0056 '/
Inlet Invert= 83.55', Outlet Invert= 83.30'



140 HAVERHILL STREET PIPE DESIGN

Type II 24-hr 10 YEAR Rainfall=5.10"

Prepared by {enter your company name here}

Printed 10/1/2024

HydroCAD® 10.10-7b s/n 02248 © 2022 HydroCAD Software Solutions LLC

Page 12

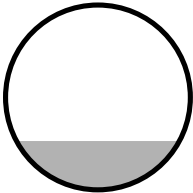
Summary for Reach 11R: CB6 TO DMH5

Inflow Area = 0.191 ac, 100.00% Impervious, Inflow Depth > 4.86" for 10 YEAR event
Inflow = 1.53 cfs @ 11.90 hrs, Volume= 0.077 af
Outflow = 1.52 cfs @ 11.90 hrs, Volume= 0.077 af, Atten= 1%, Lag= 0.1 min
Routed to Reach 13R : DMH5 TO JELLYFISH

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 9.28 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 2.64 fps, Avg. Travel Time= 0.2 min

Peak Storage= 6 cf @ 11.90 hrs
Average Depth at Peak Storage= 0.26' , Surface Width= 0.88'
Bank-Full Depth= 1.00' Flow Area= 0.8 sf, Capacity= 10.11 cfs

12.0" Round Pipe
n= 0.013 Corrugated PE, smooth interior
Length= 36.0' Slope= 0.0806 '/
Inlet Invert= 86.00', Outlet Invert= 83.10'



140 HAVERHILL STREET PIPE DESIGN

Type II 24-hr 10 YEAR Rainfall=5.10"

Prepared by {enter your company name here}

Printed 10/1/2024

HydroCAD® 10.10-7b s/n 02248 © 2022 HydroCAD Software Solutions LLC

Page 13

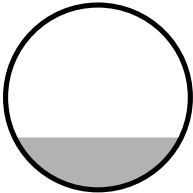
Summary for Reach 12R: CB5 TO DMH4

Inflow Area = 0.187 ac, 100.00% Impervious, Inflow Depth > 4.86" for 10 YEAR event
Inflow = 1.51 cfs @ 11.90 hrs, Volume= 0.076 af
Outflow = 1.50 cfs @ 11.90 hrs, Volume= 0.076 af, Atten= 1%, Lag= 0.1 min
Routed to Reach 8R : DMH3 TO DMH4

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 8.28 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 2.35 fps, Avg. Travel Time= 0.3 min

Peak Storage= 7 cf @ 11.90 hrs
Average Depth at Peak Storage= 0.28' , Surface Width= 0.90'
Bank-Full Depth= 1.00' Flow Area= 0.8 sf, Capacity= 8.67 cfs

12.0" Round Pipe
n= 0.013 Corrugated PE, smooth interior
Length= 37.0' Slope= 0.0592 '/
Inlet Invert= 85.79', Outlet Invert= 83.60'



140 HAVERHILL STREET PIPE DESIGN

Type II 24-hr 10 YEAR Rainfall=5.10"

Prepared by {enter your company name here}

Printed 10/1/2024

HydroCAD® 10.10-7b s/n 02248 © 2022 HydroCAD Software Solutions LLC

Page 14

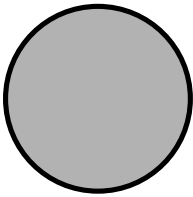
Summary for Reach 13R: DMH5 TO JELLYFISH

Inflow Area = 1.987 ac, 82.04% Impervious, Inflow Depth > 4.51" for 10 YEAR event
Inflow = 8.97 cfs @ 11.93 hrs, Volume= 0.746 af
Outflow = 7.96 cfs @ 12.03 hrs, Volume= 0.746 af, Atten= 11%, Lag= 6.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 4.56 fps, Min. Travel Time= 0.0 min
Avg. Velocity = 1.80 fps, Avg. Travel Time= 0.1 min

Peak Storage= 19 cf @ 11.90 hrs
Average Depth at Peak Storage= 1.50'
Bank-Full Depth= 1.50' Flow Area= 1.8 sf, Capacity= 7.08 cfs

18.0" Round Pipe
n= 0.013 Corrugated PE, smooth interior
Length= 11.0' Slope= 0.0045 '/
Inlet Invert= 82.60', Outlet Invert= 82.55'



140 HAVERHILL STREET PIPE DESIGN

Type II 24-hr 10 YEAR Rainfall=5.10"

Prepared by {enter your company name here}

Printed 10/1/2024

HydroCAD® 10.10-7b s/n 02248 © 2022 HydroCAD Software Solutions LLC

Page 15

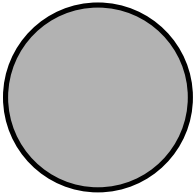
Summary for Reach 14R: CB10 TO DMH9

Inflow Area = 0.135 ac, 100.00% Impervious, Inflow Depth > 4.86" for 10 YEAR event
Inflow = 1.10 cfs @ 11.89 hrs, Volume= 0.055 af
Outflow = 0.84 cfs @ 11.92 hrs, Volume= 0.055 af, Atten= 24%, Lag= 1.5 min
Routed to Reach 15R : DMH9 TO JELLYFISH FILTER

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.72 fps, Min. Travel Time= 0.7 min
Avg. Velocity = 0.93 fps, Avg. Travel Time= 1.9 min

Peak Storage= 38 cf @ 11.93 hrs
Average Depth at Peak Storage= 0.67'
Bank-Full Depth= 0.67' Flow Area= 0.3 sf, Capacity= 0.83 cfs

8.0" Round Pipe
n= 0.013 Corrugated PE, smooth interior
Length= 107.0' Slope= 0.0048 '/'
Inlet Invert= 100.52', Outlet Invert= 100.01'



140 HAVERHILL STREET PIPE DESIGN

Type II 24-hr 10 YEAR Rainfall=5.10"

Prepared by {enter your company name here}

Printed 10/1/2024

HydroCAD® 10.10-7b s/n 02248 © 2022 HydroCAD Software Solutions LLC

Page 16

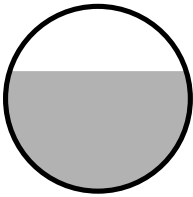
Summary for Reach 15R: DMH9 TO JELLYFISH FILTER

Inflow Area = 0.258 ac, 100.00% Impervious, Inflow Depth > 4.86" for 10 YEAR event
Inflow = 1.82 cfs @ 11.90 hrs, Volume= 0.104 af
Outflow = 1.79 cfs @ 11.91 hrs, Volume= 0.104 af, Atten= 2%, Lag= 0.6 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 3.36 fps, Min. Travel Time= 0.4 min
Avg. Velocity = 1.05 fps, Avg. Travel Time= 1.3 min

Peak Storage= 43 cf @ 11.90 hrs
Average Depth at Peak Storage= 0.65' , Surface Width= 0.95'
Bank-Full Depth= 1.00' Flow Area= 0.8 sf, Capacity= 2.41 cfs

12.0" Round Pipe
n= 0.013 Corrugated PE, smooth interior
Length= 79.0' Slope= 0.0046 '/
Inlet Invert= 99.91', Outlet Invert= 99.55'



140 HAVERHILL STREET PIPE DESIGN

Type II 24-hr 10 YEAR Rainfall=5.10"

Prepared by {enter your company name here}

Printed 10/1/2024

HydroCAD® 10.10-7b s/n 02248 © 2022 HydroCAD Software Solutions LLC

Page 17

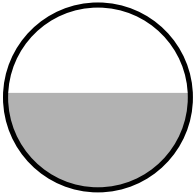
Summary for Reach 17R: CB9 TO DMH9

Inflow Area = 0.122 ac, 100.00% Impervious, Inflow Depth > 4.86" for 10 YEAR event
Inflow = 0.99 cfs @ 11.89 hrs, Volume= 0.049 af
Outflow = 0.99 cfs @ 11.89 hrs, Volume= 0.049 af, Atten= 1%, Lag= 0.1 min
Routed to Reach 15R : DMH9 TO JELLYFISH FILTER

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Max. Velocity= 5.34 fps, Min. Travel Time= 0.1 min
Avg. Velocity = 1.56 fps, Avg. Travel Time= 0.2 min

Peak Storage= 3 cf @ 11.89 hrs
Average Depth at Peak Storage= 0.35', Surface Width= 0.67'
Bank-Full Depth= 0.67' Flow Area= 0.3 sf, Capacity= 1.83 cfs

8.0" Round Pipe
n= 0.013 Corrugated PE, smooth interior
Length= 17.0' Slope= 0.0229 '/
Inlet Invert= 100.40', Outlet Invert= 100.01'





RANGER ENGINEERING GROUP, INC.
130 Main Street Suite 202
Salem, NH 03079
Tel: 978-208-1762
www.rangereng.com

Underground Detention System Buoyancy Calculations

Overall size of detention system = 75' long x 45' wide x 2.75' tall = 9,281 cubic feet.

Calculate Uplift

Weight of water displaced = 75' x 45' x 2.75' x 62.4 pounds /cubic foot (weight of water)

Uplift force = 79,150 pounds

Calculate weight of system when system is dry

System uses 7563 cubic feet of stone. (From Hydrocad Wizard)

Stone voids = 40%.

Convert cubic feet of stone to equivalent volume of solid stone = 7563 x 0.60 = 4,538 cubic feet of stone

Weight of stone = 4,538 x 150 pounds per cubic foot = 680,670 pounds

Weight of stone in the system is greater than the weight of water being displaced. The weight of the stone will counteract the uplift force of the water. The system will not float.
