Portland Metro Levee System Feasibility Study

Integrated Draft Feasibility Report and Environmental Assessment

Appendix E – Pump Station Risk Assessment
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Appendix E – Pump Station Risk Assessment

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1. Introduction

The Portland Metro Levee System (PMLS) Feasibility Study (study) is a flood risk management general investigations feasibility study being conducted by the Portland District U.S. Army Corps of Engineers (Corps) in partnership with the Columbia Corridor Drainage Districts Joint Contracting Authority (CCDD). The purpose of the study is to analyze current flood risks in the system, develop projections of future without-project conditions, and identify flood risk management options that could meet current and future needs within the policies and regulations of the Corps. Implementation of this study could lead to a federally supported construction component if a solution is found to be in the federal interest.

The purpose of this appendix is to document an assessment of the major pump stations operating within the study area, identify and characterize risks for pump station performance, and identify pump station improvements to be evaluated further in the feasibility study. The appendix provides an overview of the Corps’ Engineering Manuals (EM) and other relevant standards. It also summarizes information provided by the Multnomah County Drainage District (MCDD), which operates and maintains all pump stations evaluated.
2. Background

Six exterior pump stations and three interior pump stations were evaluated. Additional, smaller interior pump stations in the study area are not included in this analysis. The majority of the evaluated pump stations were constructed prior to the most recent revision of the Corps’ pump station standards (EM 1110-2-3102 (USACE, 1995) and EM 1110-2-3105 (USACE, 1999). Pump station inspections in 2016 found that multiple stations may not follow standard design recommendations or meet pumping requirements described in the Corps’ manuals (Parametrix, 2016). The stations are owned by PEN 1, PEN 2, MCDD, and SDIC. All are operated and maintained by MCDD staff under a cooperative agreement. Table 2-1 provides an overview of pump station capacities and the specifications of pumps at each station.

<table>
<thead>
<tr>
<th>Station</th>
<th>Location</th>
<th>Rated Capacity (cubic feet/second)</th>
<th>Measured Capacity¹ (cubic feet/second)</th>
<th>Pump #</th>
<th>Type</th>
<th>Rated Capacity (cubic feet/second)</th>
<th>TDH (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEN 1 PIR</td>
<td></td>
<td>45.7</td>
<td>not available</td>
<td>1</td>
<td>Vertical Turbine</td>
<td>29.0</td>
<td>Unknown</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>Vertical Turbine</td>
<td>16.7</td>
<td>31.0</td>
</tr>
<tr>
<td>PEN 2 Schmeer Road</td>
<td></td>
<td>89.1</td>
<td>33.4</td>
<td>1, 2</td>
<td>Mixed Flow</td>
<td>44.6</td>
<td>31.0</td>
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<tr>
<td>PEN 2 13th Avenue</td>
<td></td>
<td>82.4</td>
<td>33.4</td>
<td>1</td>
<td>Mixed Flow</td>
<td>40.1</td>
<td>29.0</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>Mixed Flow</td>
<td>42.3</td>
<td>26.0</td>
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<tr>
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<td>552.6</td>
<td>412.2</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>2, 4</td>
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<td></td>
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<td></td>
<td></td>
<td>3</td>
<td>Axial Flow</td>
<td>49.0</td>
<td>15.0</td>
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<tr>
<td>MCDD Pump Station 2</td>
<td></td>
<td>29.0</td>
<td>18.9</td>
<td>1, 2</td>
<td>Axial Flow</td>
<td>14.5</td>
<td>Unknown</td>
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<tr>
<td>MCDD AirTrans</td>
<td></td>
<td>63.5</td>
<td>48.1</td>
<td>1, 2, 3</td>
<td>Mixed Flow</td>
<td>21.2</td>
<td>19.5</td>
</tr>
<tr>
<td>MCDD Broadmoor</td>
<td></td>
<td>26.7</td>
<td>22.7</td>
<td>1, 2</td>
<td>Mixed Flow</td>
<td>13.4</td>
<td>Unknown</td>
</tr>
<tr>
<td>MCDD Pump Station 4</td>
<td></td>
<td>606.1</td>
<td>490.2</td>
<td>1, 2, 3, 4</td>
<td>Mixed Flow</td>
<td>150.2</td>
<td>32.0</td>
</tr>
<tr>
<td>SDIC Sandy</td>
<td></td>
<td>82.4</td>
<td>87.5</td>
<td>1</td>
<td>Mixed Flow</td>
<td>48.5</td>
<td>11.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2</td>
<td>Mixed Flow</td>
<td>47.2</td>
<td>11.0</td>
</tr>
</tbody>
</table>

¹Measured capacity from field testing (Brown & Caldwell 2019) or provided by MCDD for this analysis. Applicability of all values for this analysis was verified by MCDD.
3. Engineering Manuals and Relevant Standards

3.1. Overview
EMs 1110-2-3102 and 1110-2-3105 provide design recommendations for pump stations. EM 1110-2-3102 details general design and layout, and EM 1110-2-3105 details mechanical and electrical design. The EMs are meant as best practices guides for successful operation of pump stations and do not dictate how a station must be designed. However, the use of the words “must,” “shall,” or “mandatory” in these EMs indicates a requirement. This section identifies measures from the manuals and from other pump design guidelines and industry-recognized best practices that are relevant to pumps in the study area.

3.2. Requirements
This section provides an overview of projected requirements per EM 1110-2-3105. The Hydraulic Institute (HI) design guidelines and requirements are referenced multiple times in EM 1110-2-3105. The HI guidelines address the design, use, and placement of the pumps. Key requirements that are applicable for the PMLS are as follows:

- **Anti-Reverse Rotation (EM 1110-2-3105, Section 9-9)**—Pump motors shall be equipped with an anti-reverse rotation device on the high-speed shaft to address worst-case reverse torque loading.
- **Backflow Prevention (EM 1110-2-3105, Section 7-4)**—For stations with a discharge below the maximum discharge pool elevation, two means of backflow prevention shall be provided.
- **Siphon Breakers (EM 1110-2-3105, Section 7-4)**—For any station utilizing a siphonic recovery discharge, a siphon breaker valve is required at the crest of the discharge.
- **Vibration (ANSI/HI 9.6.3)**—Vibration severity shall be within a “good” range or better with a velocity of 0.0785 inches per second or lower. Vibration shall be measured in accordance with HI requirements in ANSI/HI 9.6.3.
- **Power for Lighting and Auxiliary Services (EM 1110-2-3105, Section 3-2)**—A continuous electric supply for lighting and other auxiliary services is required.
- **Station Auxiliaries (EM 1110-2-3102 Chapter 8)**—Various auxiliary equipment listed in this requirement should be included in each pump station design. Each station should have a crane or crane access, trash rakes, appropriate fire protection as per NFPA 101 Chapter 28, and appropriate heating and ventilation.
These requirements should be included in applicable pump station improvements designed and evaluated in the feasibility study.

## 3.3. Proposed Changes to Pump Station Engineering Manuals

At the time of this report, the Corps’ pump station engineering manual is being updated. It is anticipated to be published in Fiscal Year 2020. The authors of this appendix were permitted to view a copy of the updated engineering manual prior to its release to identify proposed changes that may affect the findings of the pump assessment and to identify considerations for design of pump station improvements to facilitate compliance with expected new requirements. The following were identified as potential changes to the engineering manual that would likely have an impact on the findings of this report or be design considerations in future phases of the project:

- **Capacity**—Pump stations should provide the number or capacity of pumps such that, if one were to fail, the station would maintain at least two-thirds of the original required station capacity.

- **Redundancy**—The only mention of redundancy in EM 1110-2-3105 is of backflow prevention. However, it is common practice among Corps facilities to not have single points of failure. Items such as float switches and alarms should have secondary measures in place to reduce risk of failure. Secondary measures can be in the form of duplicate systems or other ways to operate the system, such as manual starting of the pumps.

- **Instrumentation**—Operability of the system should be able to be determined by reading instrumentation installed at the pump station. Pressure gages and flow meters can confirm whether pump operation is appropriate or there are significant leaks in the system or other issues with the system. Measures such as vibration monitoring allow operators to catch potential methods of failure well before they occur.

- **Access**—Access to the station and its various components is critical. In most cases, crane access to the station and a staging area are needed. Within the pump station, components should be easily reachable.

- **Tests**—EM 1110-2-3105 identifies tests to be performed upon construction of a new system or purchase of new components. However, with many of these stations not operating or operating in a limited capacity during summer, they may malfunction during a subsequent storm event. Periodic tests to confirm performance prior to the wet season are recommended.
4. Data Provided

4.1. As-Built Drawings
Drawings are available for all pump stations evaluated except the PEN 2 Schmeer Road pump station. A field visit was conducted to verify features of the as-built drawings. Because drawing sets are not considered complete, missing information was obtained during the field visits.

4.2. Operation and Maintenance Manuals
Operation and maintenance plans for the PMLS pump stations and were provided by MCDD and reviewed for this analysis.

4.3. Pump Curves and Data
Pump curve data is available for all the pump stations and was consolidated in the 2016 report *Pump Station Condition Assessment* (Parametrix, 2016). Updated pump curves for MCDD and PEN 2 were developed for drainage master plans prepared for the two levee districts in 2018 (Parametrix, 2018). A pump performance curve indicates how a pump will perform in regard to pressure head and flow. A curve is defined for a specific operating speed (rpm) and a specific inlet/outlet diameter. The pumping efficiency is how pump performance is measured.

4.4. Pump Station Deficiencies
See Section 5 for a detailed breakdown of pump station deficiencies as identified by previous studies and during the March 2019 site visit to the pump stations by the study team, which included representatives of MCDD.

4.5. MCDD Commissioned Reports
The following reports have been developed by various parties under contract to MCDD and were referenced in the evaluation of pump station deficiencies and pump station elevations pertinent to this analysis:

- *Critical Elevation Selection for MCDD and PEN 2 Drainage Master Plans* (Brown and Caldwell, 2018)
- *Pump Station Force Main and Outfall Condition Assessment* (Parametrix, 2017)
- *Pump Station Condition Assessment.* (Parametrix, 2016)
4.6. Pump Station Pertinent Elevations

Two key elevations for this pump evaluation are the “pump-on elevation” and the “critical elevation inducing pump station failure.” The pump-on elevation identifies the water surface elevation at each pump station that initiates operation of each pump in that station. The critical elevation is the water surface elevation at each station at which it is no longer safe to operate the pump station or at which inundation of pump station infrastructure causes the pump station to cease operation. When the water surface elevation reaches the critical elevation, the pump station is no longer operable.

MCDD provided data on these elevations for each pump station, as listed in Table 4-1. The listed elevations were applied in this pump station evaluation as well as in the interior drainage analysis conducted for the feasibility study (Appendix A (Hydrology and Hydraulics)).
### Table 4-1 Pump Station Pertinent Elevations

<table>
<thead>
<tr>
<th>Location</th>
<th>Pump #</th>
<th>Pump-On Elevation (feet NAVD88)</th>
<th>Critical Elevation inducing Pump Station Failure (feet NAVD88)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEN 1 PIR</td>
<td>1</td>
<td>8.5</td>
<td>15.06</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>7.0</td>
<td></td>
</tr>
<tr>
<td>PEN 2 Schmeer Road</td>
<td>1</td>
<td>3.5</td>
<td>8.28</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>3.8</td>
<td></td>
</tr>
<tr>
<td>PEN 2 13th Avenue</td>
<td>1</td>
<td>4.3</td>
<td>8.1</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>4.5</td>
<td></td>
</tr>
<tr>
<td>MCDD Pump Station 1</td>
<td>1</td>
<td>11.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>11.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>11.5</td>
<td>15.38</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>12.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>13.0</td>
<td></td>
</tr>
<tr>
<td>MCDD Pump Station 2</td>
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<td>7.5</td>
<td>9.48</td>
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<td>2</td>
<td>7.8</td>
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<td>5.5</td>
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</tr>
<tr>
<td></td>
<td>2</td>
<td>6.0</td>
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</tr>
<tr>
<td></td>
<td>3</td>
<td>6.5</td>
<td></td>
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<tr>
<td>MCDD Broadmoor</td>
<td>1</td>
<td>6.5</td>
<td>8.98</td>
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<td>2</td>
<td>6.8</td>
<td></td>
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<tr>
<td></td>
<td>3</td>
<td>13.3</td>
<td></td>
</tr>
<tr>
<td>SDIC Sandy</td>
<td>1</td>
<td>11.5</td>
<td>15.5</td>
</tr>
</tbody>
</table>

1Elevations initially sourced from “Technical Memorandum: Critical Elevation Selection for MCDD & PEN 2 Drainage Master Plans” (MCDD 2018) and verified by MCDD Operations staff for this application. NAVD88 = North American Vertical Datum of 1988
5. Pump Station Deficiencies

Pump station deficiencies with a likelihood to lead to pump station failures were identified based upon review of available pump station maintenance reports, interviews with MCDD operations and maintenance staff, and field observations.

Failure probabilities identified for the feasibility study are a function of elevation at the pump station and the pertinent elevations presented in Table 4-1. No failures are expected at any station until its pump-on elevation is met or exceeded (for this analysis the average pump-on elevation across all pumps in the station was used to be conservative). Failure of each pump station is considered assured once the critical operating elevation is met or exceeded. The probability of failure for each pump station is linked to the probability of the storm event that results in a water surface elevation at the pump station that meets or exceeds the pertinent elevations.

All identified failure modes in this analysis were found to be a result of one of the following:

- **Mechanical Deficiency**—Pump stations with pumps operating outside of their pump curve are expected to have a likelihood of failure when operating. The likelihood of failure is assumed to be 0 percent until the pump-on elevation and then increase linearly as elevation increases. Once a storm event occurs that meets the station’s critical elevation, the probability of failure is considered to be 100 percent.

- **Capacity Deficiency**—Pump stations with an inadequate capacity have a vertical failure mode probability curve. For these pump stations, the probability of failure is considered to be 0 percent until a storm event occurs where the water surface meets the critical elevation of the pump station. At that point the probability of failure is considered to be 100 percent.

- **Intake Deficiency**—Pump stations that have been identified as having a potential failure mode related to the intake or trash rack deficiency have a sloped failure mode probability curve. The probability of failure is considered to be 0 percent until the pumps turn on and to increase linearly as the water surface elevation increases. With higher water levels, more debris is carried in the water column into the pump trash racks and intakes. The probability of failure is considered to be 100 percent when water level meets the critical elevation.

- **Infrastructure Deficiency**—Identified pump station infrastructure deficiencies that could lead to pump station failure included deficient outfall pipelines. Any pump station with identified infrastructure deficiencies also had an identified capacity and/or intake deficiency, and the probability of failure function for the other predominant category was applied.

Some pump stations were identified as having multiple categories of deficiencies.
5.1. PEN 1 PIR

5.1.1. Identified Deficiencies

The following deficiencies were identified:

- **Communications**—The SCADA system modem has failed, disabling communication.

- **Flow Monitoring**—The station has an electromagnetic flow meter on the discharge pipe. This meter has been reported to give inaccurate readings, so the actual flow for the station cannot be confirmed.

- **Piping**—The piping on the Pump 2 discharge is misaligned with the pump outlet.

- **Valves**—Pump 2 does not have an isolation valve on the discharge. Pump 1 has an isolation valve on the discharge, but it is not operational.

- **Pumps and Motors**—The motor for Pump 1 failed a megger test in 2014. MCDD has reported that it was repaired in 2017. Pump #1 has reduced capacity due to deterioration and can no longer produce enough flow to actuate a siphon condition. Repairs to Pump #1 could address this issue. Pump 2 was not designed for this station, rather it was relocated from a different station. Pump 2 is operating outside its curve as shown by vibration of the pump and motor. When a pump operates outside of its curve it is less efficient. This produces more wear on the pump motor as well as the bearings and impeller. A pump running outside of its curve will have a tendency to experience cavitation and increased vibration. Vibration will increase the wear of the pump bearings. Cavitation can cause pitting on the internal pump casing and the impeller and, if severe enough, pitting and erosion of the discharge pipe. For these reasons Pump 2 has a likelihood of failing during operation. Figure 5-1 shows Pump 1 and Pump 2 at PEN 1 PIR.

- **Pressure Gages**—There are no pressure gages on any of the pumps.

5.1.2. Potential for Failure of Pump Station

Due to the condition of Pump 2, this station has a likelihood of mechanical failure while operating. The other identified deficiencies are not expected to lead to pump failure and are not recommended to be considered further in this study; they may be pursued by the pump owner or operator. For this study, the probability of failure for PEN 1 PIR is 0 percent until water gets up to the pump-on elevation and then increases linearly with elevation until the critical elevation is met, at which point the pump is considered failed (100 percent) as shown in Figure 5-2 (Note that on all Pump Failure Probability figures in this appendix, that annual exceedance probabilities (AEP) are noted along the horizontal axis).
5.1.3. Recommended Measures

To address the risk of mechanical failure, replacing Pump 2 would be an effective measure. Pump 2 operates outside of its curve. Over time this can cause erosion of the impellers and discharge pipe and lead to pump and station failure. Pump station capacity should be addressed at the time of pump replacement.

*Figure 5-1 PEN 1 PIR Pump Station; Pump 1 on Left, Pump 2 on Right*
5.2. PEN 2 Schmeer Road

5.2.1. Identified Deficiencies

The following deficiencies were identified:

- **Flow Monitoring**—The station has an electromagnetic flow meter on the discharge pipe. This meter has been reported to give inaccurate readings, so the actual flow for the station cannot be confirmed.
- **Pressure Gauges**—There are no pressure gauges on any of the pumps.
- **Ventilation**—There is no means of ventilation for the pump station.
- **Heating**—A portable electric space heater is the only source of heating. This source has a high chance of failure and is not able to maintain operational temperature.

5.2.2. Potential for Failure of Pump Station

This pump station is well maintained and has not been reported as being overwhelmed in large storm events. The pump station is not expected to fail until the water surface at the station reaches or exceeds the critical elevation as shown in Figure 5-3. The remaining deficiencies were not identified to lead to pump failure and are not recommended to be considered further in the study; they may be pursued by the pump owner or operator.
5.2.3. Recommended Measures

No improvements were identified at this pump station.

5.3. PEN 2 13th Avenue

5.3.1. Identified Deficiencies

The following deficiencies were identified:

- **Flow Monitoring**—The station has an electromagnetic flow meter on the discharge pipe. This meter has been reported to give inaccurate readings, so the actual flow for the station cannot be confirmed.

- **Secondary Level Control/Alarm**—Improperly operating float switches cause the pumps to shut off inadvertently.

- **Intake**—The intake is not properly sized. During a large storm event, the intake is too small for the pumps to keep up with the pumping needs. This station could fail during a storm event.

- **Pipe Supports and Discharge Pipeline**—The supports do not properly support and restrain pipes. They are susceptible to separating and leaking. The coating has failed on the exposed portions of the discharge pipeline. At several joints the pipeline leaks. See Figure 5-4.
• **Pumps and Motors**—Pumps are not able to keep up with large storm events even while operating simultaneously. While this is partly due to the undersized intake, pump capacity is also a limiting factor for this pump station.

• **Pressure Gauges**—There are no pressure gauges on any of the pumps.

• **Heating**—There is no heating for the pump station. The only source of heat is the electrical panels, which are insufficient to heat the station to an appropriate operating temperature.

• **Other Concerns from MCDD**—MCDD has reported that there are concerns of settlement of the pump station. Staff have noticed the discharge pipelines for both pumps have begun to shift, reducing the space between the pipe and the wall penetration for the pipelines. In addition, they have noticed that the soil below the discharge lines and adjacent to the pump station foundation has begun to sink, as shown in Figure 5-5 and Figure 5-6. MCDD is monitoring the pump station for additional signs of settlement and has installed witness points to measure any change in elevation between the pump station foundation and the sounding soil.

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**Figure 5-4** PEN 2 13th Avenue Pump Station Discharge Lines—Left: Not Properly Supported, Right: Leaking Joint
5.3. Potential for Failure of Pump Station

Due to the inability of the pumps to accommodate storm events as a result of limited pump capacity and the undersized intake, this station has a likelihood of failure during storm events as shown in Figure 5-7. Since these intake and capacity deficiencies were identified as having a likelihood of leading to pump station failure, measures to address these deficiencies should be carried forward for evaluation in the feasibility study. Addressing the structural deficiencies with the existing discharge pipelines should also be carried forward for further evaluation. The remaining identified deficiencies are not expected to lead to pump failure and were not recommended to be considered further in the study; they may be pursued by the pump owner or operator.
5.3.3. Recommended Measures

Replace the discharge pipelines and pipe supports. If replaced, the discharge pipelines should be sized to allow for an increase in pumping capacity in the future.

It may be possible to increase the size of the intake to increase conveyance of water to pumps and therefore increase the pumping capacity. Pump capacity should also be increased.

The pump station operator should continue to monitor the settlement of the pump station. If significant settlement is found in the future, the pump station may need to be replaced, but such replacement is not being considered in this feasibility study.

5.4. MCDD Pump Station 1

5.4.1. Identified Deficiencies

The following deficiencies were identified:

- **Trash Rack**—The trash rack is an automatic system. It has many electrical issues that impact operation, and the screen often clogs, causing the pumps to shut down.

- **Pumps and Motors**—Pumps 1 and 5 are not in service. Pump 1 experienced vibration and was shut down. Pump 5 was removed and has been repaired. MCDD is planning to replace pumps and motors for Pumps 1, 3, and 5. As such, replacement of these pumps is not considered further in this feasibility study.
Appendix E – Pump Station Risk Assessment

- **Lubrication Pump**—This station utilizes a lubricating pump, which is reported to clog often. Foot valves on the pump are reported to break and cause the pump to lose its prime.
- **Ventilation**—Ventilation methods are insufficient to keep the building cool during summer.
- **Planned Maintenance and Upgrades**—Pumps 1, 3, and 5 are scheduled to be replaced with new pumps and low voltage motors. The pumps will restore the pump station to its originally designed pumping capacity. The design of the replacement pumps is underway. The trash rake is also planned to be upgraded.

### 5.4.2. Potential for Failure of Pump Station

Because the trash rack cannot keep up with current demand, this station would have a high chance of failure during a storm event. However, since MCDD has plans to repair the rack, this intake deficiency is not considered in this study. The probability of failure is considered zero until water reaches the critical operating elevation, at which point it goes to 100 percent, as shown in Figure 5-8. The remaining identified deficiencies were not identified to lead to pump failure and are not recommended to be considered further in the study; they may be pursued by the pump owner or operator.

### 5.4.3. Recommended Measures

All identified pump capacity and trash rake deficiencies are part of planned maintenance and upgrades by MCDD. There are no other measures at this pump station that are recommended for further evaluation in the feasibility study.

![Figure 5-8 MCDD Pump Station 1 Failure Probability Function](image)
5.5. MCDD Pump Station 2

5.5.1. Identified Deficiencies

The following deficiencies were identified:

- **Electrical Enclosures**—The pumps’ electrical enclosures are not properly sealed. There is condensation and corrosion present within the panels.

- **Flow Monitoring**—The station has an electromagnetic flow meter installed on the discharge pipe. This meter has been reported to give inaccurate readings, so the actual flow for the station cannot be confirmed.

- **Trash Rack**—The screen is difficult to hand rake and may cause buildup of debris and safety concerns.

- **Discharge**—The pumps discharge into a gravity outfall that limits the total amount of water that can be pumped. A schematic of the gravity drain is presented in Figure 5-9.

- **Pressure Gauges**—There are no pressure gauges on any of the pumps.

5.5.2. Potential for Failure of Pump Station

This pump station’s capacity has been reported to be insufficient during a storm. In a storm, MCDD has used a portable pump to provide additional capacity at this location. Without the additional capacity of the portable pump, the station would become inundated and fail. The gravity outfall further limits pumping capacity. This capacity deficiency is reflected in the probability of failure function in Figure 5-10. The remaining identified deficiencies are not expected to lead to pump failure and were not recommended to be considered further in the study; they may be pursued by the pump owner or operator.
5.5.3. Recommended Measures

To address capacity deficiencies, the pump station could be upgraded with an additional pump and discharge pipeline that is not connected to the gravity outfall.
5.6. MCDD AirTrans

5.6.1. Identified Deficiencies

The following deficiencies were identified:

- **Trash Rack**—There is significant deflection of the trash rack at the base during operation of the trash rake. Components of the automatic trash rake have been known to seize up. The NCDD AirTrans pump station trash rack is shown in Figure 5-11.
- **Pressure Gauges**—There are no pressure gauges on any of the pumps.
- **Heating**—No heating is installed on this station. The only source of heat comes from the electrical components, which are insufficient.

![Figure 5-11 MCDD AirTrans Trash Rake](image)

5.6.2. Potential for Failure of Pump Station

Due to the condition of the trash rack, risk of failure for this station starts once the water surface elevation at the pump station reaches the pump-on elevation and increases with elevation up to the critical elevation, at which point the chance of failure is 100 percent, as shown in Figure 5-12. The remaining identified deficiencies are not expected to lead to pump failure and are not recommended to be considered further in the study; they may be pursued by the pump owner or operator.
5.6.3. Recommended Measures

Modifying or replacing the trash rake would improve the reliability of the pump station.

5.7. MCDD Broadmoor

5.7.1. Identified Deficiencies

The following deficiencies were identified:

- **Flow Monitoring**—The station has an electromagnetic flow meter on the discharge pipe. This meter has been reported to give inaccurate readings, so the actual flow for the station cannot be confirmed.
- **Trash Rack**—The screen is difficult to rake. The intake was designed for an automatic system but is currently hand raked. The MCDD Broadmoor pump station trash rack is shown in Figure 5-13.
- **Piping**—Discharge piping is PVC and is exposed to the environment. Piping is showing signs of degradation.
- **Pressure Gauges**—There are no pressure gauges on any of the pumps.
5.7.2. Potential for Failure of Pump Station

Accumulation of debris on the trash rack is the most likely failure mode for this pump station. This station has a low chance of failure at the pump-on elevation, with increasing probability of failure as elevation increases at the pump station, as shown in Figure 5-14. The remaining identified deficiencies are not expected to lead to pump failure and are not recommended to be considered further in the study; they may be pursued by the pump owner or operator.

Figure 5-13 MCDD Broadmoor Debris Screen

Figure 5-14 MCDD Broadmoor Pump Failure Probability Function
5.7.3. **Recommended Measures**
Installing an automatic trash rake or modifying the trash racks to work better with the hand raking operation would address the debris issues.

5.8. **MCDD Pump Station 4**

5.8.1. **Identified Deficiencies**
The following deficiencies were identified:

- **Flow Monitoring**—The station has an electromagnetic flow meter installed on the discharge pipe. This meter has been reported to give inaccurate readings, so the actual flow for the station cannot be confirmed.
- **Intake**—Although the overall pump capacity is deemed to be appropriate, the intake was not designed for the current pump configuration and appears to be too small.
- **Trash Rack**—The pump station utilizes an automatic trash rake system, as shown in Figure 5-15. This system cannot keep up with the amount of debris present. The screen often clogs, and pumps shut down.
- **Pressure Gauges**—There are no pressure gauges on any of the pumps.
- **Heating**—A portable electric heater is the only source of heat. This heater has a high chance of failure and is not able to maintain operational temperature.

5.8.2. **Potential for Failure of Pump Station**
This station would have a chance of failure during a storm event as shown in Figure 5-16 because of the identified trash rake deficiency and undersized intake. The other identified deficiencies were not identified to lead to pump failure and are not recommended to be considered further in the study; they may be pursued by the pump owner or operator.

5.8.3. **Recommended Measures**
Upgrading trash rakes to better clean the screens would increase reliability. Improvements to the intake to increase station capacity should be considered and evaluated. If intake improvements alone are not enough to increase the station’s reliability, then an additional pump should be considered.
Pump Station Deficiencies

Figure 5-15 Pump Station 4 Trash Rake

Figure 5-16 MCDD Pump Station 4 Failure Probability Function
5.9. SDIC Sandy

5.9.1. Identified Deficiencies

The following deficiencies were identified:

- **Secondary Level Control/Alarm**—Float switches do not operate properly and cause unwanted pump shutdowns.
- **Communications**—The programmable logic controller has failed and does not communicate with the supervisory control and data acquisition (SCADA) system.
- **Flow Monitoring**—The station has an electromagnetic flow meter on the discharge pipe. This meter has been reported to give inaccurate readings, so the actual flow for the station cannot be confirmed.
- **Intake**—The intake is too small for pump capacity. The flow separators in the pump intakes have failed and have been removed. This has adversely affected the pumping performance of the station.
- **Pumps and Motors**—The pumps are not able to keep up with large storm events even while operating simultaneously.
- **Pressure Gauges**—There are no pressure gauges on any of the pumps.
- **Other Observations**—The Sandy pump station is located in a low and narrow drainage, as shown in Figure 5-17. The floor of the pump station is only a few feet above the normal water level of the drainage channel. MCDD has stated that the water level has flooded the floor of the pump station in some storm events (e.g. February 1996). Staff were able to access the pump station, but safety of personnel was a concern. MCDD stated that as farmland has been developed and runoff increased, the pump station has experienced more instances where it has been overwhelmed.

5.9.2. Potential for Failure of Pump Station

Due to the inability of the pumps to handle discharge from some storm events, and the likelihood of being inundated, this station is expected to fail from a capacity deficiency when the water surface at the station reaches the critical elevation, as shown on Figure 5-18. The other identified deficiencies were not identified to lead to pump failure and are not recommended to be considered further in the study; they may be pursued by the pump owner or operator. The intake deficiency is viewed as contributing to the capacity deficiency at this pump station.

5.9.3. Recommended Measures

Replacing the Sandy pump station with a new pump station with increased capacity and an elevated pump station floor would also address the undersized intake deficiency. Automated trash rakes would also increase the reliability of the new pump station.
5.10. Summary of Failure Modes and Recommended Measures

Table 5-1 summarizes the deficiencies that were identified as potentially leading to pump station failure and recommended measures to reduce the risk of pump station failure. Deficiencies not directly contributing to a potential failure of a pump station are not included in Table 5-1 and will not be addressed as standalone measures in this feasibility study.
### Table 5-1 Summary of Dominant Potential Failure Modes and Recommended Measures

<table>
<thead>
<tr>
<th>Station</th>
<th>Dominant Potential Failure Mode</th>
<th>Recommended Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEN 1 PIR</td>
<td>Mechanical Deficiency: Pump 2 operates outside of the pump curve, resulting in a chance of failure during operation. Failure is considered assured when the water surface at the pump station reaches the critical elevation.</td>
<td>Replace Pump 2</td>
</tr>
<tr>
<td>PEN 2 Schmeer Road</td>
<td>Failure is considered assured when the water surface at the pump station reaches the critical elevation. No failures modes were identified that would be expected to result in pump failure prior to inundation at the critical elevation.</td>
<td>None identified</td>
</tr>
<tr>
<td>PEN 2 13th Avenue</td>
<td>Intake, Capacity, and Infrastructure Deficiencies: Intake is too small for the pump station capacity. Pump capacity is limited. Discharge pipeline is degraded and failing. These deficiencies result in a chance of failure during operation. Failure is considered assured when the water surface at the pump station reaches the critical elevation.</td>
<td>Increase the size of the intake. Add pump capacity. Replace discharge pipeline.</td>
</tr>
<tr>
<td>MCDD Pump Station 1</td>
<td>Failure is considered assured when the water surface at the pump station reaches the critical elevation. No failures modes were identified that would be expected to result in pump failure prior to inundation at the critical elevation.</td>
<td>None identified¹</td>
</tr>
<tr>
<td>MCDD Pump Station 2</td>
<td>Capacity and Infrastructure Deficiencies: Pumps cannot keep up in a storm event and discharge into a gravity outfall that limits capacity that can be pumped. Failure is considered assured when the water surface at the pump station reaches the critical elevation. No other failures modes were identified that would be expected to result in pump failure prior to inundation at the critical elevation.</td>
<td>Add additional pump and discharge line.</td>
</tr>
<tr>
<td>MCDD AirTrans</td>
<td>Intake Deficiency: Trash rake has a high likelihood of jamming, resulting in a chance of failure during operation. Failure is considered assured when the water surface at the pump station reaches the critical elevation.</td>
<td>Redesign or replace the trash rake.</td>
</tr>
<tr>
<td>MCDD Broadmoor</td>
<td>Intake Deficiency: Intake screen gets blocked. Failure is considered assured when the water surface at the pump station reaches the critical elevation.</td>
<td>Add automated trash rack/rake.</td>
</tr>
<tr>
<td>MCDD Pump Station 4</td>
<td>Intake and Infrastructure Deficiencies: Clogged trash rack and undersized intake result in a chance of failure during operation. Failure is considered assured when the water surface at the pump station reaches the critical elevation.</td>
<td>Redesign or replace the trash rake. Improve intake.</td>
</tr>
<tr>
<td>SDIC Sandy</td>
<td>Capacity and Infrastructure Deficiencies: Pumps cannot keep up in a storm event. Failure is considered assured when the water surface at the pump station reaches the critical elevation. No failure modes were identified that would result in pump failure prior to inundation at the critical elevation.</td>
<td>Replace the pump station at higher elevation with automated rake.</td>
</tr>
</tbody>
</table>

¹: Failure modes are identified in this report but are currently programmed to be addressed by owner.
6. Items for Further Evaluation

The following sections describe items that have been identified as potential risks to the reliability of the pump stations or that may not be consistent with Corps best design practices. A more detailed evaluation could be undertaken for items that are deemed critical to operation.

6.1. Pump Sizing

Current estimates of storm event flows show that only PEN 1 PIR, MCDD Pump Station 1, and MCDD Pump Station 4 have capacities that exceed a 5% AEP (20-year) storm. Six pump stations may lack the capacity needed to convey a 20-year storm flow:

- PEN 2 NE 13th Avenue
- PEN 2 Schmeer Road
- MCDD AirTrans
- MCDD Broadmoor
- MCDD Pump Station 2
- SDIC Sandy

All have pumps that either do not meet capacity requirements or are operating outside of their pumping curve. PEN 2 NE 13th Avenue and SDIC Sandy are unable to keep up with pumping demand during periods of high runoff. PEN 1 PIR Pump 2 is operating outside of its curve, as it was relocated from a different pump station. MCDD AirTrans and MCDD Broadmoor both have intake/rack deficiencies that adversely affect capacity.

Conversion of farm land into industrial use and other development has contributed to increased pumping demand at the above pump stations and is expected to result in future increases in demand. Interior drainage analysis performed for this study is documented in Appendix A (Hydrology and Hydraulics).

Proposed changes to EM 1110 2 3105 may require that new pump stations maintain 2/3 of the required capacity with one pump out of service. If this level of resilience is desired by the existing pump owners in the future, additional capacity upgrades beyond those recommended in this study may be required.

6.2. Transfer Switch and Backup Power

Standby generators (stationary or portable) are the preferred method to provide backup power to the stations, but there are no transfer switches at the stations to transfer power to a standby generator.
Limited access to some stations—particularly PEN 2 13th Avenue, MCDD Broadmoor, and SDIC Sandy—may make it difficult to transport a portable generator to the station during flood events.

Best practices recommend a receptacle and a properly sized manual transfer switch for a portable generator connection.

**6.3. Redundancy and Backup Measures**

Some form of redundancy or backup measure for systems critical to operation should be provided. Although not required for successful operation, many of the systems on each station have no means of redundancy installed. It is advisable to check for any single points of failure and any intermittent methods of operation in the event of such failure.

**6.4. Back Flow Prevention**

Best practices require two means of back flow prevention if the discharge is below the maximum discharge pool. Current stations utilize either a flap gate or a siphon break as the source of back flow prevention on the discharge pipes. Most of the pump stations only utilize one of these methods. More information can be found in EM 1110-2-3105 Section 7-4.

**6.5. Trash Racks**

Section 9-2 in EM 1110-2-3105 details trash protection systems, including safety measures associated with the design of the rake. Due to excessive failure of the automatic trash rakes and debris buildup, the EM suggests ensuring the appropriate type of rake was selected based on the debris present.

**6.6. Intake**

Intake sizing is an issue for three of the pumps listed in Section 6.1. If new pumps are needed, South Florida Water Management District (SFWMD, 2008) Section 2.5 has guidelines for suction configuration.

**6.7. Access**

SDIC Sandy, PEN 2 13th Avenue, and PEN 1 PIR are not readily accessible to cranes. In the event of pump failure, it would not be easy to replace or repair pumps. SDIC Sandy also exhibits tight clearance around pumps, impeding the ability to maintain the system.

**6.8. Tests and Inspection**

Maintenance records are available for PEN 1 PIR, PEN 2 13th Avenue, MCDD Pump Station 1, and SDIC Sandy. EM 1110-2-3105 Chapter 11 details typical pump station hydraulic tests. With
upgrades and modifications done since construction, pump and station tests should be performed prior to flood events to ensure the station is operating as designed.

6.9. Instrumentation

SFWMD (SFWMD, 2008) Section 2.6 states that the discharge configuration shall allow for accurate flow measurements and an accurate static head determination. The current stations do not have pressure gages, and most do not have a working flow meter. This impedes use of a pump curve to verify pump capacity. Other instrumentation that may be applicable to these stations includes temperature monitors, vibration monitors, valve position indicators, and water level gauges.
7. References


Parametrix. 2016. Pump Station Condition Assessment. Portland, OR.

Parametrix. 2017. Pump Station Force Main and Outfall Condition Assessment, Portland, OR.


