

Structural Condition Assessment

Town of Swansea

Palmer River Pump Station
Raw Water Pump Station
Old Providence Road Bridge
Swansea, MA 02777



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Table of Contents

Structural Condition Assessment Town of Swansea

1	Introduction.....	1
1.1	Executive Summary.....	1
1.2	Scope of Services.....	2
2	Observations.....	3
2.1	Description of Structures.....	3
2.1.1	Palmer River Pump Station.....	3
2.1.2	Raw Water Pump Station.....	3
2.1.3	Old Providence Road Bridge.....	
2.2	Observations.....	4
2.2.1	Palmer River Pump Station.....	4
2.2.2	Raw Water Pump Station.....	4
2.2.3	Old Providence Road Bridge.....	4
3	Calculations and Discussion.....	5

1 Introduction

Fuss & O'Neill, Inc. (F&O) was retained by the Town of Swansea to perform building and bridge structural condition assessments of the Palmer River Pump Station, Raw Water Pump Station and Old Providence Road Bridge (also called the Miles Bridge) over the Palmer River, in conjunction with a Public Water Supply Infrastructure Vulnerability Assessment project. This project was completed under the Municipal Vulnerability Preparedness action grant program administered by the state's Executive Office of Energy and Environmental Affairs (EEA).

The evaluation included visual inspections to verify the accuracy of the available design documents and assessment of the condition of the structures. In addition, calculations were completed to assess the impact of increasing base flood elevations (BFE) due to projected sea level rise on the vulnerability of the structures, and recommendations made to mitigate the risks due to increasing BFE at the sites.

1.1 Executive Summary

The purpose of this Condition Assessment was to observe and report on the physical condition of the Palmer River Pump Station, Raw Water Pump Station and Old Providence Road Bridge over the Palmer River, and discuss appropriate steps to reduce their vulnerability to flood conditions.

From our visual inspection, we determined that the condition of all the structures is excellent. Minimal damage, deterioration or construction flaws were identified, and none represented a reduction in structural capacity.

The Palmer River Pump Station does have vulnerability to flooding due to revisions to the base flood elevations since its design. Specifically, the main floor of the building was designed to be set at elevation 11.0 feet NAVD 1988. A land survey conducted as part of this project indicate that actual floor elevation is slightly lower, at 10.86 feet. The base flood elevation at the time of the building design was 10.0 feet, so the original design appropriately set the main floor of the building one foot higher than the flood elevation. Changing climate has resulted in an increase in the local base flood elevation to 12.0 feet, which now places it nearly 14" above the existing floor. Future sea level rise will exacerbate this condition.

Calculations of the effect of this increased flood elevation have determined that the building foundations and exterior walls do have sufficient strength to support the increased flood waters under the current base flood elevation, and there is no net buoyancy at this flood level. The most significant concern in this scenario is that the basement level, which contains pumps and other equipment, would be inundated if the flood level or wave height exceeds 10.86 feet. Currently, hatches on the exterior and the interior ship's ladder with alternating treads provide openings in the main level slab that would allow water in if it reaches the slab level. Other than major reconstruction or relocation of the pump station, the only feasible approach to protecting the lower level would be to provide a water-tight bulkhead around the perimeter of the main slab level or provide water-tight seals at the exterior hatch doors and build a bulkhead around the interior ship's ladder opening.

Further analysis of conditions of increasing flood elevations indicate that the structure becomes buoyant at a water elevation of 17 feet, which corresponds to sea level rise of 5 feet, projected to occur by 2080.

The Old Providence Road Bridge has a deck elevation roughly between 8 and 10 feet, so it was constructed below the original design flood elevation. Nevertheless, the bridge is elevated several feet above the approaches on both sides, as well as the surrounding land for a large distance. Therefore, it is unlikely that fast-moving flood water poses a more significant risk now or in the foreseeable future than at the time the bridge was constructed.

The Raw Water Pump Station is well above the base flood elevation, and is not vulnerable to flooding even after many years of projected sea level rise.

1.2 Scope of Services

This Condition Assessment consisted of visual inspections of the Palmer River Pump Station, Raw Water Pump Station and Old Providence Road Bridge over the Palmer River to verify general conformance with the design documents and identify any damage, deterioration or modifications that may affect the integrity of each structure.

The assessment was limited to evaluating the structural integrity of the referenced structures and did not include an evaluation of architectural, MEP and non-structural building or site elements, nor did it include a Code review of the buildings, site or inspected elements. No structural analysis was performed to assess original or remaining capacity of floor, roof or wall elements, other than evaluation of the impact of increasing flood elevations on the structures.

Photographs of typical conditions and conditions of concern or requiring remedial action have been included in *Appendix A*.

2 Observations

2.1 Description of Structures

2.1.1 Palmer River Pump Station

The Palmer River Pump Station consists of a reinforced concrete platform built up on concrete foundation walls 6'-0" above the surrounding grade, with a single-story split rib windowless concrete masonry bearing wall structure above supporting a gable formed wood truss roof over a portion of the footprint of the main level platform slab (see photo #1). The main level (at elevation 11.0 feet according to the construction drawings) is accessed by an exterior concrete stair. The lower level of the pump station (at elevation -4.0 feet according to the construction drawings) is accessed through an alternating tread ship's ladder at the interior (see photo #2). Three hatches through the main slab on the exterior of the masonry enclosure provide access to large equipment at the lower level (see photo #3). The masonry structure is accessed from the concrete platform by a double door on the street (south) side.

A small wood stair on the east side of the building appears to have been added to provide access to elevated meters and electrical boxes on that side of the building (see photo #4). This stair does not appear on the original construction drawings.

The foundation of the building is a 3'-0" thick concrete mat that extends 4'-0" in every direction beyond the basement walls. From these observations, it appears the mat and foundation walls were designed to accommodate hydrostatic pressure from flood water. This assumption was verified through independent calculations.

2.1.2 Raw Water Pump Station

The Raw Water Pump Station is a single-story split rib concrete masonry bearing wall structure supporting a gable formed wood truss roof (see photo #5). The floor of the building is at elevation 23.0 feet, just above the surrounding grade elevation and well above the current base flood elevation. There are two 5'-0" deep pits covered with steel grating on the east and west sides of the building. The building is accessed through a double door on the street side and a single door on the side.

The building has a low profile, and openings in the split rib block exterior are limited to the two doors, several louvers, an exhaust fan and several narrow vertical strip windows.

2.1.3 Old Providence Road Bridge

The Old Providence Road Bridge is a precast concrete structure spanning approximately 150 feet across the Palmer River. A cornerstone indicates the bridge was constructed in 2007. The structure consists of precast concrete hollow core planks spanning 30 feet between concrete abutments and a series of four interior concrete piers, each supported on five 16" diameter steel pipe piles (see photo #6). Steel H-piles support the abutments.

The plank segments are locked together and into the piers with cast-in-place concrete infill beams and doweled cast-in-place sidewalks, curbs and Texas rails. An insulated 8" water main is mounted along the south side of the bridge.

The elevation of the bridge deck varies from 7.84 feet at the approach on the west side to 9.85 feet at the high point. The entire bridge deck is below the design flood elevation in place at the time it was constructed.

2.2 Observations

2.2.1 Palmer River Pump Station

1. The overall structure, including the concrete slab and foundation walls, exterior masonry and roofing are in excellent condition. The roof structure is not exposed to view, but there is no evidence of deflection, water infiltration, or anything else that might suggest structural degradation.
2. The three exterior hatches are already exposed to surface rainwater, and would likely provide some protection from flood water, but it is unclear whether they would remain watertight under 13.68" of water. Some staining from water infiltration was evident (see photo #7). Similarly, the double door entrance into the masonry enclosure likely cannot prevent flood water from entering the building and ultimately filling the basement level.
3. A 2'-0" deep sump pit lies at the center of the west side of the basement (see photo #8). Some standing water was evident near the pit and at other locations at the basement level.
4. Pipe supports within the building are generally constructed with galvanized steel, but several supports were found that consist of painted steel (see photos #9 and 10). These were reportedly replaced or modified following the original construction. No pipe support details are indicated on the original structural drawings.

2.2.2 Raw Water Pump Station

1. The equipment and pipes inside the building are supported with galvanized steel frames and Unistrut framing (see photo #11).
2. Several minor random cracks were noted in the slab on grade (see photo #12).
3. Some discoloration was noted on the exterior face of the split rib block at the rear (see photo #13). This is likely the result of exposure to surface water.

2.2.3 Old Providence Road Bridge

1. The water flowing in the river under the bridge appears to move very slowly. There are likely fluctuations in the flow rate depending on tides.

2. All bridge elements appear to be in good condition, but a spalled area with some exposed, moderately rusted reinforcing was found at the joint at the north side of east abutment (see photo #14). It appears the spall was patched previously, but further spalling has occurred.
3. Evidence of water infiltration was found at the joint between the east abutment and the deck planks from below (see photo #15).

3 Calculations and Discussion

The current base flood elevation at the location of the Palmer River Pump Station and Old Providence Road Bridge is 12.0 feet, two feet higher than the base flood elevation at the time of design and construction. The impact of this change on the structures is as follows:

Palmer River Pump Station: Flood elevation increases from one foot below the main level slab to one foot above the main level slab.

Bridge: Flood elevation increases from approximately 1'-6" above the high point of the bridge deck to 3'-6" above the bridge deck, which corresponds roughly to the top of the rail.

Raw Water Pump Station: Flood elevation remains far below the floor slab and the sump pits, from 13'-0" below the slab to 11'-0" below the pits.

F&O has analyzed the effect of the increased flood elevation on the Palmer River Pump Station structure, and determined that the as-built foundation walls are capable of resisting the increased hydrostatic pressure due to the higher water level, and the structure maintains a factor of safety of 1.25 against uplift due to buoyant force with the higher floor elevation. However, once the water level reaches the elevation of the main level slab (10.86 feet, according to current survey data), the basement will become inundated through the hatches and ship's ladder opening and the hydrostatic pressure will be relieved. Unfortunately, this will also fill the basement with water and likely damage all equipment contained within it.

The bridge deck is subject to a worst-case water velocity of 2.1 feet/second and a maximum wave height of 1.8 feet. This yields lateral forces on the order of 6 psf, far below the design wind loads. Therefore, the bridge is not vulnerable to displacement or uplift under the design flood conditions.

The Raw Water Pump Station is well above the revised flood elevation, so there is no vulnerability to report.

There are several options to address the potential inundation of the Palmer River Pump Station:

1. Construct a 2'-3" high bulkhead around the perimeter of the main level slab.
2. Install a water-tight door at the double door entrance to the masonry enclosure and water-tight equipment hatches, and construct a 2'-3" high bulkhead around the interior opening to the basement.

Either option requires construction of four additional steps up to clear the new bulkhead. In Option 1, four steps from the top of the bulkhead down to the main platform slab elevation are also required. Finding space for this stair in Option 2 would pose a challenge, and in Option 1, would likely require reconstruction of the exterior stair. In Option 2, the ship's ladder would also need to be extended within the new bulkhead.

Recommendations for bridge repairs are limited to deck joint and spall repairs at the abutments. No remedial measures are required for the Raw Water Pump Station.

Additional calculations were prepared to evaluate the increasing vulnerability due to future sea level rise and corresponding increases to the base flood elevations. The impact of sea level rise to the bridge structure is not significant, since the bridge is fully immersed already during the current base flood. The impact to the Raw Water Pump Station is also minimal, since the structure will remain above the base flood elevation well into the future. The impact of rising sea levels will, however, impact the Palmer River Pump Station.

In order to prevent inundation of the lower level of the Palmer River Pump Station subsequent to sea level rises, a higher bulkhead would need to be constructed to correspond to the design floor elevation. This would require more stairs to access the building, or construction of a water-tight access panel to the current platform. The uplift due to buoyancy approaches the full weight of the structure at a flood elevation of 17.0 feet, or 5.0 foot rise in sea level. This increase is projected to occur around 2080. At this point, the structure could become buoyant. The exterior basement walls and mat footing are capable of resisting this water pressure, so buoyancy is the mode of failure in this scenario.

To extend the useful life of the building beyond this point, it would be necessary to add mass to the building to prevent buoyancy. This can be done several ways, but the most cost-effective would be to cast a section of concrete around the perimeter doweled into the exterior side of the foundation wall above grade. However, water elevations in the area may prevent access for maintenance. Therefore, the town should consider and plan for the construction of a new building at an alternative location in lieu of replacement or upgrades prior to realizing impacts from rising sea levels.

Appendix A

Photographs



Photo #1 – Palmer River Pump Station south elevation

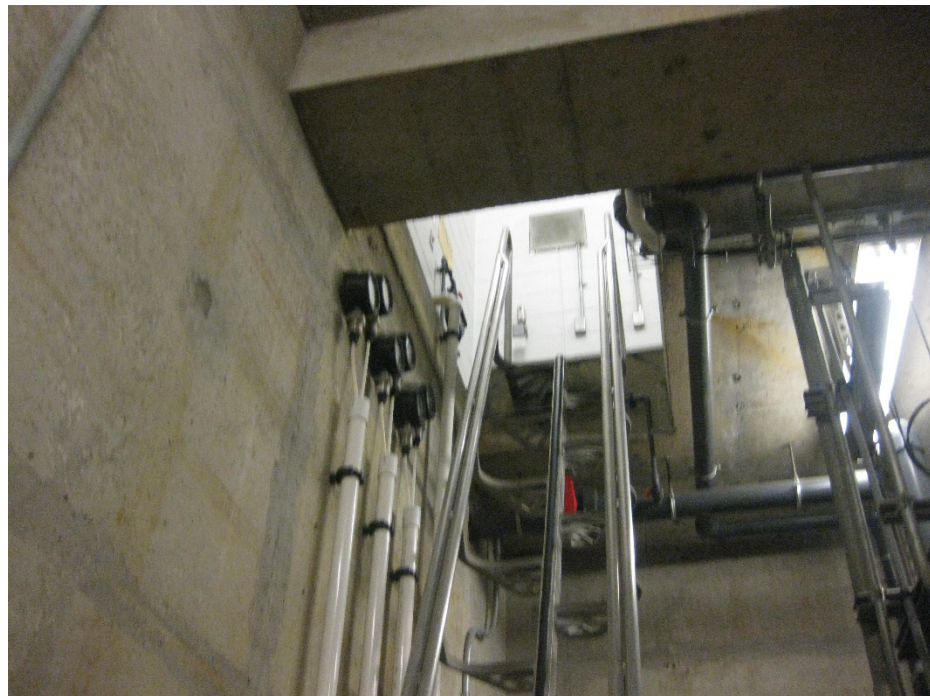


Photo #2 – Ship's ladder to lower level



Photo #3 – Equipment hatches at main slab exterior



Photo #4 – Wood stair at east elevation



Photo #5 – Raw Water Pump Station



Photo #6 – Old Providence Road Bridge



Photo #7 – Water stains at underside of equipment hatches



Photo #8 – Sump pit in basement level



Photo #9 – Galvanized steel pipe supports



Photo #10 – Painted steel pipe supports



Photo #11 – Equipment and pipe supports at Raw Water Pump Station



Photo #12 – Cracks at the slab on grade



Photo #13 – Discoloration at rear exterior wall



Photo #14 – Spalling at bridge abutment



Photo #15 – Signs of water infiltration at abutment