Section 4

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SECTION 4

HYDRAULIC MODELING

4.1 INTRODUCTION AND MODELING SOFTWARE

One component of the development of the Sewer Master Plan was the development of a sewer system hydraulic model. Because a system-wide hydraulic model requires significant effort, including accurate vertical data on the collection system as well as extensive flow monitoring, the Town selected a limited area for hydraulic modeling as part of the Master Plan development. While the extent of the model developed to date is limited, the Town will be able to expand the model and use it to evaluate the impacts of proposed development on existing infrastructure in the future.

The Town requested that the model be used to evaluate how increased flow rates from select proposed projects discussed in Section 3 would impact the existing interceptors in these areas. Specifically, the Town selected the Souhegan River interceptor and the Baboosic Brook interceptor for modeling as part of the Sewer Master Plan development.

InfoSWMM by Innovyze was selected to develop the working hydraulic model. InfoSWMM is a fully ArcGIS integrated dynamic rainfall-runoff simulation model. It allows the user to create, edit, modify, run, map, analyze, and design sewer network models and instantly review, query and display simulation results from within ArcGIS. InfoSWMM is run as an extension within the ArcGIS program.

InfoSWMM runs the most recent version of the EPA SWMM5.0 computational engine, and as such, is capable of accounting for various hydrologic and hydraulic processes such as:

- Time-varying rainfall
- Routing direct runoff, dry weather flows, and external inflows
- Using a wide variety of standard closed and open conduit shapes, model flow dividers, pumps, weirs, and orifices
- Applying external flows from surface runoff, RDII, and dry weather sanitary flow

- Modeling backwater, reverse flow, surcharging, surface ponding, and tidal effects on the system

4.2 DATA COLLECTION

4.2.1 Hydraulic Data

The model was developed using GIS data supplemented and updated with record drawing data. The following data was obtained and reviewed:

- Arc-GIS shape file data for the entire sewer system from the Town of Merrimack containing manhole and pipe descriptions, identifications, locations, and rim and invert elevations
- Sewer system drawings from the Town of Merrimack entitled Woodland Park Sewers River Crossing, containing data on the Conifer Street Siphon
- Arc-GIS aerial imagery obtained from the National Agriculture Imagery Program (NAIP)
- Base mapping data obtained from the Town of Merrimack

An initial review of the data determined that a number of rim and invert elevations were incorrect or missing throughout the collection system. After reviewing original drawings, the Town was able to provide updated data for the two interceptor sewers for input into the model. Updated data for the remaining system was not available at the time of this Plan.

As such, a working hydraulic model was created for the two interceptor sewers, for which a complete data set was available. Once data has been provided to fill the remaining gaps in the GIS data set, the entire collection system can be populated into the InfoSWMM model as part of a future effort.

For this analysis, the hydraulic portion of the InfoSWMM model consists of the following system entities:

- Pipe Data
    - Length

  - Diameter
  - Slope
  - Material
- Manhole Data
  - Invert Elevations
  - Depth of Cover (provides ground surface elevation)

Overall, the InfoSWMM model for the two interceptors contains 138 Nodes (manholes) and 136 Links (pipes) for a total of 30,235 linear feet. A schematic of the InfoSWMM model for the Souhegan River and Baboosic Brook interceptors is shown in Figure E-1 in Appendix E.

4.2.2 System Flow Meter Data

As part of the Sewer Master Plan development, sewer flow meters were installed and maintained by the Town at various points along the two interceptors as recommended by Wright-Pierce. The purpose of the flow metering was to determine existing wastewater flows within the collection system during dry and wet weather conditions.

Flow meter data from six separate manholes was used to establish existing condition flows within the modeled interceptors, including:

- Manhole 43403 – Cross country manhole near Beacon Drive (Souhegan River interceptor)
- Manhole 43107 – Manhole along Glenwood Lane (manhole is not part of modeled interceptor sewer, but flows into the Souhegan River interceptor at MH 43105)
- Manhole 435 – Manhole downstream of Conifer Street Siphon (Souhegan River interceptor)
- Manhole 406 – Manhole near bottom of Souhegan River interceptor
- Manhole 506 – Manhole near the bottom of Baboosic Brook interceptor
- Manhole 542 – Cross country manhole adjacent to Bramber Lane (Baboosic Brook interceptor)

The Souhegan River interceptor metering was performed during two separate periods using area-velocity style meters. Manholes 43403 and 43107 were metered between March 22, 2012 and May 7, 2012, and manholes 435 and 406 were metered between May 18, 2012 and August 9, 2012. The Baboosic Brook interceptor metering at MH 506 was performed between September 12, 2012 and September 24, 2012, and between October 3, 2012 and October 23, 2012 at MH 542. Unfortunately, the data collected at MH 506 was deemed unusable as the flows appear to have been below the minimum tolerance for the flow meter to capture, likely due to the large pipe diameter.

Several small rain events were observed throughout the metering periods; however, the meters showed that the sewer system in these areas experience no responses to rainfall. The meter located in manhole 406 captured flows during a larger rain event on June 2, 2012 (1.5 inches in 24 hours), but the meter showed no response to the rain event. The results of the flow metering efforts are summarized in Table 4-1. Hydrographs of the flow metering data have also been included in Appendix E as Figures E-2 through E-6.

TABLE 4-1: FLOW METER SUMMARY

Meter Number	Meter Location	Metering Period	Average Daily Flow (MGD)	Peak Flow (MGD)	Peaking Factor
1	MH 43403	3/23/12 to 4/5/12	0.019	0.048	2.5
2	MH 43107	3/22/12 to 5/7/12	0.079	0.269	3.7
3	MH 435	6/6/12 to 8/9/12	0.173	0.381	2.2
4	MH 406	5/18/12 to 8/6/12	0.457	0.838	1.8
5	MH 542	10/3/12 to 10/23/12	0.185	0.479	2.6

4.2.3 Existing Condition Flows

As noted in the previous section, flow metering showed that the sewer system in the metered areas experiences little to no response to rainfall events which indicates minimal inflow or infiltration related to wet weather. In fact, peak instantaneous flows observed in the system throughout the metering efforts occurred on days with no rainfall.

As a result of this observation, hydrologic modeling was not required to estimate rainfall dependent inflow and infiltration in the system. Instead, constant peak flow rates observed at each meter were directly entered into the hydraulic portion of the model to estimate existing base flow conditions. Table 4-2 summarizes the existing base flow rates and locations added to the model.

TABLE 4-2: INFOSWMM BASE FLOW ALLOCATIONS

Interceptor	Model Insertion Manhole	Meters Referenced	Peak Flow Rate (MGD)
Souhegan	MH 43454	Meter 1	0.05
Souhegan	MH 43105	Meter 2	0.27
Souhegan	MH 435	Meter 3 and 4	0.52
Baboosic Brook	MH 543	Meter 5	0.48
Baboosic Brook	MH 535	Meter 5	0.10(1)
Baboosic Brook	MH 530	Meter 5	0.13(1)
Baboosic Brook	MH 518	Meter 5	0.19(1)
Baboosic Brook	MH 511	Meter 5	0.66(1)

Notes:

1. Meter data not available, flow rate estimated based on number of units and peaking factor observed at Meter 5.

The amount of meter data available at the time this model was created was fairly limited. The most accurate and well-calibrated hydraulic models are based on extensive flow data collected over time through various seasons and peak flow events (i.e. flows generated during wet weather or special events such as a holiday or Super Bowl Sunday). While this is a good start, it is highly recommended that the Town continue with their flow monitoring efforts.

Additionally, due to the low existing flows and the large pipe size on the lower part of the interceptor, flow meter data along the Baboosic Brook interceptor was only available for the upper half of the tributary area. In this instance, the existing condition base flow rates for the lower half of the tributary area were estimated based on the number of units contributing flow in each tributary area and then adjusted based on the system peaking factors and patterns observed at upstream locations (this is the same method that was used to estimate the proposed project flows as described in Section 3.5).

4.2.4 Future Condition Flows

The InfoSWMM model for the two interceptors also considered potential future flow rates that would be added to the system if the projects proposed in Section 3 are constructed.

4.2.4.1 Souhegan River Interceptor

For the Souhegan River interceptor, future projected flows were input into the model at four locations along the interceptor as follows:

- Manhole 43442: Flows from Projects 8, 17, 22, 31, 35, 36, 37 and 38
- Manhole 43439: Flows from Project 2
- Manhole 43406: Flows from Project 3
- Manhole 431: Flows from Projects 16 and 25

Section 3 of this report describes the procedures used to determine the potential future peak daily flow rates generated by each of these areas. These flow rates were used to create typical daily diurnal pattern hydrographs in 15-minute increments for each area. A diurnal pattern corresponds with water usage during a typical weekday or weekend day, where instantaneous flow rates typically peak around 6:00 or 7:00 a.m. with a smaller secondary peak around 8:00 p.m. The individual hydrographs were created for each area using a similar pattern to those observed in the interceptor sewer meter data. These hydrographs were inserted into the model as additional flow rates to the existing flows previously discussed. Table 4-3 provides a summary of these additional flows rates.

TABLE 4-3: INFOSWMM FUTURE FLOW ALLOCATIONS FOR THE SOUHEGAN RIVER INTERCEPTOR

Future Flow Area	Model Insertion Manhole	Daily Flow Rate (MGD)	Peak Instantaneous Flow Rate (MGD)
Projects 8, 17, 22, 31, 35, 36, 37 and 38	MH 43442	0.525	0.795
Project 2	MH 43439	0.098	0.149
Project 3	MH 43406	0.031	0.047
Projects 16 and 25	MH 431	0.052	0.079

4.2.4.2 Baboosic Brook Interceptor

A similar approach was taken for the Baboosic Brook interceptor portion of the model to determine potential impacts from future flows. Future flows were input into the model at four locations along the interceptor as follows:

- Manhole 546: Projects 20 and 32
- Manhole 540: Projects 5, 6, 10, 23, 24, 28 and 33
- Manhole 518: Projects 9 and 26
- Manhole 526: Projects 14, 15, 19 and 21

Individual hydrographs were created using the same procedures described for the Souhegan River interceptor. Table 4-4 provides a summary of these flow rates.

TABLE 4-4: INFOSWMM FUTURE FLOW ALLOCATIONS FOR THE BABOOSIC BROOK INTERCEPTOR

Future Flow Area	Model Insertion Manhole	Daily Flow Rate (MGD)	Peak Instantaneous Flow Rate (MGD)
Projects 20 and 32	MH 546	0.040	0.089
Projects 5, 6, 10, 23, 24, 28 and 33	MH 540	0.122	0.274
Projects 9 and 26	MH 518	0.157	0.352
Projects 14, 15, 19 and 21	MH 526	0.060	0.134

4.3 INFOSWMM HYDRAULIC MODELING RESULTS

4.3.1 Existing Condition Performance – Souhegan River Interceptor

The InfoSWMM model was run with the listed base flow allocations (Table 4-2) to establish the existing condition performance for the Souhegan River interceptor. The existing conditions model run predicted that the interceptor, under the peak flow assumptions, is operating at approximately 6% to 33% of its full flow depth, both above and below the Conifer Street siphon. Peak flows predicted for existing conditions were 0.32 MGD upstream of the siphon and 0.84 MGD at the downstream end of the interceptor. Table 4-5 summarizes model predictions versus actual meter peak flows for existing conditions. Figure E-7 in Appendix E shows the existing condition hydraulic grade line (HGL) profile of the entire modeled Souhegan River interceptor.

TABLE 4-5: MODEL VS. METER EXISTING CONDITIONS FLOW RATES

Meter Location	Metered Peak (MGD)	Modeled Peak (MGD)	% Difference
MH 43403	0.048	0.048	0%
MH 435	0.381	0.381	0%
MH 406	0.838	0.838	0%
MH 542	0.479	0.480	0.2%

The model was also run to estimate the existing capacity of the Conifer Street siphon. For the purposes of this model, the capacity of the siphon is considered to have been reached when the water surface elevation in the upstream siphon influent chamber (MH 43101) reaches the elevation of the shelf in the structure, 2.27 feet above the invert of the siphon. The estimated capacity of the siphon is also dependent on several other factors and assumptions. The GIS data (and subsequent supplemental information) obtained from the Town indicates that the siphon discharge structure (MH 437) has identical invert in and invert out elevations of 173.23 feet. However, the construction plans of the siphon structure indicate that the siphon drains into MH 437 at an elevation that is 0.75 feet above the invert of the structure, or 173.98 feet. This difference in elevation has the potential to change the estimated capacity of the siphon by approximately 0.21 MGD.

Table 4-6 summarizes the predicted capacity of the siphon under both conditions (it should be noted that additional flow beyond what is shown in Table 4-6 could pass through the siphon if the upstream water surface elevation was allowed to rise above the table of the upstream siphon structure noted in the previous paragraph). Figure E-8 in Appendix E shows the HGL profile of the siphon under the projected peak capacity conditions. It should be noted that the estimated low end peak capacity of the Conifer Street siphon indicated in Table 4-6 roughly confirms

Keach-Nordstrom Associates, Inc.'s (KNA) capacity estimate of 1.204 from 1998[1].

TABLE 4-6: INFOSWMM PEAK FLOW CAPACITY CONIFER STREET SIPHON

Assumed Invert Out (feet)	Predicted Siphon Capacity (MGD)	Capacity of Siphon Currently Utilized[(1)]
173.98	1.242	25.8%
173.23	1.454	22.0%

Notes:
1. This column is calculated by dividing the existing peak flow rate for the siphon of 0.32 MGD (as discussed at the beginning of this section) by the predicted siphon capacities noted in the second column.

Both 6-inch pipes of the siphon were assumed to be online and completely clean for this analysis.

4.3.2 Existing Condition Performance – Baboosic Brook Interceptor

The model was run with the listed base flow allocations (Table 4-2) to establish the existing condition performance for the Baboosic Brook interceptor. The existing conditions model run predicted that under the peak flow assumptions, the interceptor is operating at approximately 18% to 44% of its full flow depth. Table 4-5 summarizes model predictions versus actual meter peak flows for existing conditions at MH 542. Figure E-9 in Appendix E, shows the existing condition HGL profile of the entire modeled Baboosic Brook interceptor.

4.3.3 Future Condition Performance – Souhegan River Interceptor

After the baseline performance of the interceptor was established, the model was run with the future flow hydrographs to determine the impacts that upstream developments may have on the Souhegan River interceptor. Downstream of the Conifer Street siphon, the model predicts peak flows of approximately 1.80 MGD, causing the sewers in this section to operate at levels that are still generally below the 50% full flow depth. Upstream of the siphon, the model predicts peak flow rates that range from 0.8 to 1.21 MGD, causing the system in this section to operate at

[1] Sewer Study for J.W.F. Real Estate & Development Corp., Baboosic Lake Road, Merrimack, New Hampshire; August 31, 1998; Keach-Nordstrom Associates, Inc.

levels that range from 10% to 60% of its full flow depth. Figure E-10 in Appendix E shows the future condition HGL profile of the entire modeled Souhegan River interceptor. Table 4-7, also in Appendix E, compares the maximum full flow depths of the Souhegan River interceptor to the projected peak flows (d/D).

At the Conifer Street siphon, the model predicts a peak future flow rate of 1.21 MGD, which is just under the model-calculated low-end capacity of the siphon of 1.24 MGD. This causes the upstream siphon chamber to reach a maximum water surface elevation of 184.18 feet, or a depth of 1.69 feet, approximately 0.58 feet below the shelf of the structure. This in turn causes the pipe run just upstream of the siphon (segment 43103 to 43101) to surcharge slightly (under 2.5 inches in the manholes directly upstream of the siphon) due to backwater, under peak flow conditions. This is the only pipe segment to surcharge under future flow conditions.

It should be noted that the existing peak flow of 0.32 MGD and the projected future peak flow of 1.21 MGD are considerably lower than estimated in the KNA analysis (existing 1998 peak flow of 0.818 MGD; projected future peak flow of 3.317 MGD, which is almost half of the current peak flow for the entire Town). The reasons for the discrepancy between the estimates are as follows:

- KNA used an average daily flow assumption of 80 GPD/Capita with population projections for that area from the 1997 Facilities Plan[2] which turned out to be extremely high compared to actual Town population of 45,460 in 2000 (which is 180% higher than the actual population at that time). W-P used an average daily flow assumption of 210 GPD/Parcel (70 GPD/Capita and three people per parcel) and estimated the actual number of parcels that would be served by the future projects. As the population projections were extremely inflated, KNA's projected average daily flow was also inflated.
- KNA estimated the existing peak flows at the time using standard design values. W-P used actual flow meter data provided by the Town.

[2] Facilities Plan for Interceptors and Trunk Sewers, Merrimack, NH, February 1977, Hamilton Engineering Associates

- KNA used an infiltration flow assumption of 150 GPD/acre and used the total acreage for the drainage area. W-P used an infiltration flow assumption of 300 GPD/In-Diam-Mi and the estimated the actual length of interceptor and collector sewer pipe. Although KNA's estimate is a standard approach, it also provides an extremely conservative infiltration estimate. (Example: Using KNA's method, a one acre parcel would have an infiltration estimate of 150 GPD. Using W-P's method, a one acre parcel with 100 linear feet of eight inch collector sewer in front of it would have an infiltration estimate of 95 GPD.)
- KNA assumed a constant peak flow rate along the entire pipe without taking into consideration that peak flows attenuate as they travel through the collection system (i.e. If a peak flow of 0.5 MGD was estimated for the Baboosic Lake area, the siphon, which is several miles downstream, would not see that same peak flow. Over time, it would attenuate). W-P used the InfoSWMM model which takes into account flow attenuation.

4.3.4 Future Condition Performance – Baboosic Brook Interceptor

After the baseline performance of the interceptor was established, the model was run with the future flow hydrographs to determine the impacts that future developments may have on the Baboosic Brook interceptor. The model predicts that future peak flows in the interceptor will range from 0.57 MGD in upstream sections to 2.31 MGD at the downstream end, causing the interceptor to operate at levels that are 22% to 48% of its full flow depth, meaning the pipes in the interceptor remain under half full for the duration of the model run. Figure E-11 in Appendix E shows the existing condition HGL profile of the entire modeled Baboosic Brook interceptor. Table 4-8, also in Appendix E, compares the maximum full flow depths of the Baboosic Brook interceptor to the projected peak flows (d/D).

4.4 INFOSWMM MODELING CONCLUSIONS

The purpose of the InfoSWMM model was to help evaluate the impacts that increases in flow rates from new developments would have on the Souhegan River and Baboosic Brook interceptors.

4.4.1 Souhegan River Interceptor

Much of the analysis for the Souhegan River interceptor revolved around the capacity of the Conifer Street siphon, which has been viewed as a potential choke point in the system. The existing conditions model run for the interceptor showed that the interceptor, including the siphon, was operating well under its peak full flow capacity. The capacity of the siphon was predicted by the model to be between 1.24 and 1.45 MGD.

The future conditions model run for the Souhegan River interceptor predicted that the interceptor was generally capable of accepting the projected future flows with some minor pipe surcharging predicted in the vicinity of the siphon. Future peak flows at the siphon were projected to be approximately 1.21 MGD, which is just under the predicted low end capacity of the siphon, indicating that the siphon would be capable of accepting the projected future flows. However, it should be noted that if the siphon was even partially clogged, it could cause a surcharge condition and possibly a sanitary sewer overflow. Additionally, as noted previously, the elevations in the GIS system are considerably different the than elevations shown on the plans which could have an effect on the capacity estimate of the siphon. As such, the Town may wish to perform the following additional investigation:

- Hire a surveyor to confirm the rim and invert elevations of the interceptor and the siphon and adjust the InfoSWMM model as needed.
- Install a flow meter upstream of the siphon over an extended period of time to confirm peak flows. The peak flow event used for the model occurred over the Fourth of July holiday weekend which is a good event to use for peak flow estimation; however the meter at the siphon was only installed for three months during the summer. It is possible that the siphon may see higher peak flows during another time of year (e.g. during the Super Bowl or during the school year as it is downstream of the middle school).
- Drain, clean and inspect each siphon barrel with closed-circuit TV equipment to confirm they are clean and in good condition. Continue with regular cleaning if and when actual flows begin to approach the estimated peak future flow.

4.4.2 Baboosic Brook Interceptor

The Baboosic Brook interceptor was also modeled for both existing and future condition flow rates. The model predicted that the interceptor was capable of accepting all future flows while remaining at under 50% peak full flow capacity.

4.4.3 Additional Considerations

It is important to consider that the InfoSWMM model for both interceptors was created using limited meter data. Peak flows from each of the metering periods was used to create what are believed to be conservative baseline flow conditions in the model; however, as previously noted, several assumptions and peaking factors were used (based on the flow meter data) in determining impacts from potential future condition flow rates.

It may also be prudent to consider verifying the rim and invert elevations used in the model via actual field survey. As noted, GIS data was used to build the initial segments of the model; however, due to breaks in the data, a number of edits were required based on additional information provided by the Town. As the Town indicated in their correspondence, multiple drawings sets were used to generate these changes to make the model work and some of the changes were based on drawing sets with different vertical datums.

Section 5

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SECTION 5

EXISTING INFRASTRUCTURE NEEDS AND COSTS

This section summarizes upgrades to the Town's existing collection system which will be required to provide additional capacity for the future proposed projects (presented in Section 3) or to address known existing problems. At the end of a Section, a summary of recommendations has been provided. With the exception of the capacity limitations noted in this section, the existing collector sewers and interceptors have adequate capacity to handle projected future flows. Additionally, Pearson Road Pump Station, Burt Street Pump Station and Heron Cove Pump Station appear to have adequate existing capacity and will not be affected by the proposed future projects, so an increase in pumping capacity will not be required. However, upgrades to these stations should be completed as needed to replace aging equipment.

5.1 CONIFER STREET SIPHON

As summarized in Section 4 of this Plan, the capacity of the Conifer Street siphon is approximately 1.24 MGD to 1.45 MGD which roughly confirms Keach-Nordstrom Associates, Inc.'s (KNA) capacity estimate of 1.204 from 1998[1]. Based on the assumptions discussed in Section 4, it appears that the siphon has adequate capacity to handle peak future flows.

5.2 EXECUTIVE PARK DRIVE TURNPIKE CROSSING

In the 1980's, when the Executive Park Drive area was being developed, the developer extended sewer from the east side of the F. E. Everett Turnpike beneath the turnpike and then cross-country adjacent to a stream. During construction, the developer constructed a temporary turnpike crossing by hanging the sewer pipe in an existing culvert which conveys stream flows beneath the turnpike with the intent to come back and jack under the highway for the final sewer crossing. However, the final crossing was never constructed and the sewer still runs under the

[1] Sewer Study for J.W.F. Real Estate & Development Corp., Baboosic Lake Road, Merrimack, New Hampshire; August 31, 1998; Keach-Nordstrom Associates, Inc.

turnpike through the culvert. Sewer was also later extended from Executive Park Drive to serve several neighborhoods on the south end of Turkey Hill Road.

Although capacity of the existing crossing is adequate to handle future peak projected flows and there have been no issues to date, the crossing is vulnerable to damage as it is directly adjacent to a stream which can swell considerably during spring months and wet weather events. If the interceptor in this area were ever damaged, it could have severe environmental impacts. Additionally, access to the crossing is very limited due to the steep grade and the distance from the road.

In order to minimize the potential for environmental damage and to address the accessibility issue, we would recommend that a pump station be constructed on Executive Park Drive. The station would collect sewage that drains to the crossing and pump it to the Continental Boulevard sewer where it would then flow to Thornton's Ferry Pump Station by gravity using another existing turnpike crossing. The estimated cost to construct the new pump station and approximately 1,800 linear feet of force main is $1,040,000.

We would strongly recommend that this issue be addressed as soon as possible and definitely prior to the construction of Projects 29, 30 and 34 (Project Grouping 4) or Project 27 which include sewer extensions that will drain to this turnpike crossing.

5.3 TURKEY HILL ROAD/BON AVENUE/BIGWOOD DRIVE/CROSS-COUNTRY GRAVITY SEWER

If Projects 27, 29, 30 and 34 are completely sewered as shown in Figure 3-1, projected flows to portions of the existing 8-inch diameter sewer on Turkey Hill Road, Bon Avenue, Bigwood Drive, and part of the cross country sewer to Executive Park Drive will likely be approaching or exceeding the capacity of the pipe. The GIS data indicates that several sections of this line were installed at less than minimum slope and one is completely flat. As such, we recommend that the Town conduct flow metering on Bigwood Drive to define existing flows and to determine the remaining capacity of the existing sewer prior to the design of the proposed projects.

An estimated cost to upsize the sewers in this area has not been provided as the extent of the work is unknown.

5.4 SOUHEGAN PUMP STATION

Based on existing flow data (refer to Section 2.5.3 for information on existing flows) and future flow projections for the areas draining to Souhegan Pump Station, it is estimated that the future peak instantaneous flow to the pump station could be approximately 2.48 MGD if all of the proposed projects are constructed. A summary of the future peak instantaneous flow calculation is included in Appendix D. (Note that the Underwood Engineers, Inc. evaluation[2] estimated a future peak flow to this station of about 3.0 MGD; however, this was determined by assuming a 30% increase in flows rather than considering actual potential future sewer extension projects as the information was not available at the time.) Underwood indicates that the pump station can pump flows as high as 2,000 GPM (2.88 MGD); however, it is unclear whether this flow rate is achieved with two or three pumps. Due to the age of the pumps and a concern about the station's ability to handle peak flows, the evaluation recommended that the existing pumps be replaced within the next two to five years with two pumps capable of pumping a combined flow of about 2,100 GPM and a third equally sized pump as a stand-by. This proposed capacity will be more than adequate based on projected future flows and can be further defined during preliminary design.

Underwood estimated the cost to upgrade the pump station to be about $1,146,000 in April 2011 (ENR Index 9027) or $1,195,000 in current dollars (ENR Index 9412, December 2012).

5.5 THORNTON'S FERRY PUMP STATION

Based on existing flow data (refer to Section 2.5.5 for information on existing flows) and future flow projections for the areas draining to Thornton's Ferry Pump Station, it is estimated that the future peak instantaneous flow to the pump station could be approximately 6.19 MGD if all of the proposed projects are constructed. A summary of the future peak instantaneous flow

[2] Souhegan Pump Station Evaluation Report, April 2011, Underwood Engineers, Inc.

calculation is included in Appendix D. (Note that the Underwood Engineer's Inc. evaluation[3] estimated a future peak flow to this station of about 5.83 MGD; however, this was determined by assuming a 30% increase in flows rather than considering actual potential future sewer extension projects.) As the pump station evaluation indicated an existing pumping capacity of about 3,000 GPM (4.32 MGD), a capacity upgrade will be required in the future. Additionally, much of the equipment, including the pumps, has reached the end of its design life and an upgrade is highly recommended within the next two to five years. During preliminary design of the upgrade, pump sizing should be carefully considered to determine whether a pumping system can be provided that will efficiently handle existing flows as well as potential future flows or if provisions should be made to upsize pumps in the future or to add an additional pump.

Underwood estimated the cost to upgrade the pump station to be about $1,168,000 in April 2011 (ENR Index 9027) or $1,218,000 in current dollars (ENR Index 9412, December 2012).

5.6 WASTEWATER TREATMENT FACILITY

Based on existing flow data (refer to Section 2.5.1 for information on existing flows and loads) and future flow projections from this master plan study, it is estimated that the future peak instantaneous flow to the WWTF could reach 6.5 MGD (assuming Project 4 is selected) or 7.4 MGD (assuming Project 11 is selected). These flows assume that all projects envisioned within this master plan are constructed, but that there are no increases in flow from either existing users (such as Anheuser-Busch) or any new development within areas currently served by sewers. A summary of the future peak instantaneous flow calculations is included in Appendix D (note that the Underwood Engineers, Inc. evaluation[4] did not include an estimate of future peak instantaneous flow to the WWTF.).

The WWTF was originally designed to handle a peak flow of 10 MGD; however, there is a known bottleneck at the bypass to the equalization tanks at the head of the plant that limits the plant to around 7 MGD while the equalization tanks are offline. In the future, if and when flows

[3] Thornton's Ferry Pump Station Evaluation Report, April 2011, Underwood Engineers, Inc.
[4] Comprehensive Facility Evaluation, January 2011, Underwood Engineers, Inc.

at the WWTF begin to approach 7 MGD, an evaluation will be required to identify and address hydraulic bottlenecks within the WWTF and to determine whether or not a third secondary clarifier will be required in order to continue to meet permit requirements during periods of high flows. Wright-Pierce is currently developing the preliminary design for the Phase 2 WWTF upgrade which includes replacement of the influent pumps. The intent is to maintain the current pumping capacity which will be more than adequate to handle the projected future flows.

Underwood estimated the cost of the Phase 2 WWTF Upgrade to be about $3,919,000 in January 2011 (ENR Index 8938) or $4,127,000 in current dollars (ENR Index 9412, December 2012). An updated scope and cost estimate will be provided by Wright-Pierce under the preliminary design contract with the Town.

5.7 SUMMARY OF RECOMMENDATIONS

The following is a list of recommendations that will support the development of a number of the proposed future projects. The following recommendations are supplemental to the Town's existing CMOM program. The Town should continually assess the condition of the existing collection system (vertical assets) and utilize the VueWorks® asset management software to prioritize repairs and/or replace of select portions of the collection system.

- Conifer Street Siphon
  - Drain, clean and TV inspect the siphon.
  - Survey the siphon and update the InfoSWMM model to confirm the estimated capacity of the siphon.
  - Install a flow meter in the upstream Conifer Street siphon structure to confirm existing average and peak flows.
- Conduct flow monitoring upstream of the Executive Park Drive turnpike crossing to establish existing average and peak flows. (This flow monitoring data can also be used to evaluate whether or not the existing 8-inch diameter "interceptor" upstream of the cross-country line between Bigwood Drive and Executive Park Drive has adequate capacity to accept future

project flows from Projects 27, 29, 30 and 34. Note that survey of this line will be required in order to evaluate the capacity of the line.)

- Based on results of the flow monitoring, design and construct the turnpike crossing pump station and eliminate the Executive Park Drive turnpike crossing.
- Upgrade Souhegan Pump Station.
- Upgrade Thornton's Ferry Pump Station.

Section 6

SECTION 6

PRIORITY RANKING OF FUTURE PROJECTS

The ranking presented here is based on current information. Certain ranking criteria are subject to change over time (e.g. interest from private developers), so there must be flexibility to account for future changes. The ranking procedure developed can be used by the Town to rate future projects and to reconfirm priorities moving forward. Additionally, the ranking of projects does not mean that projects must be completed in the sequence presented or that the Town will fund all or even a portion of the project.

6.1 RANKING CRITERIA

When weighing the benefit of one project against another project, there are many technical, environmental and financial factors that influence the priority ranking. A list of five criteria was developed to evaluate the proposed projects discussed in Section 3. Each project was given a rating for each criterion and then the total project score was tabulated. The criteria selected are as follows: impediments to onsite septic system treatment; accessibility to the existing collection system; consistency with Community Master Plan and interest/demand for project; environmental concerns; and unit cost. The following sections give a description of each criterion.

6.1.1 Impediments to Onsite Septic System Treatment

With the exception of a few projects (e.g. Project 4 – Continental Boulevard Interceptor Extension, Alternate A or Project 11 – Continental Boulevard Interceptor Extension, Alternate B), the proposed projects will serve properties that have already been developed and are currently served by individual onsite septic systems. The ability of an individual property to sustain a septic system is affected by several factors including, but not limited to, size of the property (i.e. available area to site a septic system after required setbacks from adjacent properties, wells, etc.) and soil types. As there was no significant data on failed septic systems available, these factors were used to determine which areas are better able to sustain individual septic systems.

Figure 6-1 at the end of this section shows parcels that are smaller than 0.5 acre and parcels that are between 0.5 acre and 1.0 acre. For the purposes of this study, it is generally assumed that parcels greater than one acre have adequate space available for a septic system and parcels less than a half-acre would be more likely not to have adequate space available for a septic system (based on current building codes).

Figure 6-2 at the end of this section indicates the soil characteristics for the Town based on permeability, depth of soil, ability to drain, etc. A well-draining soil with a high rate of permeability will be better able to support a septic system than a poorly draining soil or one with a low rate of permeability.

Figure 6-3 at the end of this section shows the existing water distribution system for the Town. Parcels served by public water will have more space available for a septic system than a parcel with a private well due to setback requirements. There were only two project areas that do not already have public water: Project 35 (Greatstone Drive Collector Sewers and Pump Station No. 3) and Project 17 (Baboosic Lake South Collector Sewers and Pump Station No. 2). The category score for Project 35 was not reduced as most of the parcels are greater than 1.0 acre. The category score for Project 17 was reduced as most of the parcels in the project area are between 0.5 acre and 1.0 acre; however this did not have an effect on the final results of the project scoring.

Scoring: Potential scores for this category range between zero and five; a score of five indicates the lowest ability to sustain septic systems.

Example 1: Project 9 (Clay Street Collector Sewers and Pump Station No. 5) would have a higher score than Project 38 (Baboosic Lake Road South Collector Sewers) as the parcels in Project 9 are primarily less than a half-acre whereas parcels in Project 38 are greater than one acre.

Example 2: Project 20 (Cathy Street North Collector Sewers) would have a higher score than Project 5 (Bedford Road North Collector Sewers) as Project 20 has a soil rating of primarily "C" and some "A" and "B" whereas Project 5 has a soil rating of "A". Table 6-1 below summarizes the soil ratings.

TABLE 6-1: DESCRIPTION OF SOIL RATINGS

Rating	Description
A	High infiltration rate, deep soils, well drained to excessively drained sands and gravels
B	Moderate infiltration rate, deep and moderately deep soils, moderately well and well drained soils with moderately coarse texture
C	Slow infiltration rate, soils with layers impeding downward movement of water, soils with moderately fine or fine textures
D	Very slow infiltration rate, soils are clayey, high water table or are shallow to an impervious layer

6.1.2 Accessibility to the Existing Collection System

This category considers two different factors: the proximity of the proposed project to the existing collection system and whether or not the downstream facilities have the capacity to handle the projected future flow.

Scoring: Potential scores for this category range between zero and five; a score of five indicates that the proposed project can tie directly into the existing collection system and that the downstream facilities have the capacity to handle the future projected flow.

Example: Project 8 (Baboosic Lake Road Interceptor Extension, Phase I) would have a higher score than Project 17 (Baboosic Lake South Collector Sewers and Pump Station No. 2) as Project 8 will tie directly into the existing collection system whereas Project 17 requires that Projects 8, 36 and 37 be constructed first.

6.1.3 Consistency with Community Master Plan and Interest/Demand for Project

This category considers whether or not the project is consistent with the Town's future plans for development and the interest/demand in the project based upon resident or developer input.

Information on future areas to be targeted for development was provided by the Town Planning Board and the draft Community Master Plan. Of the areas targeted for development, the only area that does not currently have sewer is the area described by VHB as the Airport Access Road Corridor (northeast corner of Merrimack to the east of the F. E. Everett Turnpike and adjacent to the new airport exit).

Information on current interest or demand for the project was provided by the Town. Current interest/demand could mean that a developer has expressed interest or submitted plans for a particular development, an existing neighborhood has expressed interest in a sewer extension, an extension has already been designed, or discussion has occurred about the need or interest in a sewer extension to a certain area.

Scoring: Potential scores for this category range between zero and five; a score of five indicates that the proposed project will support the Town's future development plans and/or there is current interest or demand for a particular project.

Example: Project 7 (DW Highway North Interceptor Extension and Pump Station No. 9) has been given the maximum score of five as it will support the Airport Access Road Corridor redevelopment that is discussed in the draft Community Master Plan and there appears to be local interest/demand for this project. Project 2 (McQuestion Road North Collector Sewers), 3 (Mayflower Drive Collector Sewers) and 5 (Bedford Road North Collector Sewers) were given a score of 4 because either a sewer extension project has already been designed (Project 3) or a developer had proposed a new development to be served by sewer (Projects 2 and 5). Projects 8 (Baboosic Lake Road Interceptor Extension, Phase I), 14 (Ministerial Drive Collector Sewers and Pump Station No. 6), 4 (Continental Boulevard Interceptor Extension, Alternate A) and 11 (Continental Boulevard Interceptor Extension, Alternate B) have been given a score of three because some interest/demand for these projects has been expressed by either residents (Projects 8 and 14) or the Town (Projects 4 and 11). The remaining projects were given a score of two.

6.1.4 Environmental Concerns

This category considers the potential impact to sensitive environmental resources such as surface water and wetlands if a project is not constructed (i.e. if a number of septic systems fail adjacent to a lake, it could degrade the water quality). Figure 6-4 at the end of this section shows the existing surface water and wetlands within the Town.

Scoring: Potential scores for this category range between zero and five; a score of five indicates that the proposed project is directly adjacent to a significant protected feature.

Example 1: Projects 17 (Baboosic Lake South Collector Sewers and Pump Station No. 2) and 22 (Baboosic Lake North Collector Sewers and Pump Station No. 1) would have a higher score than Project 38 (Baboosic Lake Road South Collector Sewers) as they are both directly adjacent to Baboosic Lake whereas Project 38 is not adjacent to a sensitive water body or other protected feature.

Note: Each project is scored individually based only on environmental features directly adjacent to or in each project area; upstream projects will have no influence on the score for downstream projects (i.e. although Project 8 (Baboosic Lake Road Interceptor Extension, Phase I) must be constructed before Project 22 (Baboosic Lake North Collector Sewers and Pump Station No. 1), Project 22 has been given a score of five as it is adjacent to Baboosic Lake while Project 8 has been given a score of two as it contains some minor wetlands). The intent is to provide a final ranking of projects that will be an unbiased representation of the most important project to the least important project with the understanding that even if Project 22 is a higher priority than Project 8, Project 8 will still need to be constructed before Project 22.

6.1.5 Unit Cost

This category considers the cost per gallon per day of future projected flow to construct a project based on total estimated project cost and the projected future average daily flow for the project.

Scoring: Potential scores for this category range between zero and five; a score of five indicates the project with the lowest unit cost.

Example: Project 6 (Patten Road North Collector Sewers) would have a higher score than Project 31 (Bean Road Collector Sewers and Pump Station No. 4) as Project 6 has a lower unit cost than Project 31. Refer to Table 6-2 in the next section for a summary of estimated project costs, projected average daily flows and unit costs.

6.2 PRIORITY RANKING OF FUTURE PROPOSED PROJECTS

Table 6-2 below is a list of all proposed projects ordered by final project ranking and includes the project scores and the cost-benefit ratio for each project (the total cost of each project divided by the project score to develop a unique number that factors the cost for the project per point of score). The cost-benefit ratio is used as a tie breaker when the project score for two or more projects is equal. Table 6-2 also includes the additional sewer users to be served, the projected average daily flow, the estimated project cost, and the unit cost (cost per gpd) for each project.

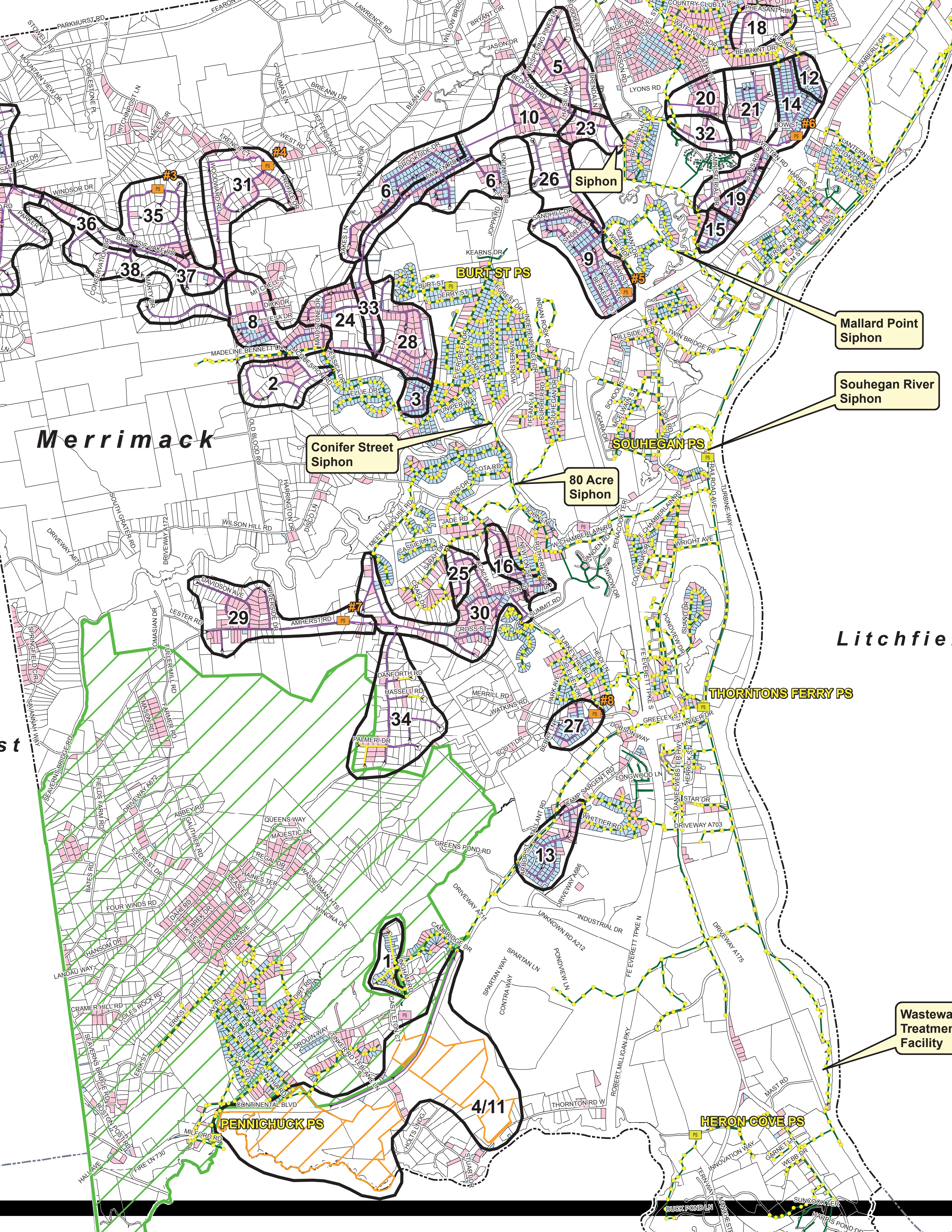
The top five projects listed in Table 6-2 ranked high primarily because of the following factors:

- Low unit cost
- Good access to the existing collection system
- Consistency with Community Master Plan or interest/demand for the project
- Environmental concerns

If the Town elects to construct any of the ranked projects, it is recommended that the Town issue a survey to all prospective users to determine septic system age, condition, problems, etc. to the confirm public interest in extending sewer to that area (if most septic systems have recently been replaced and are functional, homeowners are likely not going to want to pay to connect to the sewer system). The Town may also wish to conduct a preliminary design of the sewer. The survey and preliminary design will confirm the environmental need for the project, as well as the cost and feasibility of providing sewer to the area.

Table 6-2: Project Ranking

Project Area Description	Add. Residential Sewer Users	Avg. Day Flow (GPD)	Project Cost	Cost per GPD	Imped. to Onsite Treatment	Access to Existing Collect. System	Consist. w/CMP and Interest/ Demand	Environ. Concerns	Unit Cost
ke East Collector Sewers	45	9,500	$1,060,000	$112	4	5	2	5	3
Road North Collector Sewers	109	29,100	$1,770,000	$61	2	5	4	3	5
Drive Collector Sewers	35	8,400	$590,000	$70	2	5	4	2	5
Boulevard Interceptor Extension (Alt. A)	222	60,400	$2,080,000	$34	1	5	3	4	5
ad North Collector Sewers	109	27,400	$2,150,000	$79	1	4	4	3	5
North Collector Sewers	147	36,600	$3,530,000	$96	4	3	2	4	4
ay North Interceptor Extension and Pump Station No. 9	Comm./Indust.	61,200	$1,900,000	$31	1	5	5	0	5
ke Road Interceptor Extension, Phase I	80	21,600	$2,480,000	$115	3	5	3	2	3
Collector Sewers and Pump Station No. 5	145	35,500	$4,080,000	$115	5	5	3	0	3
errimack Interceptor Extension, Phase II	105	30,200	$4,100,000	$136	4	4	2	4	2
Boulevard Interceptor Extension (Alt. B with Pennichuck PS flows)	222 + Pennichuck	408,400	$5,410,000	$13	1	3	3	4	5
Road Collector Sewer	22	5,400	$490,000	$90	3	5	2	1	4
nt Road East Collector Sewers	77	18,600	$1,480,000	$80	3	5	2	0	5
Drive Collector Sewers and Pump Station No. 6	118	28,500	$3,410,000	$119	3	5	3	1	3
South Collector Sewers	31	7,600	$680,000	$89	3	5	2	0	4
eet Collector Sewers	38	9,600	$1,000,000	$104	3	5	2	0	4
ke South Collector Sewers and Pump Station No. 2	186	46,300	$5,640,000	$122	3	2	2	5	2
n Collector Sewer	24	6,100	$650,000	$107	2	5	2	1	3
North Collector Sewers	37	9,200	$860,000	$94	2	4	2	1	4
North Collector Sewers	31	8,100	$980,000	$121	4	5	2	0	2
Road Collector Sewers	61	15,700	$1,770,000	$113	3	4	2	1	3
ke North Collector Sewers and Pump Station No. 1	161	38,900	$5,390,000	$139	3	2	2	5	1
errimack Interceptor Extension, Phase I	24	7,100	$1,150,000	$163	2	5	2	3	0
Southwest Collector Sewers	54	13,700	$1,430,000	$105	2	2	2	2	4
Collector Sewers	20	5,200	$630,000	$121	2	5	2	0	2
South Collector Sewers	33	9,400	$1,540,000	$163	2	5	2	2	0
enue Collector Sewers and Pump Station No. 8	45	11,000	$1,710,000	$156	2	4	2	2	1
Southeast Collector Sewers	84	21,700	$2,500,000	$115	2	2	2	2	3
ad West Collector Sewers and Pump Station No. 7	97	25,300	$3,950,000	$156	3	3	2	2	1
ad East Collector Sewers	126	33,000	$4,000,000	$121	2	4	2	1	2
Collector Sewers and Pump Station No. 4	86	22,900	$4,190,000	$183	2	4	2	3	0
South Collector Sewers	13	3,900	$720,000	$185	2	5	2	0	0
errimack Interceptor Extension, Phase III	22	6,600	$930,000	$141	1	3	2	2	1
oad Collector Sewers	96	24,000	$3,100,000	$129	2	3	2	0	2
Drive Collector Sewers and Pump Station No. 3	61	16,300	$3,280,000	$202	2	3	2	2	0
ke Road Interceptor Extension, Phase III	22	6,800	$1,050,000	$154	2	3	2	0	1
ke Road Interceptor Extension, Phase II	28	8,500	$1,340,000	$157	2	4	2	0	0
ke Road South Collector Sewers	44	12,300	$1,840,000	$150	1	2	2	2	1
TOTALS(2):	2,638	1,089,600	$82,780,000						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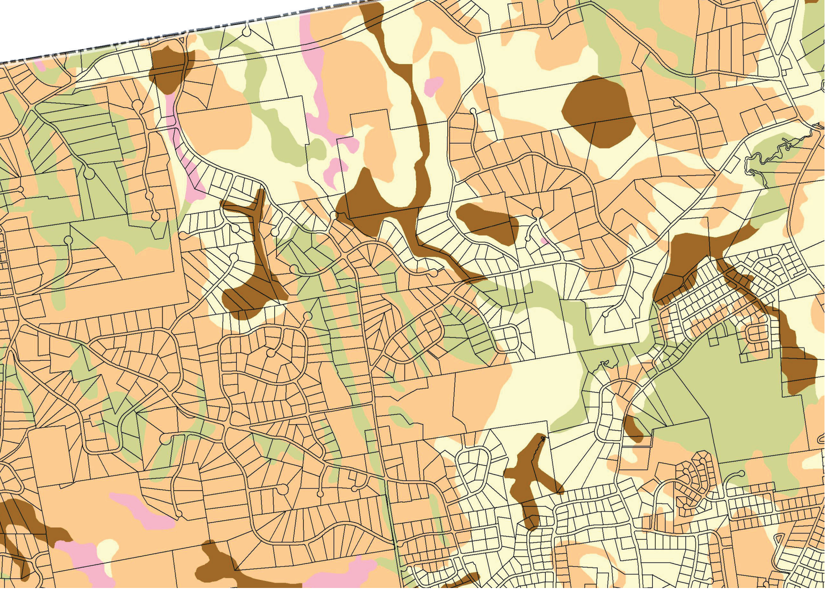

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