Moodna Creek Watershed Flood Summit:

Summary and Possible Next Steps

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1. INTRODUCTION

The Moodna Creek watershed covers 115,600 acres – or 180 square miles – of the eastern side of Orange County, New York. The watershed includes all or portions of 22 municipalities; it stretches from small sections of Warwick and Tuxedo to the south, up to Newburgh and Montgomery to the north and then spans an area from Goshen and Hamptonburgh to the west, to the towns of Cornwall and Highlands to the east. Moodna Creek eventually empties into the Hudson River just north of the Village of Cornwall-on-Hudson.

On July 9, 2012 approximately 40 community members, municipal officials, state and county staff, and other interested stakeholders gathered in the South Blooming Grove Fire Hall to attend the Moodna Creek Flood Summit. The Summit was convened in response to the flooding the followed hurricanes Irene and Lee in 2011, and the purpose was several-fold: first, Julie Moore, P.E. and Jeremy Krohn, P.E. of Stone Environmental, Inc., reviewed basic river functions and flood impacts. Ms. Moore specifically spoke about identifying, understanding, and addressing flood-related hazards. Second, Mr. Krohn led a hands-on opportunity for participants to model flood hazards and mitigation techniques using the Emriver Em2 Geomodel stream simulator (Little River Research and Design; Carbondale, IL). During the final portion of the forum, Ms. Moore presented an overview of approaches for improving flood resiliency and strategies for prioritizing implementation efforts, solicited specific input from the audience, and facilitated conversations between stakeholders.

Simulations by the Emriver EM2 Geomodel helped Flood Summit participants increase their understanding of stream dynamics and the impacts of hydrologic modifications resulting from culverts, dams, and bridges.

The goal of this report is to identify possible next steps that decision makers and stakeholders could employ in order to assess, plan, design, prioritize, fund, and implement actions that will reduce flood hazards and improve resiliency within the Moodna Creek Watershed.

2. MOVING FORWARD

Reducing flood hazards within any watershed is a multi-faceted effort that includes reducing stormwater runoff, providing flood storage, and minimizing or eliminating conflicts between rivers, people, and their property. As with any significant endeavor, improved flood resiliency will not be immediate. Improved health of the Moodna Creek Watershed will be contingent upon steady, deliberate, sustained action.

The Orange County Water Authority and the more recently formed Moodna Creek Watershed Intermunicipal Council have invested in improving the health of the Moodna Creek Watershed. Their efforts have produced the *Moodna Creek Watershed Conservation and Management Plan* (the Plan) (March 2010); the process for creating the Plan involved public meetings, discussions with residents and municipal officials, interviews with local professionals in relevant fields, and field investigations.. The Plan provides a broad characterization of the watershed and summarizes a wide array of available information, including existing conditions and known issues within the watershed. The document also includes an extensive list of suggested actions. This report is intended to build upon the Plan by focusing directly on the assessment, planning (including analysis and design), and implementation of measures to address flooding within the watershed and the two threads that tie conservation and management together: leadership and funding. This is a substantial task that will require consistent, organized leadership and funding. As recommended in the Plan, the establishment of a dedicated agent or office that is directly responsible for the management of stormwater within the watershed should be seriously considered as this would help ensure consistent leadership and funding.

2.1. Assessment: Focusing on Stormwater, Flooding, and Geomorphology

The goals of the *Moodna Creek Watershed Conservation and Management Plan* were to:

- summarize existing conditions in the watershed;
- identify and describe issues that are important to local communities and stakeholders, including assets, existing problems, risks, and opportunities; and,
- develop a prioritized list of action items and recommendations for addressing identified issues.

A possible next step would be the development of a Watershed Resiliency Evaluation, which would compile the pertinent information summarized in the Plan and then seek out the remaining information needed to provide a clear picture of the origins and outcomes of flood events in the Moodna Creek Watershed. It should specifically include:

- a stream geomorphic assessment;
- a flood storage, conveyance, and hazard analysis;
- GIS analysis documenting:
    - impervious surfaces
    - stormwater outfalls
    - locations of bridges and culverts
    - location of floodways
    - currently accessible floodplains
    - potentially accessible floodplains
    - dams

- constrictions
- areas known to be susceptible to flooding and flood-related damage

The foundation of the Watershed Resiliency Evaluation would be the stream geomorphic assessment (SGA). An SGA is a study that provides an "understanding of the natural tendencies of a stream, its current condition, and what changes may be anticipated in the future which can be invaluable to making sound protection, management, and restoration decisions"[1]. The State of Vermont has set forth a list of *Stream Geomorphic Assessment Protocols* and published an associated handbook which can be accessed at: http://www.vtwaterquality.org/rivers/htm/rv_geoassesspro.htm.

Fluvial erosion along the Moodna Creek contributed to the undermining of portion of the County Route 74/Forge Hill Road bridge in the Town of New Windsor during the tropical storms of 2011.

The SGA will provide information on the relative stability and current flood resiliency of Moodna Creek and its tributaries. It will highlight problem stream segments which will likely be associated with those specific threats or areas identified in a Flood Hazard Analysis. The Flood Hazard Analysis provides information on areas known to be in danger of inundation or fluvial erosion for specified storm events.

GIS can then be used to analyze the above information along with other watershed attributes, including topography, impervious surfaces, soil types and conserved lands. With all the information arranged in a spatial format, relationships become more apparent and problems can be linked to root causes and potential areas for improvement.

In short, the Watershed Resiliency Evaluation will advance work completed in developing the Plan, focusing on stormwater and flood-related concerns within the watershed and identifying high-priority conservation and management practices that could be implemented to reduce flood hazards and improve resiliency. The overall cost of a Watershed Resiliency Evaluation is tied

[1] Vermont Department of Environmental Conservation: Watershed Management Division; http://www.vtwaterquality.org/rivers/htm/rv_geoassess.htm; accessed 8/3/112

closely to the level of detail required, including the number of stream and river miles identified for direct assessment. Based on the discussion during July 9th workshop, it is reasonable to assume that completing this work for the whole of the Moodna Creek watershed with a suitable level of detail would likely cost between $100,000 and $150,000.

2.2. Planning

Clearly defining a problem is often the major part of the work involved in developing an effective solution. Once all issues are defined and root causes understood, design and decision making is significantly simplified.

2.2.1. Typical Issues and Mitigation Measures

2.2.1.1. Infiltration and Detention

The first step in reducing flood hazards is to control stormwater flows. Stormwater is simply rainwater that does not infiltrate the soil, but instead runs off overland to streams, rivers and lakes. Some amount of runoff is natural; however, development–including roads, parking lots, and structures—can both greatly increase the amount of runoff and reduce the time it takes for water to reach receiving streams. The result is more water in streams and rivers in a shorter amount of time, resulting in higher peak flows and contributing to flooding issues.

Stormwater runoff can be reduced at the source by increasing the amount of water that is infiltrated into the soil. This natural process can be encouraged by minimizing the amount of impervious area within the watershed. Alternatively, low impact design measures such as rain gardens and porous pavement can be utilized to enhance onsite infiltration.

Following infiltration, the next best option is to capture and detain stormwater, and then release it slowly. This task is naturally accomplished in wetlands. A first step is often to ensure the long-term protection and viability of natural wetlands throughout the watershed. Alternatively, low impact design measures such as bioretention facilities and constructed-wetland systems can be used to mimic the roll of natural wetlands by temporarily detaining and filtering stormwater.

Typical costs for measures to increase infiltration can range from $1000 for a small rain garden that can treat stormwater from one residential home to over $100,000 for a large system utilizing bioretention or constructed wetlands to treat stormwater from a larger impervious area or housing development. The Vermont Department of Environmental Conservation[2] has estimated the cost of stormwater best management practices (BMPs),

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[2] http://www.vtwaterquality.org/stormwater/docs/swimpairedwatersheds/sw_tmdl_implementation_report_FINAL.pdf

including construction, maintenance and inspection, and land opportunity costs, using the following cost function for both detention and infiltration BMPs:

Total Cost = Installation Cost [**I**] + Land Cost [**L**] + Fixed Cost [**F**]

- Installation Cost [**I**] represents the material and labor expenses related to the construction of the BMP.
- Land Cost [**L**] represents the land value. Land cost is negligible if the BMPs are installed in small areas (such as bioretention ponds or infiltration basins) or underground storages.
- Fixed Cost [**F**] represents the cost associated with designing and permitting activities.

Due to cost information on maintenance and inspection not being available, these costs were not included in the equation.

Detention BMP:

Cost = (**I** * Detention Volume (ft^3)) + (Detention Surface Area (acres)***L)** + **F**

I = $5 per ft^3 and **L** = $ 217,800 per acre

F = [$ 2,000 per BMP)

Infiltration BMP:

Cost = **I** * BMP volume (ft^3) + **F**

I = $6 per ft^3

F = [$ 2,000 per BMP**]**

2.2.1.2. Flood Conveyance and Storage

Flow of stormwater over the surface of land is, to a large extent, a natural process. Likewise, streams and rivers naturally flood at times. It can be a goal of a community to minimize the unnatural intensity and duration of stormwater runoff as a means to help reduce the severity of floods. However, not all flood events can be avoided, and therefore it is critically important to minimize current and prevent future conflicts between infrastructure and anticipated stream and river inundation areas during high flow events.

In steeper terrain, a stream or river’s need for expansion takes the form of flood conveyance channels, or flood chutes. These are natural areas where excess water can move downstream. It is important to identify these areas and eliminate conflicts by locating infrastructure outside the flood hazard zone. Identified flood hazard areas can also be strengthened by leaving them in a forested condition. The dense growth of a riparian forest works to dissipate energy of a flood while protecting the soil and structure of the stream channel. In general, riparian buffers are a measure that helps ensure that a stream or river has room to expand without causing undue damage to the stream channel (e.g., over-widening) or local infrastructure.

In flatter valley bottoms, rivers expand and inundate the adjacent land commonly known as the floodplain. In these areas, much of the damage to property occurs as a result of being underwater. However, even in these areas, the river channel cannot be viewed as static. The river must be given room to meander across the valley bottom. Energy is also dissipated by travelling through the meanders, much as a skier controls speed by making turns as they travel down the slope. Due to natural geomorphic processes, the river channel will shift back and forth. And while riprap and other structural controls can help control the river in a particular location they often have the unintended consequence of increasing the shift in downstream river segments. Providing the room to accommodate a shifting channel, in the form of a protected river corridor, helps to make sure channel evolution occurs at a slow and predictable state. River scientists refer to this as "dynamic equilibrium".

In either of these scenarios, the important point is to give the stream or river the room it needs to handle flood events. If the water does not have access to a floodplain or flood chutes, it is forced to continue downstream. As water flows downstream without dissipating energy, it gathers momentum, causing more stress (e.g., erosion) on the streambanks, channel bottom, and adjoining properties. Again, think about a skier travelling straight down the slope, unable to carve turns to dissipate energy and having no area where they can "bail out."

Flood conveyance and storage is typically improved with good planning and zoning, and through conservation efforts. Conserving land as floodplains and river corridor easements have costs related to land acquisition; in addition, it can be challenging to find an entity willing to steward the easement. One example of an entity that has risen to this challenge is the Vermont River Conservancy (VRC)[3]. VRC got its start purchasing easements to provide river access for paddlers and to popular swimming holes, but over the past five years it has grown to fill an important niche in corridor conservation. In turn, VRC recently expanded their mission statement to include flood resiliency. This example also points to the potential for synergy between efforts to improve flood resiliency and those designed to protect open space.

2.2.1.3. Constrictions

Constrictions in a river can come in various forms. The two most common occurrences are undersized bridges and culverts. The construction cost of these structures is related in large part to their size. For this reason, we are inclined to make these structures as small as possible. Most modern structures are

A culvert under Museum Village Road was unable to accommodate high flows resulting from a storm event. Such a scenario is a common cause of ponding and flooding throughout the Moodna Creek Watershed.

[3] http://www.vermontriverconservancy.org/

designed to handle a certain level of flow. The result is that the structure conveys flow up to a certain point and then water begins to back up upstream of the structure. The immediate result is increased stress at the constriction and in the downstream channel where the water emerges from the structure. This causes erosion of the channel and banks analogous to spraying soil with a strong stream from a garden hose. As the backwater accumulates it can reach a point where it overtops the road, causing damage or failure of the road embankment. If there is no way for the water to pass around the structure, the structure may be submerged and sustain damage or even fail.

Current best practice in road-stream crossing design bases the size of the structure on the dimensions of a stable section of nearby stream channel called a "reference reach." The result is a larger structure which can cost 30% more than a conventional, less resilient design but can handle much greater flows, convey mobile debris such as trees, and, due to its resiliency, require little or no regular maintenance or attention after a flood event. There are other valuable benefits of stream simulation design including improved water quality, habitat, and aquatic organism passage. It can be argued that the upfront cost is easily justified by the reduced chance of failure and the decreased need to replace the structure before the end of its longer-than-average design life.

2.2.1.4. Dams

People have inhabited the land that drains to Moodna Creek for centuries. The water was a source of power for industry for much of this time. The remnants of this relationship exist today in the form of historic dams scattered along the Moodna and its tributaries. These dams negatively impact stream vitality in multiple ways.

Dams prevent the natural movement of sediment by trapping it in the upstream pond. As water travels over the dam and downstream, it picks up material to replace what was left upstream. This is unofficially known as the "hungry water effect". The counterintuitive result is that dams exacerbate downstream channel erosion. This can be observed at the bottom of dams where only the largest rocks and boulders or clean bedrock remain.

Dams also result in excess heating of water. Impounded water absorbs more energy from the sun than shallow, flowing water. Increasing water temperature lowers the amount of oxygen in the water. The resulting low oxygen level can cause undue stress on aquatic organisms. Historic dams can also be a barrier to aquatic organisms. The ability for aquatic organisms to move up and down stream is crucial to the health of a stream. Certain fish species seek upstream breeding grounds or cold water refugia. Less obvious are the other creatures, such as macroinvertebrates that naturally support the food chain by providing a consistent food source for other organisms as they are carried downstream.

The required investigation, engineering, and construction involved in dam removal can be extremely complex and often involves numerous state and federal permits. Costs for dam removal projects can range from $10,000 to over $1,000,000.

2.2.2. **Prioritization and Sequencing**

Once problem areas are more fully evaluated and understood, the solutions can be conceptualized and prioritized for implementation. Projects can be prioritized based on a number of factors including, but not limited to:

- Potential to reduce stormwater flows or increase stream stability
- Benefit to the community (e.g., improved emergency services or recreational access)
- Benefit to water quality
- Benefit to aquatic organisms and other wildlife
- Benefit to the community
- Feasibility/cost

Developing a rubric which can be used to score each project will aid in ranking. The rubric would be used to provide a score or ranking for each factor for each project. Multipliers can be added to certain factors to calibrate the numerical value with the importance of that trait. Total scores for each project can then be used to help add objectivity to the project planning and prioritization process.

Consideration should also be given to the order in which projects are executed. For instance, if the issue of concern is stability within the stream and the goal is to reinstate dynamic equilibrium, it would make sense to start at the top of the watershed and reduce stormwater flows before doing downstream restoration work.

3. OPTIONS FOR FUNDING WATERSHED WORK

There are a number of different strategies that communities, county governments and watershed groups have used in funding watershed improvement activities. Two of the most common are:

- Developing an inter-municipal agreement to pool resources to be used for a specific project or in support of a particular outcome.
- Establishing a "watershed utility" where users pay a fee based on land-use and contribution of runoff to the stormwater system, and the revenues raised are dedicated to stormwater pollution prevention activities.

3.1. Inter-municipal Agreements

Inter-municipal agreements are versatile instruments. They are agreements between and among municipalities that regulate a specific area or topic that impacts or infringes on more than one municipality. For purposes of land use law, "localities may agree to adopt compatible comprehensive plans and ordinances, as well as other land use regulations, and to establish joint planning, zoning, historic preservation, and conservation advisory boards, or hire joint inspection and enforcement officers." Any town, city, village, or county in New York State has the ability to enter into this type of agreement. The number of municipalities that enter into the agreements can be anywhere from two to twenty and beyond. Two illustrative examples of how inter-municipal agreements have been used are provided below.

3.1.1. **Titicus River.**

In 1995 the Towns of Lewisboro and North Salem New York and the Town of Ridgefield in Connecticut collaborated with New York City for the preservation and protection of the Titicus River Watershed. The communities desired increased water quality, for the drinking water provided to New York City from the Titicus River. This agreement provided a unique section regarding written statements released to the press. It provided that New York City would be given five days' notice of any release. It also provided that New York City would have a thirty-day time period to review and comment on "publications, reports and other written statements." This agreement further set forth the responsibilities of the participating parties regarding liability, indemnification and the renewal of the agreement.

3.1.2. **Long Island Sound**

In 1998, eleven communities joined together under the Long Island Sound Watershed Intermunicipal Council to "preserve and conserve the Long Island Sound." This committee was interested in cleaning up the Long Island Sound and the surrounding area, and improving the quality of life for individuals residing in these communities. The goals for this agreement include:

- a cleaner Long Island Sound;
- a curtailment of point and nonpoint source pollution; and,
- preserving the open space and natural resources in and around the Sound.

The agreement also delineates shared interests among the communities including the increased economic value of the business and industrial districts, improvement of air and water quality, reduction of noise and traffic, open space and recreational opportunities, and the "cultural, social, scenic, aesthetic and historical assets of the area." The results to be achieved by this committee include obtaining funding from county, state, and federal agencies.

3.2. Watershed Utilities

Across the country, communities are establishing and levying fees for watershed or stormwater utilities (SWUs) to manage stormwater and address water quality-related issues. It is easiest to think of a utility fee the way we think of an electric utility fee or gas utility fee, except the utility that is provided is the management of stormwater. A survey performed in 2012 by Western Kentucky University reports over 1,300 SWUs have been formed throughout 39 states, although to date none have been formed in New York State (Campbell 2012).

A stormwater utility has several distinct advantages as a source for funding stormwater management compared to funding such endeavors with general fund appropriations. First and foremost, such a utility fee provides a stable source to fund watershed management and improvement efforts as compared to general fund appropriations which tend to ebb and flow with the political tide. Second, many of the assessment options discussed below present a more equitable apportionment of fees amongst residents than does a tax based upon property value or income. Third, for fees that are based upon the amount of impervious surface (and thus highly correlated to stormwater runoff), the potential for the fees to assist in behavior modification (i.e., the reduction in impervious surfaces) can be expected to increase.

There are several ways that a government body can assess a stormwater utility fee:

- Flat fee. The flat fee is a uniform charge that each property is assigned. Flat fee models usually charge a set fee to residential properties and a higher fee to non-residential properties such as commercial entities, schools, government buildings, etc. The flat fee is egalitarian in that all residential properties and all non-residential properties contribute equal shares toward stormwater management and it is easy to administer and does not require individualized assessments.
- Tiered fee. The tiered fee is similar to the flat fee, but the fees are further broken down into tiered categories which account for different types of properties' varying impacts to stormwater. A tiered fee assessment model will usually take the form of ascending fee values that are ranked according to the amount of impervious surface found on a property or by another factor such as dwelling type. This model is effective in that residential properties, for the most part, do not vary as greatly as non-residential properties with regard to the amount of impervious surface on the parcel.
- Variable fee (ERU). The majority of stormwater utilities use a variable fee assessment model that is often referred to as the Equivalent Residential Unit (ERU) to assess stormwater utility fees for non-residential properties. The idea is that the average amount of impervious surface for residential properties is determined (usually by a random sampling of residential units), and this amount becomes the ERU. Non-residential properties are then assessed stormwater utility fees individually, based upon how many ERUs they contain.

Campbell's study found that the most common method to determine fee rates was the use of an Equivalent Residential Unit and that typical monthly fees ranged from $0 to $22 per month with the average being $4.20 per household per month (Campbell 2012).

4. SUMMARY

Improving the health of a watershed can have far reaching benefits in the surrounding community. The possible next steps described in this report could not only lead to a reduction in flood hazards in the Moodna Creek Watershed but also will result in an altogether healthier watershed. Water quality will be improved and habitat and aquatic organism passage will be enhanced. This leads to a healthier ecosystem which can more readily support sport fishing and inspire passive recreation like boating, swimming/wading, streamside hiking, and bird watching. Provided there is sufficient public access, a healthy ecosystem can significantly impact local economies by supporting recreationalists both from within and outside the watershed. Living in close proximity to recreational assets is known to increase the "livability" of communities. Likewise, property values improve when local recreational resources increase in quality or quantity. This bodes well for sustaining watershed improvements; the more people experience and enjoy a natural resource, the more willing they are to protect and improve that resource. In other words, developing recreational use of a river increases awareness and willingness of people to buy in to the importance of the health of a watershed.

A community that understands and values a watershed also becomes an asset when taking actions to improve water quality and reduce flood hazards. A supportive community is more likely get involved and support projects or see benefits resulting from the collection of a modest stormwater utility fee.

This report has provided suggested direction for taking the next step towards reducing flood hazards in the Moodna Creek Watershed. Much of the conceptual information and specific issues were already well documented in the *Moodna Creek Watershed Conservation and Management Plan.* More than anything, significant long-term improvements in the watershed will depend on a steady, deliberate, and coordinated effort to ensure the prioritization, planning, funding, and implementation of stormwater improvement projects.

5. REFERENCES

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