Pumping Station Improvements in Floodplains and Floodways

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ABSTRACT

Many pumping stations are located in floodplains or floodways and often require improvements to protect them from floodwaters. Such improvements can vary. Sometimes, floodwalls are necessary to protect the entire station or perhaps just the wet well. Many utilities consider earthen berms (i.e. miniature levees), but they can collect significant amounts of rainwater. Electrical control buildings require protection via flood doors or panels. Providing operator access for maintenance and inspection during such severe events is always a goal, but in some cases not feasible given existing station location and permit implications.

This paper will focus on several recently completed pumping station projects that are in floodplains and floodways. These projects required various physical improvements such as flood-proof doors, stop logs/panels and walls. Other systems may require flood-proofing as well. For instance, to avoid reverse flow into buildings via floor drains, backwater valves may be necessary. Electrical conduits might need sealing, too. Even redundant sump pumps for valve vaults or dry wells might be prudent.

Permitting requirements can also vary. Federal, state and local permits are often necessary. One of the most critical permits is associated with floodway encroachment, which is different from floodplain encroachment. Any project in a floodway must be reviewed to determine if it impedes flow and increases flood heights. An engineering analysis must be conducted before a permit can be issued. The analysis should be based upon a step-backwater computer model used to develop the 100-year floodway shown on the Flood Insurance Rate Map (FIRM). Many projects are designed to avoid this costly and potentially drawn out certification process, especially since there is no guarantee that the modeling effort will indicate that improvements will not increase flood waters and negatively affect upstream property. On a recent project, GHD worked with the permitting agency and developed a plan that successfully balanced removal of existing soil and then addition of new improvements (i.e. no net increase in floodway impact) and successfully avoided the need for modeling and a No-Rise Certification.

Local permitting requirements can also directly affect the project. Building codes can preclude the location of electrical components within 1 to 3 vertical feet above the 100-year base flood elevation. As such, when dealing with existing systems, flood-proof doors and sealed penetrations through buildings are necessary.

Flood protection improvements must balance cost, constructability issues, permit requirements and maintaining operator access during severe wet weather events.

KEYWORDS

Pumping stations, floodway, floodplain, base flood elevation, wastewater collection system

INTRODUCTION

By design, many sanitary sewers and pumping stations are located adjacent to waterways. Streams and rivers have a natural downhill gradient and paralleling them with sewers takes advantage of this natural gravity flow. When sewers get deep or there’s no need for them to extend further downstream, a pumping station is necessary. Often, this occurs near a water body, which means the station could be subject to flood waters.
Each state has minimum design criteria that establishes standards such that sewage pumping stations are protected and maintain service during most flood conditions. Many states have the following requirement “Wastewater pumping station structures and electrical and mechanical equipment shall be protected from physical damage by the 100 year flood. Wastewater pumping stations should remain fully operational and accessible during the 25 year flood.” While some stations were constructed before minimum standards were developed, if upgraded they must meet modern requirements. In some cases, compliance with modern requirements can be costly and difficult.

Utilities must evaluate many criteria when upgrading stations that are subject to flooding. Of obvious concern is the entry of floodwaters into the station’s superstructure which can inundate and render the entire station useless. This is not, however, the only consideration. Can flood waters migrate through drains, electrical conduits or even floor drains back into the station? Are electrical systems subject to flooding? Are auxiliary backup systems protected? Can operators access the station during the flood? Will structures float? If any of these are an issue, a correction measure is necessary.

This paper presents a discussion of various concepts adopted to provide flood protection to ensure pumping station operation during flood events.

**METHODOLOGY**

Environmental agencies have regulations that require structures and electrical and mechanical equipment be protected from physical damage by the 100-year flood. The 100-year flood elevation is also known as the base flood elevation (BFE) or 100-year floodplain. The BFE is the area adjoining a river, stream, or watercourse covered by water in the event of a 100-year flood, which has a 1% probability of occurring in any given year.

How do we determine if a station is affected by floodwaters? The Federal Emergency Management Agency (FEMA) administers Flood Insurance Rate Maps (FIRM). FIRM illustrate flood zones. Flood zones are also shown on many geographic information systems (GIS) maps available from FEMA and various state, county or local agencies. FIRM designate low to moderate risk areas, high risk areas and undetermined risk areas. In other words, the maps delineate various floodplains and also the floodway. Table 1 defines each hazard area.

Where pumping station protection is required up to at least the BFE, reference Zone AE area on a FIRM. Elevations are typically shown on these maps, but not always. Where elevations are shown, the datum can be either National Geodetic Vertical Datum 1929 (NGVD 29) or North American Vertical Datum 1988 (NAVD 88). Thus, the differences between FIRM datum and local surveyor used datum must be accounted for because they can often be 0 feet to over 1 foot vertically different.

Floodplains and floodways are different. Floodways are located within the floodplain. A floodway is the channel of a river or other watercourse and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than a designated height – see Figure 1. Construction within a floodway is limited because of concerns regarding upstream increases in flood elevations that could adversely impact those areas and property. In many locations across the country, some types of construction outside of the floodway, but yet in the floodplain is permissible. This outside area is also known as the floodway fringe. Each state or local community is different and may restrict improvements/construction in a floodplain, too. Exceptions for essential facilities such as water and wastewater systems are sometimes included in local regulations.

Sometimes, stations are located within a floodway. Pumping station improvements that require an expanded footprint are far more challenging. The following paragraph, from the Southern Tier Planning Commission of New York, provides a very succinct description of FEMA’s requirements for working in floodways. “No new development is permitted within the regulatory floodway unless a licensed
professional engineer demonstrates that the proposed encroachment shall not result in any rise in the 100-year flood elevation. Federal standards do not allow communities to issue variances for development within the floodway that would result in increased flood levels. However, there are some situations (such as dams, bridges, or roads) in which a project in the floodway may be justifiable even though it would cause a rise in the flood elevation. This necessitates that the flood hazard map be changed to reflect the new hazard. The applicant must apply to the FEMA for (1) a conditional letter of map revision (CLOMR) before the development occurs and (2) a final letter of map revision after the development has been completed.

To demonstrate that pumping station improvements will have no impact, a No-Rise Certification is necessary. A No-Rise Certification requires a technical evaluation by a professional engineer to certify that current flood levels are unaffected. Therefore, the change between pre and post-improvement flood levels must be 0.00 feet. In some cases, improvements completely within the “shadow” of an existing structure may be approved without the need for modeling, but an engineer’s certification is still required. A shadow is defined as the area immediately adjacent to and downstream of an existing structure where flow is diverted around the upstream structure such that the downstream structure has no impact on floodwaters. Thus, if a station is expanded or modified, adherence to these requirements is necessary.

By review of floodplain and floodway mapping, engineers can determine a station’s current and expected compliance with the regulations. Where they do not, options are available.

Protecting open top structures.
Some pumping stations have open top wet wells. Unfortunately, these types of structures are susceptible to inundation by floodwaters. Often flood walls are added to protect these systems. They can be block or cast-in-place concrete. The height should extend above the BFE. Consideration of extending the wall's height above the 500 flood elevation may be appropriate and cost effective. Once these walls are constructed, access can be limited. While steps or ladders up and over the wall can be provided to gain access into the encapsulated area, access for equipment through doorways is often necessary. Entryways such as these can be protected by two main methods; doorways and flood panels. Flood doors are hinged and have gaskets to seal openings. They can be closed rather quickly. Flood panels are assembled in pieces and take a little more effort than doors. Gaskets are provided between each panel.

Protecting buildings.
Water can enter buildings through several areas. These include floor drains, ventilation louvers, toilet or sink fixtures, doors, electrical conduit and faulty walls. Often overlooked, wastewater from a flooded wet well can travel back into the building through flood drains. These should be sealed and a sump pump(s) installed to force any drainage within the dry well back into the wet well. Louvers can also be a pathway for water. Generally, moving these to a higher elevation or installation of roof fans can resolve this issue, unless the louver is associated with an indoor generator. If so, the issue becomes far more complicated to resolve. Flood-proof single doors are available. Flood panels are available for double doors or rollup doors. Another overlooked pathway for water includes electrical conduit. Electrical conduit can be open from a vault that floods and water can travel through the conduit and up into the base of electrical panels. Conduit seals can prevent or limit water intrusion though.

Protecting ancillary systems.
Aside from equipment located within the station, protection of outdoor generators, transformers, substations, odor control systems, chemical feed systems may be necessary. Generators can be installed on elevated platforms. Sometimes, they are located away from the station at a higher elevation, but available space and cost may limit this option. Relocation of transformers and substations may be necessary. Odor control and chemical feeds can be relocated, elevated or protected by walls.

Protecting the entire site.
Instead of the individual systems just described, another option would be to protect the site as a whole by constructing a flood wall or levee around the entire site. Rainwater captured within this area must be accommodated. Drain pipes and storm water pumping stations can be used. Drain pipes allow water to
drain out of the area and a one-way valve on the pipe prevents water from entering the site. Unfortunately, the one-way valves can clog with debris (sticks, rocks, leaves, etc.) and become ineffective. Storm water pumping stations are also an option and should be sized to accommodate peak wet weather rainfall. Regardless, systems that encapsulate the entire site must comply with local and federal regulations for work within the floodplain.

RESULTS

Flood protection options are routinely evaluated during pumping station upgrades. The following illustrates two pumping station upgrade projects that were recently completed. One station was located within the floodway and the other within the floodplain.

Pumping Station No. 1.
This station is located adjacent to a significant creek and within the floodway. It was constructed in the early 1970s, when below-grade, prefabricated dry-pit/wet-pit stations were prevalent. The top of dry well and generator building were elevated and a dirt mount provided around them. Prefabricated, below-grade stations are unfortunately susceptible to flooding and with dry-pit pumps and electrical panels below grade, could catastrophically fail. The generator building was originally located about 10 feet above grade to protect from flood waters. However, over the years the BFE level increased and is now at least 1 foot above the station’s finished floor elevation. Existing electrical systems would not meet current code requirements for vertical separation from the BFE.

Since this station was located in the floodway, few options were available to avoid a prolonged permitting process. Station expansion must have no net increase of footprint. To avoid extensive permitting, the existing building was reused to house electrical equipment. Thus, no new building was constructed within the floodway. The dry-pit was converted to a wet well for submersible pumps, which by design can operate in completely flooded conditions. Regardless, the top of wet well was extended several feet above the BFE. The building’s finished floor elevation is, however, below the BFE. Thus, flood doors were added. Electrical systems (utility meter) on the building’s exterior were raised above the BFE per local codes. Electrical systems within the building were also raised, but flood doors were still added to limit or eliminate water intrusion.

The biggest design issue that required significant regulatory coordination in such a short amount of time was the generator’s new location. With electrical panels located in the building, the generator had to be located outdoors. An elevated platform concept was discussed with the state and ultimately allowed, but it had to be constructed on stilts. The generator was located somewhat in the “shadow” of the building. Since no net increase in fill was allowed the existing mound of soil around the station was regarded and partially removed to accommodate the new layout.

Operator access during a flood condition was considered. Options include an elevated roadway or simply boating out to the station. Because of the magnitude of flood levels and location within a floodway, access during the most extreme events up to and including a 100-year event was not feasible.

Pumping Station No. 2.
This large submersible station is located in a floodplain. During severe events, floodwaters entered the open top wet well and inundated the station. Atop the wet well and valve vault were junction boxes and hatches. Below the junction boxes, a clear opening into the wet well was provided for the pump cables. The hatches above pumps and valves were not water tight. Within the valve vault are pneumatic control valves and various electrical switches. If they became submerged, the valves could fail. Thus, the vaults had a sump pump, but there was only one and it was undersized relative to the amount of water that could enter through the openings.

Concerns about floodwater seeping through the small openings and hatches required additional design considerations. An engineering evaluation was performed to determine cost-effective means to prevent this from occurring. Options included hatch replacement, junction box modification, sump pump
replacement and flood wall construction. In the end, the selected option was a narrow 3-foot high flood wall located along the edge of the wet well and valve vaults. Local regulations neither precluded nor required significant permitting to make such improvements in the floodplain given the station's purpose.

While the wall prevents waters from entering the station, additional measures for routine inspection and maintenance were necessary. Steps and ladders were added for entry into the area. Flood doors were necessary for pump retrieval at two locations. Additionally, the walls were extended above the 500-year floodplain as it required very little additional cost. Within the valve vault, a larger, duplex sump pump system was installed.

Operator access to the entire station during extreme flood conditions was considered. The existing control building is a split-level facility. The upper level was above the 500-year flood elevation. The lower level was within the 100-year flood level. Operators can gain access from the upper end of the project site and enter the control building and then proceed down to the lower elevations. Since the flood protection walls that encompassed the wet well and valve vault extended to the control building, access to several of the sewage pumps and valves was possible.

**DISCUSSION**

Many pumping stations are well within a floodplain and some are even located within a floodway. Federal regulations identify requirements for working within a floodway. Some states and local agencies may have additional floodway requirements that meet or exceed federal ones. Regulations relating to floodplains are often presented at the state or local level. When designing improvements, a thorough understanding of these requirements can often help avoid regulatory delays and costly permitting.

If encroachment into the floodway is necessary, it can be done provided there is absolutely no increase in the BFE resulting from the encroachment. A hydrologic model is used to determine changes if flood levels will change. Depending upon the condition of the existing model and nature of the encroachments, substantial analysis efforts may be required. Ultimately, it still may not be possible to demonstrate no increase. When there is an increase in the BFE, encroachment within the floodway may be allowed through a conditional letter of map revision (CLOMR).

Depending upon local requirements, proof of no impact may also be necessary when constructing in a floodplain. Consultation with local and county planning departments should provide insight into whether, or not, additional work is required for improvements within the floodplain.

**CONCLUSIONS**

Differences between floodways and floodplains can dictate how station improvements are made. Working within floodplains typically has less regulatory requirements. Modifications within a floodway are more difficult, may not be permissible in the end and ultimately take considerably more time and effort. Knowledge and experience of the federal and local regulations for work within these areas can significantly reduce the project schedule and cost implications.

FEMA issues maps (FIRM) to determine various flood zones. The elevations shown on these maps can be either NGGD 29 or NAVD 88, but as maps are updated, they are converted to the NAVD 88 datum. In some instances, the maps do not show an elevation. An adjustment is likely necessary between FIRM datum and that used by the local surveyor. The differences can often be 0 feet to over 1 vertical foot and must be accounted for during evaluation and design.

Lastly, when working within either a floodway or floodplain, a key consideration is to limit or avoid any new construction extending above grade. If not, improvements will be considered an obstruction and proof of no impact to current floodplain elevations is necessary.
REFERENCES

1 Great Lakes-Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers; 2004; Recommended Standards for Wastewater Facilities; Page 40-1; Health Education Services; Albany, NY.


Table 1 - High risk areas as defined by FEMA

<table>
<thead>
<tr>
<th>ZONE</th>
<th>DESCRIPTION</th>
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<tbody>
<tr>
<td>A</td>
<td>Areas with a 1% annual chance of flooding and a 26% chance of flooding over the life of a 30-year mortgage. Because detailed analyses are not performed for such areas; no depths or base flood elevations are shown within these zones.</td>
</tr>
<tr>
<td>AE</td>
<td>The base floodplain where base flood elevations are provided. AE Zones are now used on new format FIRMs instead of A1-A30 Zones.</td>
</tr>
<tr>
<td>AH</td>
<td>Areas with a 1% annual chance of shallow flooding, usually in the form of a pond, with an average depth ranging from 1 to 3 feet. These areas have a 26% chance of flooding over the life of a 30-year mortgage. Base flood elevations derived from detailed analyses are shown at selected intervals within these zones.</td>
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<tr>
<td>AO</td>
<td>River or stream flood hazard areas, and areas with a 1% or greater chance of shallow flooding each year, usually in the form of sheet flow, with an average depth ranging from 1 to 3 feet. These areas have a 26% chance of flooding over the life of a 30-year mortgage. Average flood depths derived from detailed analyses are shown within these zones.</td>
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<tr>
<td>AR</td>
<td>Areas with a temporarily increased flood risk due to the building or restoration of a flood control system (such as a levee or a dam). Mandatory flood insurance purchase requirements will apply, but rates will not exceed the rates for unnumbered A zones if the structure is built or restored in compliance with Zone AR floodplain management regulations.</td>
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<tr>
<td>A99</td>
<td>Areas with a 1% annual chance of flooding that will be protected by a Federal flood control system where construction has reached specified legal requirements. No depths or base flood elevations are shown within these zones.</td>
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Figure 1 – Floodway Schematic³
Figure 2 – Flood panel for partial height walls

Figure 3 – Flood door for partial height walls
Figure 4 – Station No. 1 before improvements

Figure 5 – Station No. 1 after improvements
Figure 6 – Station No. 2 before improvements

Figure 7 – Station No. 2 after improvements
Figure 8 – Station with normal single door

Figure 9 – Station with single flood door