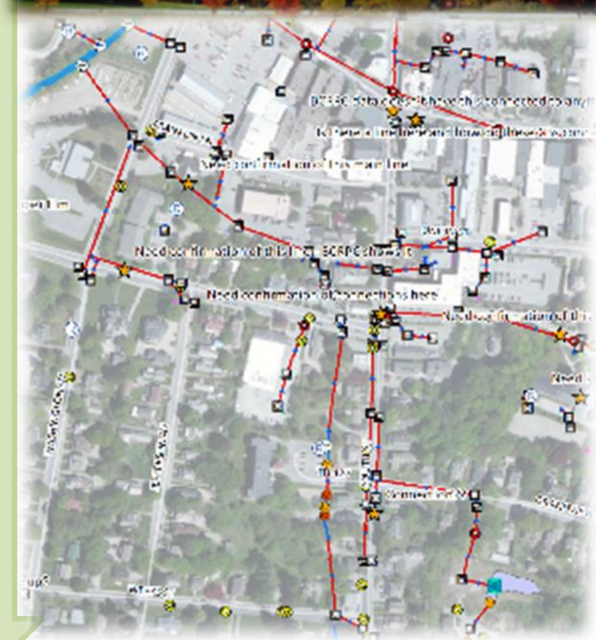

STORMWATER INFRASTRUCTURE MAPPING PROJECT

BENNINGTON AREA, VERMONT

FINAL REPORT
October 8, 2015

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APPENDICES

1 Project Overview

As part of its on-going effort to map existing stormwater infrastructure in the State of Vermont, the Vermont Department of Environmental Conservation – Watershed Management Division (VT DEC) issued a Request for Proposals in July 2014 (Contract #27744) to map all the stormwater infrastructure in Bennington, Old Bennington, North Bennington, and a small area in Shaftsbury, as well as any infrastructure related to the Bennington Bypass (VT Rte. 7a and Rte. 279). Data was to be created from plan documents related to stormwater and wastewater permits, town plan documents, any existing GIS data pertaining to stormwater and wastewater systems, and field work. All information derived from plans was to be field-verified with respect to location and connection. Additional GIS-based sources of information were to be incorporated into the existing schema of the State's geodatabase. This information includes the VT DEC's bridge and culvert data, as well as any data available from VTrans on stormwater systems for the Bennington Bypass area. Only this VTrans data was not required to be field verified.

In August of 2014 Watershed Consulting Associates, LLC (WCA) was awarded the contract and began collecting permit plans (many of which were provided by the VT DEC) and GIS data, primarily data collected by the Bennington County Regional Planning Commission (BCRPC). This data provided the basis for field work, which began in October, 2014. The Phase 1 area (primarily downtown Bennington south of Rte. 279) was finished on March 31, 2014. Field work was suspended for much of the winter as catchbasins and other infrastructure was obscured. Field work for the Phase 2 area recommenced in April, 2015 and the draft Phase 2 data was delivered to the VT DEC on June 1, 2015.

2 Data Generation Methodology

2.1 Field Work

After an initial review of GIS data collected by the BCRPC as well as georeferencing various digital plans provided by the VT DEC, WCA Staff made numerous field visits during the Fall of 2014 and the Spring and early Summer of 2015 to document stormwater and wastewater infrastructure on the ground. This work primarily consisted of using a handheld Trimble GEO XH (a sub-meter resolution mapping grade GPS unit) to collect point, line, and polygon data using the geodatabase schema developed by the VT DEC.

This data was collected 'blind', i.e. Staff did not do a thorough review of plan/GIS data prior to beginning collection. Each street was walked (or in the cases of more rural areas, driven or biked), to ensure features on the ground were mapped and verified at the same time. It was felt that this method would eliminate the tendency to look for features that were known to be on the ground, at the possible risk of not searching for additional features. Resolution of any discrepancies found in field collected versus plan data will be explained in more detail under Section 2.2 – Stormwater and Other Plan Review.

When collecting point data, the Trimble unit was located as close as possible to the center of the physical feature. At times during the field work, physically standing in the center of a point feature was not feasible – the closest approximation was then created and noted for later correction on the desktop.

When collecting line data, the approximate direction of the underground line was walked for several feet to create a line 'stub' that would indicate direction and line type that could later be elaborated and corrected using GIS desktop software. Attempts were generally made to collect GPS line data in the direction of water flow – where this was time-inefficient, the data was later corrected on the desktop.

Polygon data (typically for stormwater Best Management Practices) was collected by walking around the outer perimeter of the feature. Where this was not feasible (large BMPs or inaccessible areas), a perimeter was walked to the maximum extent practicable, then closed off. The feature was then completed on the desktop using the most currently available aerial imagery (typically ESRI-provided 'Basemap' imagery or by referencing Google Earth imagery, whichever proved to be the most current).

Field data was then post-processed and differentially corrected using Trimble's PathFinder Office software. Differential correction was made using the nearest available set of base stations for Bennington. The shapefiles that were initially generated were then imported into a VT DEC compliant ESRI geodatabase.

In the cases mentioned above, field data was corrected on the desktop. This work typically involved moving GPS points to their true location if such collection wasn't possible in the field. In some cases, due to poor satellite reception, points had to be manually moved by referencing aerial imagery. In the case of Bennington, the resolution of the aerial imagery at 1 meter was sufficient to see many stormwater infrastructure points and guide the placement of the point. At times, Staff used Google Street View to obtain an additional reference for the point or to verify suspected point placement.

Line data, usually collected in the field as a line 'stub' was then corrected to reflect its true connection to stormwater point features. Each feature was simplified to include as few vertices as possible while still representing the line's approximate location. Line end points were snapped to stormwater infrastructure points or polygons where appropriate.

Polygon data was also simplified to include as few vertices as possible while still maintaining shape fidelity.

Finally, all field data after desktop correction was topologically corrected using ESRI's Topology toolset to remove any possible overlap errors that sometimes could occur when importing multiple datasets into a 'master' geodatabase. This resulted in a clean geodatabase that stores as few points as possible while still maintaining shape fidelity.

2.2 Stormwater and Other Plan Review

WCA Staff also made a thorough review of all available stormwater permit plans, as well as any other documents (sites plans, etc.) pertaining to stormwater or wastewater infrastructure where possible. This consisted primarily of downloading a georeferenced list of all stormwater and wastewater permits from the Agency of Natural Resources (ANR) Atlas. This list was cross-referenced with the folders of plan documents that James Pease of the VT DEC Watershed Management Division provided WCA. All plans were georeferenced, if they hadn't been already, in the ArcGIS interface to facilitate field data comparison or generation of data where necessary. A list of the permits reviewed, along with any pertinent notes regarding plans, plan review, and data incorporation, is provided in Appendix A-1 – Stormwater Permit Plan Review.

If any discrepancies were found between the plan and the field data, this was noted in the attribute table for the GIS data. If a feature was found in the field, but not seen on a plan this was noted as such. If a feature appeared on a plan, but was not found in the field, this was also noted.

Additionally, the Bennington County Regional Planning Commission (BCRPC) had previously conducted some GPS-based field work mapping in the downtown core area of Bennington. WCA obtained this data as an initial reference for our own field work, however this data was not directly incorporated into the final dataset. Rather, WCA Staff used this data to guide field work and verified it along the way, generating an entirely new dataset to import to the State's geodatabase. It was felt that pursuing this strategy would result in a more accurate dataset based entirely on infrastructure actually found on location in the field.

While WCA did initially collect plans pertaining to wastewater systems, none of this data was incorporated into the final dataset. The reason for this is that the Town, in conjunction with Forcier Aldrich and Associates (Now Aldrich and Elliott), along with Grassroots GIS, had already created a comprehensive, plan-based and field-verified dataset for the sanitary sewer extent in Bennington. Details for this dataset can be found in Section 2.6 – Sanitary Sewer Data.

2.3 Municipal Member Knowledge

WCA reached out to municipal officials numerous times over the course of this project to aid in dataset verification. RJ Joly, Highway Superintendent, Terry Morse, Water Department Superintendent, and Dan Monks, Town Planner, provided a great deal of input for the Town of Bennington, notably during a half-day session involving all three staff members. The majority of Downtown Bennington was reviewed at that point and corrected where municipal staff had direct knowledge of the system. This session, which took place in December, 2014, was then followed up by several part-days by Bennington Highway staff to specific question sites provided by WCA. Verification procedures consisted of either opening manholes to inspect pipe connections or using water to flush a line to verify connections. These inspections resulted in a majority of data pertaining to downtown Bennington being corrected.

Town of Bennington officials also put WCA in touch with officials from Old Bennington, which maintains its own systems through its own board of directors that hires work out to private contractors. Maps of issues within Old Bennington were sent to the board of directors and forwarded to the contractors themselves. Unfortunately the contractors that Old Bennington currently uses did not have any specific knowledge of the stormwater system in that area, which consists primarily of a system of catchbasins that feed an underground flow detention device for stormwater management. Plans of that system, obtained from older VTrans records, were somewhat conclusive. The exact location of the underground detention device is not definitively known.

Attempts were made to contact the road foreman for North Bennington, Norman LeBlanc. While WCA was able to speak with him, his general knowledge of the stormwater system in his area was limited and he advised that we contact RJ Joly with the Town of Bennington. After field investigation of the system, we found it generally was simple and did not require a great deal of input from municipal staff.

A similar situation was found for Shaftsbury – the portion of the system originating in Bennington and entering Shaftsbury was miniscule and self-evident. Therefore there was no need to contact municipal officials for Shaftsbury.

2.4 Incorporation of VTrans Data

The Bennington Bypass is a significant stretch of State-maintained highway that passes through Bennington. The Bypass also has a large visitors center with a large parking area and its own stormwater management system. Data for this extent was obtained from VTrans' Mapping Division. VTrans data is generally field collected using a mapping grade GPS, or generated using as-built plan documents. In addition to location and connection information, VTrans also collects condition information on each feature where possible. Crushed culverts, broken pipes, amount of sediment in culvert inlet/outlet, etc. are noted within the attribute table for these datasets. WCA felt that incorporating as much of that condition data as possible was desirable. The following workflow was used to integrate the VTrans GIS data into the VT DEC's geodatabase.

GIS data was provided as one line shapefile and two point shapefiles.

Line Data – line features, initially labeled as 'culverts', actually described both culverts and stormwater pipelines. These features were imported into the State's dataset as 'Storm lines - Existing'. Data was attributed to 'VTrans GIS Data' under 'Source'. Under 'Additional_Source_Info' it was noted that the data came from the VTrans 'SmallCulverts' database and that the data has not been independently field verified by WCA. Ownership data under 'Owner' was attributed to 'State'. No condition data was imported for this dataset.

Point Data – point features were provided as 'CulvertInlets' and 'CulvertOutlets'. Within this dataset a field labeled 'Inlet_Trea' described the inlet treatment type. These values include 'DI' – Drop Inlet, 'FLARE' – flared culvert inlet, 'CHW' – concrete headwall, 'CCRAD' – concreted cradled culvert pipe, and 'NONE' – no treatment. Of these, 'DI' was reclassified as 'Catchbasin' in the VT DEC database, while the others were re-classified as 'Culvert Inlets'. Within the 'CulvertOutlets' database these same values were present and were all re-classified as 'Culvert Outlets'. Some of these re-classified outlets were deemed to be 'Outfalls' within the VT DEC schema and were manually corrected as such.

Additional information was incorporated from the VTrans data, primarily data pertaining to the condition of the inlets or outlets, as well as any comments noted by VTrans mapping staff. This was imported in to the VT DEC dataset as follows:
"Description from VTrans mapped data: Condition = 'Inlet_Cond': Inlet/Outlet Structure = 'Inlet/Outlet_Trea': Sediment Amount = 'Inlet_Sedi': VTrans Comment = 'Inlet/Outlet_Comm'".

Additionally the majority of the VTrans data falls under a single permit – this was noted within the VT DEC database.

VTrans did not map BMP polygons or any of their treatment or conveyance swales. These were manually added via aerial photo interpretation, contour line interpretation, or both.

2.5 Generation of Overland Flow Lines

WCA created flow lines for the study area using spatial analysis methods, specifically those available using ESRI ArcGIS SpatialAnalyst HydroTools extension. Land cover data for an approximately 650 acre area concentrated in the most populated parts of Bennington was obtained from the Bennington County Regional Planning Commission. From that data, WCA then extracted all impervious surfaces with the exception of roofs and buildings. For the remainder of the study area, WCA created impervious area data using a two-phase approach. First, existing E911 road centerlines were buffered using general road widths by road class to generate road polygons. Second, on-screen digitizing was used to create other impervious areas (excluding buildings) easily visible at a 1:2000 scale from 1 meter spatial resolution digital orthophotography (data collected in 2014 by the National Agriculture Imagery Program). This digitizing effort included large parking areas but excluded most small individual driveways. Buildings were excluded as roof pitch (or lack there-of) is not captured with bare-earth LiDAR elevation data.

After we combined all impervious areas for the study area, we used LiDAR-derived elevation data (2012; 1.4 meter resolution) to determine both the direction and concentration of surface flow within these impervious areas. To do this, we used the Flow Direction and Flow Accumulation tools in ArcGIS. After reviewing the data, areas of surface flow above a threshold (greater than 60 cells must drain to each flow direction arrow) were selected to represent surface flow lines. Through our review of the generated data, we determined that this threshold allowed for good visualization of the direction of surface flow without cluttering the area with many small flow arrows. This method allowed for full coverage of the study area in an efficient, repeatable manner.

2.6 Sanitary Sewer Data

WCA initially began collecting GPS points for sanitary manholes found in the field. When speaking with the Town of Bennington about any data they might have, it was discovered that they had a complete GIS-based map of the entire system. The map was initially created by Forcier Aldrich Associates (FAA) (now Aldrich and Elliott A&E). WCA spoke with A&E principal Wayne Elliott who was involved in the project to map the system. The data was created by first field-collecting GPS locations for all structures, then adding additional information for pipe size, pipe material, and direction of flow using as-built plans provided by George LeBlanc, director of Bennington's Wastewater Treatment Facility. Elliott informed WCA that these plans generally date from the 60s or 70s on into the early 2000s. This data was then submitted to the Town so that they could manage it.

A second phase of data development occurred in 2008 when Judy Bond with Grassroots GIS became involved in creating an additional GIS database interface that could be user-updated by Town of Bennington Staff. This involved importing the data originally collected by A&E and creating new user interface allowing Town staff to go into the field and field-verify parts of the sanitary system that were created using as-built plans. Grassroots GIS helped maintain this system and update data for two years, then handed it off entirely in 2010. Since that time Linda Bermudez, Water Resources Administrative Assistant in Bennington, has been responsible for entering data collected by Town Water Department staff. As of Spring 2015, approximately 90% of the system had been field-verified and updated. The remaining 10% is primarily located in North Bennington and a small portion of Shaftsbury. Note that this data is only for the municipally managed sanitary sewer – private systems are not included in this database.

WCA imported this data into the State's geodatabase. WCA's initial work mapping sanitary manholes was reviewed to ensure that, generally, the Town's dataset was accurate – otherwise no other field verification of this system was conducted. The sanitary dataset also had considerably more features as point data – Caps, Cleanouts, Inputs, Junctions, and Pump Stations, in addition to Manholes – than the VT DEC database. These points were imported under 'Other – insert comment'. The comment field was populated as "Wastewater System 'Point Type' – 'Point_Number' – 'Point_Status'". Under 'Source' data was attributed to 'Contractor GIS/GPS' and under 'Additional_Source_Information' it was noted the 'Features collected and QA/QCed by Grassroots GIS. 'Owner' was noted as Municipal as this system does not show any private laterals.

2.7 Bennington College Data Creation

Data for Bennington College, which comprises a large area within the Phase 2 task extent, was developed largely through field data collection. The College's Engineer, Holly Anderson, informed WCA Staff that no unified stormwater plan exists for the campus. Otter Creek Engineering is the primary consulting engineer for the College and had the most complete plans. These plans were largely generated during work pertaining to other aspects of the College's physical plant (building remodeling, landscaping, other utility work) and did not deal directly with the stormwater or sanitary system in that area. Though the plans covered nearly 100% of the College's physical area, only around 30% of the stormwater features found in the field appear on this plan. Sanitary system data was also derived from this plan set.

2.8 Updates during Illicit Discharge Detection and Elimination Study

WCA was awarded the VT DEC contract #28665 to conduct an Illicit Discharge Detection and Elimination Study in Bennington and Pawlet during the spring, summer, and fall of 2015. As the mapping contractor, we saw a great opportunity to use the IDDE study to complete any updates or answer any potential lingering questions pertaining to the stormwater infrastructure.

Thus far, with the majority of the IDDE study completed, we have found a few areas where mapped infrastructure was either entirely missed or mapped incorrectly with respect to connections, etc. These areas are:

- Depot – Main Streets Intersection: It was found that the main stormwater line that picks up much of the surface drainage along Main Street outlets underground into a large concrete box culvert that carries an unnamed tributary to the Walloomsac River underground beneath the intersection in that area. Additionally, three other smaller drainage networks outlet in a similar fashion.
- East Road – Kocher Drive Intersection: It was found that a small drainage line (three catchbasins) was missed during field mapping. These features were walked during the IDDE and added into the database.

- Hillside – South Streets Intersection: A major connection between the east and west ends of Hillside street was verified during the IDDE – this is important as it verified that a significant portion of Bennington's drainage (from Grandview and Imperial Avenues) does not drain down towards Main Street as some suspected, but rather drains across Hillside Street. Additionally, opening manhole covers in this area verified some suspected pipe connections, as well as verified the path of the unnamed tributary that goes underground near the Bennington Town Offices.
- Main Street – descending from Old Bennington: It was initially thought that a large stormwater line, descending from Old Bennington, crossed Main Street and entered a swale on the north side of that road, eventually reaching an outfall on an unnamed tributary to the Walloomsac River that runs parallel to Convent Avenue. This line stays on the south side of Main Street, however, and outfalls to a large depression area that was once part of an old railroad line. Runoff largely settles out in this area before eventually overflowing to a smaller culvert and entering a smaller drainage line to the same tributary on the south side of Main Street.

3 Access Issues During Field Work

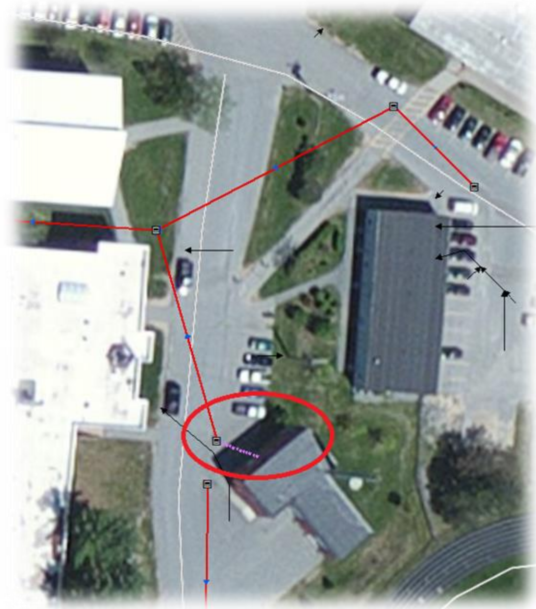
3.1 Specific Site Access Issues

During the course of this project, no significant access issues were encountered. The majority of the field collection work took place on public right of way areas. For private property areas, an attempt was made to speak with a property owner or manager. If such a person was not around, permission was obtained from someone on-site who was affiliated with the property. In cases where no one was present, data collection proceeded to the maximum extent practicable with respect to access and privacy. If a certain area was unreachable, a note was made and the data was then digitized later on the desktop using memory of the feature from the field day and aerial imagery.

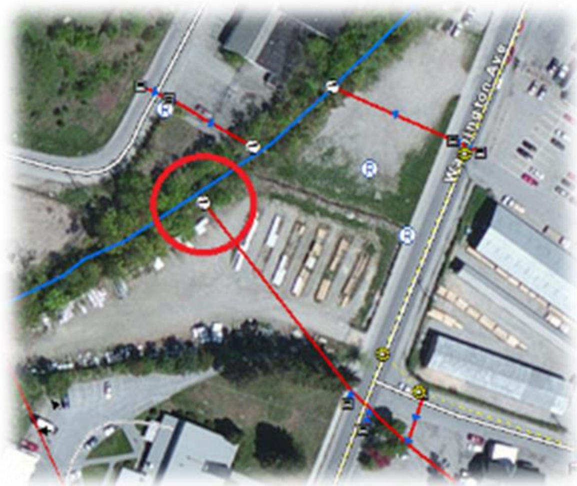
4 Illicit Discharges Noted During Field Work

4.1 Specific Issues Noted – Mt. Anthony High School:

While mapping the stormwater infrastructure at the High School, a large regular pumped flush of water was noted in a catchbasin near the school's heating plant. A follow-up visit with the school's facilities director to confirm pipe directions and connections confirmed that that flush of water was actually just groundwater pumped from around the footing of the building and into the catchbasin. Follow-up work during the IDDE seems to confirm this.

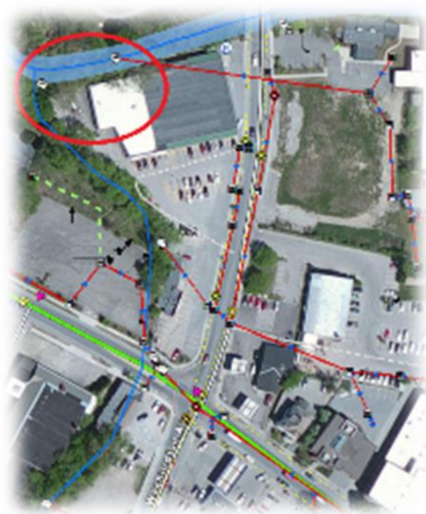


4.2 Specific Issues Noted – Outfall on Unnamed Tributary off Washington Ave



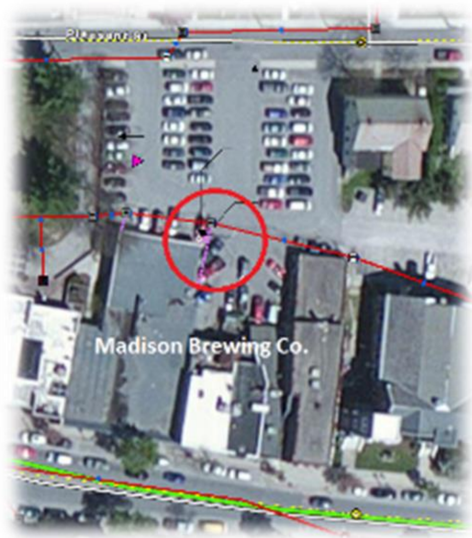
Flow was noted at this outfall during mapping in the fall of 2014 and in several of the catchbasins. It was not clear at this time whether that flow was related to a potential illicit discharge or to footing drains or underground streams. In the Bennington area, groundwater is usually near the surface, resulting in the need for footing drains for many buildings. Additionally, as Bennington has been settled for a long time, many streams have been forced underground due to development pressure. It turns out in the case of this outfall that both scenarios (footing drains and an underground stream) were causing flow in catchbasins. It was later found that there was an illicit discharge farther up this line, but not one that would have resulted in the flows observed during mapping.

4.3 Specific Issues Noted – Outfall on Walloomsac River behind VT DMV



A similar situation to the one described above was found at this large outfall on the Walloomsac River. However, in this area it turns out that the 'outfall' was actually the outlet of a large box culvert carrying an unnamed tributary of the Walloomsac River. There are several drainage networks that outlet to this box culvert – however none have been found so far to have any illicit discharges.

4.4 Specific Issues Noted – Catchbasin in parking lot behind Madison Brewing Company



An intermittent flow, originating in a catchbasin, was noted during mapping. However this issue is still ongoing – preliminary testing during illicit discharge work has not revealed any factors that clearly point to this as an illicit discharge. Investigation is ongoing.

5 General Maintenance Issues – Erosion or Infrastructure Problems

While some general maintenance issues were noted during WCA's mapping, far more have been noted and better documented during our illicit discharge study, particularly during the Outfall Reconnaissance Inventory (ORI) portion of the work. During this, we noted numerous outfalls where there was erosion, headwalls that were in need of repair, or pipes that were beginning to rust or otherwise fail. This information is best accessed using the reports that we prepared for each of the outfalls visited during the ORI. These can be seen in Appendix A-2: Bennington IDDE Outfall Reconnaissance Inventory Report. The maps will be useful in pairing the reported outfall number (specific to WCA's IDDE study) with its location. The main outfalls noted are:

Phase 1 Area:

- BTN-11: cracked retaining wall
- BTN-130: Outfall channel erosion - replace rip-rap
- BTN-128: Good location for WQ retrofit
- BTN-106: Old concrete pipe - recommend replacing
- BTN-125:Pipe partially blocked by animal activity
- BTN New 49: Pipe broken at outfall
- BTN New 60: Pipe broken at outfall
- BTN-108: Pipe bottom rusted out
- BTN-New 52: Pipe broken at outfall
- BTN New 133a: Pipe crushed at outfall
- BTN-104: Erosion below outfall - good location for retrofit
- BTN-25: Outfall is eroding - needs rip-rapping
- BTN-31: Outlet of pipe clogged with sediment - needs cleaning
- BTN New 30: Outfall eroded
- BTN New 80: Pipe crushed at outlet
- BTN-28: Minor outfall erosion
- BTN-60: Minor outfall erosoin
- BTN-12: Pipe outlet crushed
- BTN-131: Outfall eroded
- BTN-42: Outfall into forebay - forebay vegetation needs trimming
- BTN-121: Outfall eroded
- BTN-27: Outfall nearly buried by temporary construction access road to river - needs to cleared once construction is finished
- BTN-55: Outfall eroded
- BTN-19: Outfall clogged by sediment
- BTN-109: Outfall eroded
- BTN-145: Outfall partially submerged by sediment
- BTN New 89: Pipe outlet broken
- BTN-6: Pipe buried
- BTN-57: Pipe outlet crushed

Phase 2 Area:

- BTN-160: Outlet partially clogged with sediment
- BTN-146: Retaining wall near outfall cracked - flow coming out of crack
- BTN-223: Outfall eroded

- BTN-New 210: Pipe partially clogged with sediment
- BTN-154: Pipe nearly completely clogged with sediment from road
- BTN-225: Outfall partially clogged with sediment
- BTN-170: Pipe outlet partially crushed
- BTN-174: Pipe nearly plugged with sediment
- BTN-178: Outfall eroding
- BTN-161: Retaining wall above outfall is pitched and collapsing slowly
- BTN-187: Outfall eroding bank - needs armoring
- BTN-215: Overgrown and mostly buried
- BTN-205: Pipe outlet mostly plugged with sediment
- BTN-222: Pipe outlet mostly plugged with sediment
- BTN-162: Pipe partially clogged with sediment
- BTN-181: Outfall very eroded - needs riprapping
- BTN-176: Outfall to BMP - BMP is becoming overgrown with trees

Additionally, incorporating the VTrans data as we did allowed for the import of condition information and any other related maintenance comments. While we did not prepare a specific report for these features, this data is searchable within the GIS attribute table.

6 Final Notes

We believe this dataset to be an accurate representation of the stormwater infrastructure in Bennington the time of submission of this report. Nearly all data was collected solely from field work, meaning that conditions on the ground by and large match the features in the dataset. Additionally, a thorough plan review did result in updates where appropriate and the attribute table of the feature dataset reflects this.

Inevitably with a project like this, spanning such a large and varied geographic area, there is the probability that certain features have not been mapped. While we made every effort to find these features in the field or on plans, the reality is that we probably didn't capture 100% of the infrastructure on the ground or on plans. Therefore we believe that this document should be considered a 'living' document, subject to revision.

In the case of the Town of Bennington with their Town-administered sanitary sewer database, there may be an opportunity to create something similar for Town staff to use in updating stormwater infrastructure as it comes on-line or as they are able to make investigations using camera equipment, etc. A system like this could prove very useful to the State and the State's central database of stormwater infrastructure.