"Preventing Flood Damage to Businesses in Historic Downtown Snoqualmie, WA"

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1. Introduction

The City of Snoqualmie was established in 1903 and is located approximately 25 miles to the east of Seattle, WA. The downtown area is situated next to the Snoqualmie River and is commonly referred to as the historic district for its many landmarks (City of Snoqualmie, 2009). Despite the regular flooding events that the city faces, many residents and business owners find it difficult to leave and the city's population continues to grow each year. During a site visit, city officials welcomed the research team and explained some of the flooding issues faced by the historic downtown and discussed what is currently being done to help minimize the impacts of flooding. Composed of student planners and student engineers from the University of Washington, the project team seeks to combine their various backgrounds towards finding potential solutions to help speed up the post-flood recovery process in the downtown area.

2. Characterizing the Hazard

The historic downtown business district is located within the floodplain of the main stem of the Snoqualmie River and Kimball Creek (City of Snoqualmie, 2013b). The north, middle, and south forks of the Snoqualmie River converge upstream of the city. Flooding is usually gradual, so residents have abundant time (more than one day) to prepare for flood impacts. Flooding occurs frequently, with recent storms experienced in 1990, 1995, 2006, and 2009. The severity of flooding varies greatly depending on location within the city. Floodwaters can reach heights of several feet in some places, but is generally limited to one to two feet in the historic downtown area.

3. Impacts

Figure 1: City of Snoqualmie Stormwater Facilities Map (City of Snoqualmie, 2012)

Sediment Build-Up in Stormwater Conveyance Systems

Large volumes of fine sediment are carried by the Snoqualmie River and deposition of these fines is possible due to the nature of the Snoqualmie river floods. During periods of extremely high flows, the river is bottlenecked at Snoqualmie Falls and slowly backs up, eventually inundating parts of the city for several days. As a result, the fines settle out of the water column, with some settling directly into stormwater catch basins (CBs), thus significantly reducing their capacity to convey stormwater. If another large rain event occurred after the floodwaters receded, the city's stormwater system could be compromised and a second, albeit much smaller, flood event ("mini-flood") could occur. System backflow could result in water accumulating in areas that are not typically affected by riverine flooding. The City of Snoqualmie recognizes that sediment build up could be a large problem, and in order to avoid it, they vactor (vacuuming using a Vactor cleaning truck) out their CBs after flood events. While this solves the problem, it is a very expensive task. In King County, water pump operators are paid $50.22 an hour (Washington State, 2013). Considering that there are over 100 CBs located around downtown Snoqualmie (Fig. 1), pumping operations could incur substantial costs.

Minor Water Damage to Businesses

City officials classified the flood damage in the historic downtown as relatively minimal, rarely exceeding 18 inches of water for most buildings. Of the buildings affected, older buildings were noted to be more susceptible to flooding. While the structural integrity of these buildings is generally not jeopardized, even a few inches of water can have substantial consequences for business operations, including inventory loss, incurred repair and replacement costs, and delayed reopening. During a recent major flood, the historic former City Hall building was inundated with several inches of water, resulting in interior damage and the

loss of many older paper records dating back to the founding of the city. The local hardware store has also dealt with flooding in the past. As an older structure, it does not have a solid floor, and rising waters can come up through the floorboards. When the area is threatened by a flood, the employees painstakingly move much of the inventory from the ground and lower shelves to higher shelves, and surround the structure with sandbags in the hope of preventing flood waters from damaging the store.

Floodwater Damage to Utilities

Utilities typically face only minor damage from flooding. Because typical floodwaters rise slowly and velocities are relatively low, above-ground electrical distribution and communication lines are not generally impacted by floods. The biggest dangers to above-ground utilities is assumed to be at junction facilities, such as electrical substations, where connecting equipment is not located high enough off the ground and the collision of flood debris with utility poles or wires. Impacts to below-ground utilities have the potential to be more substantial. City officials described typical damage to natural gas utilities as limited to natural gas meters where gas lines connect to businesses. The response is simply meter replacement by the natural gas and electric utility provider, Puget Sound Energy (PSE). In the event of a more severe flood, floodwaters could get into natural gas pipes causing blockages that would lead to service outages (New York State, 2013). Impacts to water systems from flooding in the historic downtown are assumed to be minor. Drinking water for downtown is supplied by a spring and disinfection plant under gravity flow (City of Snoqualmie, 2013a). As long as this plant is built above the BFE, it should avoid inundation by floodwaters. Impacts to sewer systems are also relatively minor. It is assumed that Snoqualmie does not have a combined sewer/stormwater system and that the city's wastewater treatment plant is built above flood elevations. Flood impacts related to sewers fall mainly upon individual businesses: inundation of the system can cause sewage to back up into businesses. Flood impacts on utilities may be made worse if located near the Snoqualmie River, due to erosion of the riverbank. A below-ground water main at the intersection of SE River St and Park Ave SE (one block east of the historic downtown) had to be relocated from the east side of Park Ave SE.

Urban Flood Debris

Urban debris can further increase the duration of recovery efforts because of the additional time needed for the cleanup process. Items that are left loose during a flooding event may be carried away from their original location, necessitating their cleaning or removal after the flood. Using aerial maps and street view from Google, items observed and assumed to be potential urban debris in Snoqualmie include trash containers, dumpsters, tents, bikes, lawn chairs and tables, vehicles, heavy construction equipment, and hazardous wastes. Large items can cause substantial damage if they collide with utilities or structures. Hazardous wastes, such as chemical solvents, cleaners, automotive fluids, may cause water contamination and require specialized cleanup actions, while dumpsters and trash containers can further pollute the downtown area.

4. Capabilities

Sediment Build-Up in Stormwater Conveyance Systems

A cost effective approach to dealing with sediment accumulation in CB's is to prevent it from happening. Many companies manufacture sediment filters that fit over or inside of CBs and prevent sediment from entering them. There are several different options, from sediment traps which are placed inside a CB and must be emptied after the flood (Fig. 2a), filter "walls" that are placed around a CB (Fig. 2b), and grate filters which simply slide over a grate (Fig. 2c). Grate filters appear to the most appropriate option (Fig. 2d), as they can be quickly placed prior to a flood event and removed afterwards, can be easily moved by two people, and do not require workers to dump trapped sediment. In order to determine which CBs are necessary to protect, tools like GIS can be used to determine the basins in the highest risk areas (lowest elevation), and then these basins can be easily flagged for workers to locate on a map similar to Figure 1.

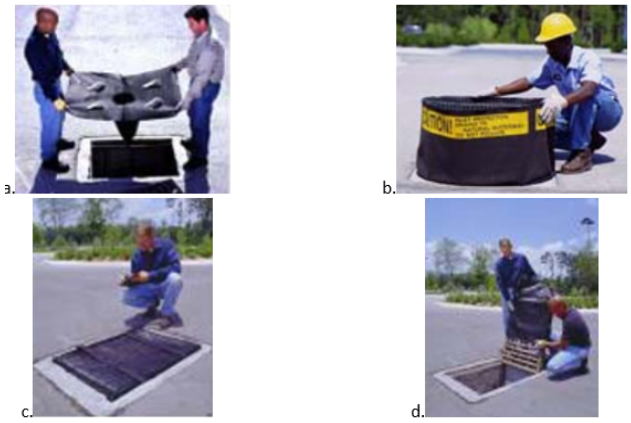

Figure 2: a-d: CB filter alternatives (Granite Environmental, 2013)

Minor Water Damage to Businesses

Given the regular threat of flooding in the historic business district, existing structures should be floodproofed to help reduce damage from rising floodwaters. Because these structures serve non-residential uses, dry floodproofing is an acceptable form of mitigation (FEMA, 2013), and would provide a more lasting and reliable alternative to sandbags around structure during floods. For businesses that rent their space, the tenant should seek prior approval from the landlord. Mitigation grant funding may be available from FEMA to cover the costs associated with dry floodproofing. Utility connections and on-site generators or batteries should be located above the BFE to reduce the threat to these services. Another practical method for flood recovery time would be to encourage businesses to select flood resistant furnishings and develop individual plans for flooding. By eliminating carpets and choosing water resistant flooring and baseboard materials, structures can be cleaned up quickly, allowing for prompt reopening. Individual businesses can adapt their operations in anticipation of a flood by moving inventory, equipment, and other important items out of the flood zone through relocation to an off-site storage facility or elevation to higher shelving within the building. It would be prudent to promote adaptation by requiring that all new buildings elevate their main floor above BFE. A good example of such a design is the local brewery: the interior consists of a concrete floor above street level with an ADA-compliant ramp connecting the entrance to this main level. In the case of flooding, this elevated first floor offers protection against rising water and subsequent damage to equipment. In addition to this elevated floor, the building has an upper seating area, creating a place of refuge for merchandise, furniture, and supplies in the case of extreme flooding. Such design elements can be codified and required by the city for future new constructions or major renovations, ensuring that first floors are made of a flood-proof material and above the BFE.

Floodwater Damage to Utilities

In order to reduce the impact of flooding, electric distribution, communication, and lighting utilities in Snoqualmie should remain above-ground. Puget Sound Energy (PSE) should regularly inspect utility

poles and their foundations to ensure that they are in good working order before a flood occurs. To prevent flood impacts to electrical substations, critical equipment should be raised above BFE, and any below-grade wires should be flood-proofed (New York State, 2013). Individual businesses can also take action to prevent flood damage to electrical utilities by elevating circuit breakers, wiring, and outlets above base flood BFE (FEMA, 2012). Gas meters damaged by flooding are typically replaced by PSE in same the location. To avoid the need future replacement, meters should be elevated above the BFE. This would require a small additional cost for pipe extension, which could be shared by PSE and the business, since it will save both of them money from repeated meter replacement. To prevent damage to the natural gas and electrical systems, PSE could also shut off service to downtown following an evacuation order by the City. Black Hills Energy, the natural gas utility provider for Waukon, SD, shut off service in June 2013 for homes immediately affected or threatened by flooding to prevent natural gas leaks from appliances whose pilot lights could be extinguished by floodwaters (Wagner, KWWL; 2013). PSE could install remote valves that would enable them to shut off natural gas service to specific areas if leaks are detected during a flood (New York State, 2013). Following a flood, the natural gas and electrical systems should be inspected by PSE before being turned back on (NIPSCO, 2013). To prevent flood impacts to drinking water, the City should ensure that the water treatment plant is located above BFE. To prevent sewer backflow into individual businesses, the City should work with them to install sewer backflow valves. These only allow sewage to flow out of a business but not back in (FEMA/SEMA, 2013).

Urban Debris

The city is very active when it comes to notifying residents that a flood is approaching. As volunteers make rounds and door-to-door stops, they can also identify items that might end up as flooding debris and ask residents to properly store or secure such items. Many homes' living quarters are elevated above the BFE, with garages underneath. High storage and shelving units can be built in garages to store smaller items such as chemical liquids, outdoor furniture, bikes and tents (Fig. 3). Vehicles and large construction equipment can be driven to higher ground. The local casino offers abundant parking space, and could

offer special discounts or dinner promotions to encourage people to move vehicles and equipment to higher ground. This would provide a service to the local community, while making use of hotel facilities that are typically empty during a storm event. Installing fences could help contain loose items within localized areas. Based on available information, it is estimated to cost approximately $20 per linear foot of fencing, including labor and materials (Homewyse, 2013). Anchoring dumpsters and garbage containers to the ground with metal cables could help prevent the spread of unwanted garbage pollution and allow for easy attachment or detachment (Town of Clinton, 2013). If garbage collection cannot be performed prior to a flood event, garbage containers should be sealed or locked to prevent contents from scattering. Since not all items can be contained, a proper cleanup procedure should be implemented to speed up the recovery process. Items requiring disposal can be collected and segregated into four piles, as was done after the recent Bolder, CO floods: general household items, electronics and appliances, woody debris and vegetation, and mud, silt, sand and rock (Boulder County, 2013). Experts should be available that know how to properly dispose of chemical or hazardous wastes. Local officials or spill response teams should be readily available to assist residents with the cleanup process. King County offers no-charge business visits, financial help and various locations for household hazardous waste disposal (King County, 2013a).

Figure 3: Examples of Overhead Garage Storage (Redlinetexas.com (above); Saferacks.com (below), 2013)

5. Conclusion

Flooding in historic downtown Snoqualmie can have a serious impact on businesses. However, many potential remedies are available to promote resilience to flooding and reduce the duration of recovery. We have presented a number of options to reduce flood impacts related to sediment build up, utilities,

buildings, and debris. Implementing these measures would enable businesses to reopen more quickly after a flood event, reducing financial losses.

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