Flood Prevention and Resiliency

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Executive Summary

Northfield is a town that is susceptible to flooding due to the proximity of many developments to the Cannon River, which flows through the downtown area. This flooding is often a result of heavy precipitation events. Due to climate change, the frequency and intensity of these events will increase. It is therefore necessary for Northfield to have a well designed and comprehensive plan to prevent floods, mitigate their damage, and be resilient to their effects. In this paper, we propose a two pronged approach that focuses on government action to prevent floods, and to increase the ability of the public to respond and prepare for these events on their own. In order to accomplish these goals, we propose that Northfield create projects to restore wetlands and floodplains to their natural state. Additionally, Northfield should begin an awareness campaign to educate citizens on proper methods of damage prevention, mitigation and recovery. This entails creating a website dedicated to flood information, public workshops where people can learn about flooding, and incentivizing personal flood resiliency. This will also allow Northfield to investigate ways in which sustainable practices can be applied to other areas of the community, such as building codes and future development. While these projects will have large short term costs, we project that in the long run they will save money by reducing future costs of repairing flood damage, thus making these steps cost effective.

I. Introduction

Flooding is something that can occur almost anywhere in the world, including Northfield. It is among the most common and harmful of natural disasters, causing about six billion dollars worth of damage in the United States and over 140 deaths worldwide per year.[1] In Northfield, the main culprit of flooding events is the Cannon River, which bisects Northfield and is prone to spill over its banks following intense precipitation events. We have seen flooding in Northfield as recently as September 2016, when Carleton College was especially impacted by the flood -- many athletic fields and buildings near the river were unusable for a couple weeks and many grass fields needed to be completely replaced, rendering them unusable for an even longer period of time . Additionally, in recent years the severity and frequency of flooding has increased due to the effects of climate change. Much of this is due to the increased frequency of 'mega-rains.' FiveThirtyEight, which describes these events has rainstorms that drop over 8 inches of rain at the center of the storm and over 6 inches over 1,000 square miles, found that Minnesota has had 11 such storms since 1973. However, climate change's effects are very apparent in this case: of those 11 storms, 8 have occurred since 2000, with 2 of those coming in just 2016.[2] As climate change continues to worsen and its many effects begin to manifest, the likelihood and severity of flooding events will increase.

We have identified multiple options that would significantly improve flood prevention and resiliency. First, information hazard awareness programs can benefit both prevention and resiliency. These programs are vital to informing residents and businesses about the potential impacts of floods, best practices for protecting one's welfare and property, post flood recovery procedures, and long term flood planning. Overall, methods of disseminating information such as

[1] Floods. (n.d.). Retrieved May 29, 2018, from https://www.nationalgeographic.com/environment/natural-disasters/floods/

[2] Koeze, E. (2018, May 17). The Midwest Is Getting Drenched, And It's Causing Big Problems. Retrieved from https://fivethirtyeight.com/features/the-midwest-is-getting-drenched-and-its-causing-big-problems/

these programs are very important for mitigating the overall negative impacts of floods. We propose that Northfield create online resources as well as publicly accessible workshops to disseminate information regarding floods.

Another option is to restore the areas surrounding the Cannon River as close to their natural state as possible. This can be done by restoring the floodplain to its original grade and slope, which provides flood water with areas to spread out and slow down. Floodplains also naturally filter the water, making the river cleaner and healthier Making an effort to maintain and restore wetlands near rivers and other areas prone to floods can also help decrease the negative effects of floods. These wetlands act as a natural buffer in the event of floods, soaking up much of the flood water and serving to decrease the severity of floods.

For the rest of this paper, we will first establish why this topic matters before looking at what Northfield is already doing on the topic of flood prevention resiliency. We will next examine what actions will yield the most significant impacts in terms of helping with this issue. Finally, we will analyze key issues in program design and implementation before finally recapping our main points.

II. Why Flood Prevention and Resiliency Matter to Northfield

Flooding is a unique event in that it affects many aspects of life, and these effects can persist over a long period of time. Two primary arenas in which floods are harmful to us are their effects on our drinking water and our economy. Flooding can cause serious harm to both of these areas, and if resiliency programs are not well maintained and effective, it can lead to long term damage to vital systems in society.

One flooding-related issue is how floods affect our drinking water. Floodwater sweeps up everything in its path, meaning it carries things such as raw sewage, animal waste, oil, chemicals, and agricultural runoff. Northfield gets much of its water from aquifers. All public water comes from this source, as does the water on both college campuses in Northfield. Contaminated flood water can seep into this aquifer during and after floods, thus polluting our drinking water. Flooding can also temporarily put wastewater treatment plants out of service, making it significantly harder to find access to clean drinking water. This was an issue during the 2010 flood in northfield, as problems with wastewater treatment made river water much dirtier.[3] Floods do not guarantee a threat to our drinking water, but they are capable of doing so via having the potential to directly pollute our aquifer as well as create issues with wastewater treatment.

Floods can also cause potentially severe economic losses. The September 2010 flood in Northfield led to an estimated $5.5 million worth of damage to athletic facilities and student housing at Carleton, and damage to city-owned infrastructure accounted for over $1 million more worth of damage. Additionally, 16 Northfield businesses reportedly sustained harm from the flood.[4] In addition to the thousands of dollars of damage to the buildings, these companies lost business and thus money due to having to stay closed for repairs. Other companies lost business due to this flood and others as well. Due to the 2010 flood, Highway 19 was partially flooded and stayed that way for a couple days, making transportation to, from, and around Northfield much more difficult. This also damaged or washed away many cars, further preventing companies from conducting business and the owners of those cars from getting to where they need, such as their workplaces. Many Northfield homeowners also experience water damage and

[3] Craig, Z., Stewart, C., Jaquette, M., & Yang, J. (n.d.). *Wading through the Muddy Floodwaters: Social Vulnerability to Flooding in Northfield, MN, a Case Study* [Scholarly project].
[4] Ibid

flooding in their basements and occasionally the lower levels of their houses. The 2013 flood was even worse for homeowners than the 2010 flood, as 20 homes sustained enough damage to displace their occupants.[5] Flooding can severely disrupt our economy and cause damage that is very expensive to repair.

By instituting and improving flood prevention and resiliency, the city of Northfield stands to benefit in multiple ways. Concerning economic losses and property damage, improving how the city deals with floods has the potential to save Northfield significant money in the long run. Putting better systems in place would lessen floods' initial and lasting effects, leading to less property damage and less disruption to business. For these reasons and more, putting better flood prevention and resiliency systems in place would benefit Northfield's economy.

Likewise, implementing these better systems would give Northfield the opportunity to conserve the surrounding environment. These systems could help the environment in such ways as preventing runoff that harms vegetation as well as destabilizing soil erosion, especially on the river banks. Additionally, many species of wildlife would benefit from these measures, helping not only those species but also ensuring that the ecosystem as a whole stays well balanced. The opportunity to help the environment as well as the Northfield economy goes hand in hand with efforts to prevent floods and also increase our resiliency following these natural disasters.

III. Northfield's Current Flood Prevention and Resilience Policies

The city of Northfield currently has limited widespread policies on flood and storm water prevention, and they have no current plans to expand or implement new policies in the future. However, the city has taken many small steps toward tackling the issue. The city places a lot of

[5] Craig, Z., Stewart, C., Jaquette, M., & Yang, J. (n.d.). *Wading through the Muddy Floodwaters: Social Vulnerability to Flooding in Northfield, MN, a Case Study* [Scholarly project].

responsibility on individual property owners to prevent flooding on their land. Each property owner is responsible for water drainage on their own property, so they must ensure that water does not pool around their foundation and that there are no drainage problems for their neighbors.[6] Northfield also manages the reduction of soil erosion from water runoff, using a permit system. It is required that all new construction and grading projects acquire a permit from the city that dictates how soil erosion will be mitigated through runoff management.[7] In order to obtain this permit, property owners must sign a waiver claiming that they will uphold Northfield's stormwater ordinances, and that they will make any necessary changes if they do not meet the necessary standards. Other ways that Northfield engages individuals in flood and stormwater prevention are through their rain barrel and rain garden incentive program[8]. Rain barrels and gardens are both capable of holding excess stormwater, limiting the amount that flows into the sewers and eventually the cannon. Northfield provides reimbursements and financial incentives to increase the number of citizens that partake in these programs.

A method that Northfield uses to prevent flooding on a large scale is with stormwater retention ponds, of which the city currently owns and maintains over thirty.[9] These are relatively small ponds that are a part of the storm sewer system. They contain water at all times, and additional stormwater flows through them on their way to the Cannon. The ponds retain some of the storm water and slow down the speed at which it reaches the river, which helps to mitigate flooding. Retention ponds also give sediments and other contaminants time to settle out of the water, preventing them from reaching the river. These ponds are fairly effective, but require a lot

[6]Simpson, S. (n.d.). *Storm Water Management*(United States, Northfield, Storm Water Management). Retrieved May 29, 2018, from https://www.ci.northfield.mn.us/304/Storm-Water-Management

[7]*CONSTRUCTION GRADING, SEDIMENT AND EROSION CONTROL PERMIT APPLICATON*[Construction Application for Erosion]. (n.d.). Minnesota, Northfield.

[8] United States, City of Northfield, Public Works. (n.d.). *Rain Garden / Rain Barrels/Native Plant Rebate*. Northfield, MN.

[9]*Storm Water Ponds Maintenance*[Description of maintaining retention ponds]. (n.d.). Northfield, Minnesota.

of maintenance from Northfield. The ponds often fill up with sediments, which limits the amount of water that they can hold. If too much sediment builds up in the ponds, they can overflow on a regular basis. Therefore, the sediments need to be removed, and this process can be labor intensive and expensive. Additional maintenance on the pond includes managing the surrounding vegetation and keeping the intake and outtake pipes clear.

In order to prevent the amount of damage done by floods, the Northfield has building codes that limit development in areas surrounding the cannon river. There are three different flooding zones, which are determined by the FEMA floodplain map.[10] The zone closest to the river is the floodway subdistrict, in which only structures with low flood damage potential can be built. This includes parking areas, parks, fences, lawns, and other structures that can easily withstand flooding[11]. The next zone is the flood fringe subdistrict, which is adjacent to the floodway. Any building is permitted to be built in this zone, as long as they comply with the underlying zoning district[12]. The only stipulation is that all structures must be elevated so that the lowest floor is above regulatory flood prevention.These building must also be built to be resilient to floods in accordance with structurally dry flood proofing classification. The most outlying zone from the river is the general floodplain subdistrict. There are no specific restrictions in this zone, but all new construction projects must complete an application. The city planner has the discretion to apply any restrictions of the other two zones if they deem fit.[13] These restrictions are inplace to increase flood resiliency. They help to ensure that the damage done by a flood will be mitigated, by not allowing flood susceptible buildings in high risk areas. Floods are then easier to recover from, because there is less damage to repair.

[10] Northfield Flood-Zones-Map [Map]. (n.d.). In *Flood-Zones-Map*. Northfield, MN. https://www.ci.northfield.mn.us/DocumentCenter/View/582/Flood-Zones-Map-PDF
[11]United States, City of Northfield. (n.d.). *Northfield Land Development Code*. Northfield, MN.
[12]Ibid
[13] Ibid

IV. Policy Suggestions

As floods are a natural event, nature has already created the most effective ways to deal with flooding through billions of years and trial and error. Human developments have greatly disrupted these natural systems, which have exacerbated the damage and harms caused by flooding. In nature, flood damage does not exist. Flooding only leads to harms when humans are being detrimentally impacted. Therefore, the more intensely and less effectively the area surrounding a river is used, the greater the potential for damage.[14] In Northfield specifically, there is a lot of development along the Cannon River, and this development has diminished nature's ability to deal with floods. Therefore, we have designed a two pronged approach to deal with flooding. The first method is to restore the natural floodplains and wetlands to their original conditions, and protect them in the future. The second prong includes expanding the ability of the public to deal with floods on their own. This can be accomplished by awareness campaigns and creating accessible information regarding personal flood resiliency and recovery.

Floodplains are the low lying areas that surround rivers and are a key component of river systems. They slow the flow of the river and hold the water when it overflows, which can protect homes and businesses. Chemicals and pollutants are also naturally filtered by floodplains, making the water the water cleaner and healthier.[15] However, floodplains are only effective if they have the proper slope and area, which is often disrupted by development. Delaware County, New York has experienced increased flooding and flood damage along the Delaware River from

[14] *BEST PRACTICES ON FLOOD PREVENTION, PROTECTION AND MITIGATION*(Rep.). (n.d.). Floods.org. http://www.floods.org/PDF/Intl_BestPractices_EU_2004.pdf

[15] WHY WE NEED TO RESTORE FLOODPLAINS. (n.d.). Retrieved May 29, 2018, from https://www.americanrivers.org/threats-solutions/restoring-damaged-rivers/benefits-of-restoring-floodplains/

intensified storms over the past twenty years.[16] After severe flooding from Tropical Storm Irene in 2011, the county decided to bring in various stakeholders and municipality leaders to find ways to mitigate flood impact. This group decided that floodplain restoration would be most effective, and they identified specific sites of interest. These sites had become filled with sediment as a result of construction processes, and the cities regraded them to have the proper slope and elevation to allow water to spread out over the floodplain. There are still additional sites they want to restore, but flooding is being reduced with each project. This has already had a tangible benefit for the community. Not only have the impacts of flooding lessened, but community members now have to pay ten percent less for flood insurance, since the projects lowered the amount of risk on FEMA's community rating system.

To follow this model, we propose Northfield should survey the floodplain of the Cannon and identify key areas that can be restored. The area that the city should focus on is south of downtown, where there is there a lot of area that does not have existing development right along the shores that would prevent floodplain restoration. The restoration of the floodplain should have significant benefits for Northfield. It would reduce the severity of flooding, by giving the water areas to spread out and slow down. This is another reason why it would be beneficial to focus on the area south of downtown, because the degree of flooding will be decreased before it reaches downtown. This would reduce the amount of damage done by the flood, saving the city and businesses in Northfield money. Additionally, Northfield partakes in the FEMA flood insurance program, similar to Delaware County. If Northfield makes these floodplain restorations, the city could also potentially see reduced insurance rates, which would citizens

[16]N. (n.d.). A Community Works Together To Restore The Floodplain And Reduce Damages. Retrieved May 29, 2018, from https://coast.noaa.gov/digitalcoast/training/walton-village.html

money. This decrease in insurance rates along with the reduced damage may outweigh the cost of restoration, making this policy economically beneficial.

Similar to floodplains, wetlands are an important part of nature's flood regulation. Wetlands are unique ecosystems that often occur along the banks of rivers, and they have the capability of storing a large amount of water to alleviate the effects of flooding. The amount of water a wetland can actually hold varies based on a variety of factors, but typically one acre of can store roughly one million gallons. Wetland vegetation can also slow the flow rate of flood waters. These properties contribute to lowered flood heights and lessen the destructive potential of a flood.[17] Numerous municipalities around the country have experienced the benefits of protecting and restoring wetlands. In Massachusetts, the U.S. Army Corps has used wetlands to prevent flood damage along the Charles River. It purchased 8,103 acres of wetland for protection, which was a much cheaper and more natural solution than installing dams and dikes.[18] It is estimated that these areas prevent over seventeen million dollars in flood damage annually. Another successful wetland restoration project was done by the Pennsylvania Department of Transportation, which restored 65 acres of wetland to offset the impact of filling wetlands during the construction of a highway. This area is alongside a creek, which previously experienced frequent and violent flooding. These new wetlands are capable of storing 63 million gallons of water and has reduced the severity of flooding in the creek.[19]

According to the U.S. Fish and Wildlife Service, a good portion of the Cannon River in Northfield is adjacent to wetlands.[20] These wetlands are concentrated south of downtown and in the Carleton College Arboretum. Northfield should implement a policy that ensures the

[17] United States, Environmental Protection Agency, Office of Water. (2006). *Wetlands: Protecting Life and Property from Flooding*.
[18] Ibid
[19] Ibid
[20] National Wetlands Inventory [Map]. (2018). In *U.S. Fish and Wildlife Service*.

protection of these wetlands and prohibits any future destruction of these areas. The possible destruction of wetlands would worsen the flooding problem, causing additional damage in the future. Furthermore, Northfield should devote funding to restore or create new wetlands in areas where it is possible. These areas would most likely be adjacent to places where there are wetlands currently. This would make it relatively easy to complete, because it involves expanding what is currently there. New wetlands would increase the amount of water being absorbed and further slow the speed of the flood. This would decrease the damage that would be done, which could save the city, businesses, and individuals money on repair costs. New wetlands would also help to filter runoff and erosion, making the water in the Cannon River cleaner. This would not only be beneficial to plants and wildlife inhabiting the river, but it would be socially beneficial for the citizens of Northfield, because people are more likely to interact with a cleaner river. Wetlands are also visually pleasing and provide nice scenery alongside a river, further increasing social benefits for Northfield residents.

There is, however, only so much area that can be dedicated to flood prevention. There will always be homes and business that are at risk of flood damage. As such, public awareness outreach is the best way to prevent serious damage to the public. One of the most important parts of flood resilience is the ability of the public to take resilience measures by themselves.[21] When considering risk of a flood, public awareness is a great way to lower the vulnerability of an exposed population. Methods of increasing public awareness include warning systems, internet resources, fliers, public workshops, and advertisement.

Northfield already has an opt-in emergency alert system, called Everbridge, that allows people to receive emergency alerts on the phone, email, or at home. This system, however, is not

[21] *BEST PRACTICES ON FLOOD PREVENTION, PROTECTION AND MITIGATION*(Rep.). (n.d.). Floods.org. http://www.floods.org/PDF/Intl_BestPractices_EU_2004.pdf

strongly advertised. In order for an opt-in system to be effective, people need to know that such a system exists. In an ideal world, everyone would be signed up to this system. As this is unlikely, Northfield should aim to at least have as many people as possible be aware of it. Another way to improve this system, as well as general flood resiliency, would be to make it a mandatory opt-in for people who live in high risk areas. This would improve flood resiliency of high risk areas by increasing the awareness of people at risk. By doing this, people would both feel safer and be safer. Flood damages would be reduced and therefore repair costs would be lower.

Second, there should be a website dedicated to flood information. This information would include warnings, predictions, damage mitigation strategies, and recovery strategies. This resource would allow users to view their location and display a "flood risk factor" for that particular area, in a manner similar to how wildfire risk is scored. The National Weather service produces charts showing flood probabilities for various rivers, including the Cannon River.[22] This information should, at least, be linked to on this new website. In order to increase accessibility, there should also be a description of the graph explaining how best to interpret the information on it.

Additionally, this website would show users a list of flood resilience best practices for their particular area. It is impossible for the government to protect every single house from a coming flood, so it is necessary for individual homeowners to understand the most effective ways to protect their property. After damage mitigation, the website would also provide information regarding how to begin clean up after a flood, as well as FEMA insurance information. For reference, the city of Harrisburg, Pennsylvania, has created a webpage that is

[22]Advanced Hydrological Prediction Servce, National Weather Service. (n.d.). Retrieved May 29, 2018, from https://water.weather.gov/ahps2/probability_information.php?wfo=mpx&gage=nrfm5

dedicated to flooding.[23] The webpage links directly to personal resilience information, flood maps, flood insurance information, relevant partner organizations, and the city flood plan. This would serve to create awareness with the public and educate them on how to best deal with floods. It would also make people more aware of when they are at risk of a flood. This tool could also provide information regarding the potential harmful effects of floods. This, again, would work to increase the safety of people who are at risk of flooding. If they know that a flood is coming, they can prepare for it. This would serve to decrease costs of flood damage, as people would be able to mitigate some of that damage on their own.

This information, however, should not only be available online. Fliers should be available at popular town locations which present an overview of damage mitigation and recovery. Another way to spread this information is at public workshops. The community could strongly benefit from volunteer or expert led seminars where they can go to learn and ask questions about flooding. This would provide an opportunity for people to ask specific questions regarding their situation, which would serve to better prepare the community as a whole. The previously mentioned fliers would also be distributed at these meetings.

Finally, Northfield should incentivize personal or commercial flood resilient renovation. This type of renovation includes moving appliances out of flood prone areas, such as basements, improving structural integrity of a building, or installing flood resilient windows. Ideally, people would be able to have a building renovation evaluated for flood resilience by Northfield. If the plan was confirmed to increase flood resilience, Northfield could offer some kind of monetary incentive, possibly in the form of a tax break, as a reward for improving the flood resiliency of their building. This would incentivize people to create flood resilient buildings, and prevent potential future costs as a result of flood damage. As this strategy would be potentially

[23] http://harrisburgpa.gov/floodplain-information-page/

expensive, Northfield should, at least, collaborate with FEMA or a building agency to create a list of guidelines that people who want to increase their own resiliency could follow.

By both alerting people to flood resilient practices, and making them aware of the dangers of flooding, people will be better equipped to deal with these issues.

It is also important to integrate this information into future development. While the principles laid out so far have been mostly focused on increasing the resiliency of existing infrastructure and property, it is necessary to plan out future developments in a way that is consistent with the known impacts of flooding. Primarily, building codes and locations must be created and chosen in accordance with flood risks in mind.

V. Key Issues in Program Design

While both prongs of our policy suggestions will be effective, increasing personal awareness will do the most for flood resiliency with the least amount of money and effort. Floodplain and wetland restoration and maintenance, most importantly, can take time to plan and implement. Awareness campaigns can be created and implemented faster and at a lower cost. As such, these campaigns will have the greatest immediate impact. However, floodplain and wetland projects could prove to be more beneficial in the long run in that they serve to reduce the severity of flooding. It is our recommendation, then, that planning for both options begin at the same time. Awareness campaigns should be implemented as soon as possible due to their immediate impact, and floodplain and wetland project planning should begin as soon as possible due to its longer planning and implementation time.

Once potential solutions are identified, the feasibility of these solutions must be examined. This entails examining the implementation process of these solutions, as well as analyzing political and economic roadblocks for making these solutions a reality. A key piece of

any sustainable development initiative is integrated decision making. This refers both to making sure that any new development is in someway also benefiting the environment, and also including all possible stakeholders in discussions regarding new initiatives. Perhaps the best place to implement this concept is when moving forwards with other sustainable development issues. For example, if Northfield moves forwards with the tiny homes project, it would be beneficial to make sure that these homes are built in a way that is flood resilient (elevated appliances, not in a high risk floodplain, flood resilient windows). It is also important to note that initiatives taken to benefit the environment may be indirectly related to flood prevention. If, for example, Northfield was creating new building codes to increase flood resilience, the could also use this time of code revision to implement green building codes.

It is important that these ideas are considered in any potential policy decision. As these initiatives are setting out to benefit as many people as possible, understanding the needs of all parties will lead to a more successful outcome.

The policies that involve attempting to restore the watershed to its natural state may face severe opposition, especially regarding economics. This is due to the fact that there is not a clear monetary incentive to complete these projects. There is no way for a floodplain or wetland restoration to generate revenue, and there will be a steep upfront cost. However, that does not mean that these projects will not be cost effective. Their goal is to reduce the damage done by flooding, which should save both the government and individuals money in the long run, as they did in New York, Massachusetts, and Pennsylvania. These policies, although cost effective in the long run, can still likely struggle to gain public support, as people are often more focused on the short term benefits. These policies would be implemented with the hypothetical (although extremely likely) chance of a severe flood occuring in the future, which may make some people

wary of such a large investment. In this regard, Northfield should be at an advantage, because the town has experienced significant flooding in the recent past. These events should make people more receptive towards flood prevention measures.

There are a few possible solutions to the issue of raising the necessary money to accomplish these projects. The city currently charges property owners a monthly stormwater utility fee, which is used to manage stormwater runoff and pollution control.[24] A portion of the revenue from this fee could be put towards these new flood prevention projects, and the monthly cost for property can be slightly increased to account for the additional spending. There is also federal funding available for flood prevention projects. FEMA has a Flood Mitigation Assistance Grant Program, which appropriates funding to municipalities for projects and planning that reduces the risk of flood damage[25]. These projects in Northfield definitely fall under this category, so receiving funding is a strong possibility.

There is the additional issue of the downtown area, which lies adjacent to the Cannon River in the natural floodplain. While there is a floodwall on the banks of the river, this area is still prone to frequent flooding. Due to the existing infrastructure and development, it is impossible to return this area to its natural state, so these policies that we proposed cannot be implemented in this area. However, this does not mean that the downtown area will not be benefited by restoring the floodplain and wetlands. These restorations will hopefully slow floods and reduce their severity. This should diminish the severity of the harms for the downtown area, especially if restorations are done upriver. Additionally, the increased public awareness policies should improve the flood resiliency of the downtown area, because people and businesses will be better prepared for a flood event.

[24] Simpson, S. (n.d.). *Storm Water Management*(United States, Northfield, Storm Water Management). Retrieved May 29, 2018, from https://www.ci.northfield.mn.us/304/Storm-Water-Management
[25] United States, FEMA. (n.d.). *Flood Mitigation Assistance Grant Program*.

With regards to public awareness, any online resource needs to be easily accessible and informative. Information on this website needs to be easy to find as well as easy to understand. The information must be written in a way that a non-expert can understand. It is important that these systems are accurate, as inaccuracies could lead to both distrust of the system and avoidable damages from flooding.

Implementation of this system would require costs to cover web development. Web maintenance and server time would need to be paid for as well. Northfield could use students from Carleton and St. Olaf to create this website, as well as populate it with relevant information. This would likely decrease costs significantly, as well as provide real world experience for environmental and computer science students.

In terms of new developments, not only do they need to be safe from flood hazards, but it is also vital that new developments do not interfere with existing floodplains and retention ponds, as this could exacerbate damages from flooding in other areas. This highlights a central principle of flood resilience - floodwater should not be passed downstream to be dealt with by another development. The existing infrastructure must exist in such a way that both mitigates current damage and naturally diminishes the flood as well as possible.

Development, if possible, should occur in areas that are not prone to flooding. However, if it is necessary that development occur in flood prone areas, they must be built in a way that is compatible with the hazards of a flood. This means following previously mentioned flood resilient building methods as well as making sure that people living in this area are aware of the flood risk and of resiliency measures. According to the "flood.org" best practices plan, development that is consistent with flood risks and economically justified reactive measures can

contribute more to flood abatement than the natural processes of floodplains and retention pond.[26]

VI. Conclusion

As previously mentioned, we first introduced flooding's general impacts and discussed the direction of the paper. We subsequently looked at problems and opportunities caused and created by floods. Specifically, we discussed how flooding can harm Northfield's economy as well as its drinking water and looked at associated economic and environmental opportunities. Next, we investigated Northfield's current actions, which include strict building codes, subsidizing rain gardens and rain barrels, and maintaining storm retention ponds. We then made our proposal in which we suggested focusing on both government action to prevent flooding as well as increasing public preparedness for these disasters. These would be accomplished via such programs as floodplain and wetlands restoration, the creation of a comprehensive website (as well as other information channels) for all flood-related information, and the promotion of personal or commercial flood resilient renovations. We finally discussed key issues in program design, a discussion that touched on potential issues such as economic impediments and the close proximity of much of downtown Northfield to the Cannon River.

[26] *BEST PRACTICES ON FLOOD PREVENTION, PROTECTION AND MITIGATION*(Rep.). (n.d.). Floods.org. http://www.floods.org/PDF/Intl_BestPractices_EU_2004.pdf

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